ANALYZING THE SPATIALITY OF CHINA'S REGIONAL INEQUALITY IN A GEOGRAPHIC INFORMATION SYSTEM ENVIRONMENT

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Abstract

Regional inequality is an essential topic in academic inquiry and policy making. With the rapid economic development after the reform and opening-up, the rising inequality in China has drawn considerable attention. While the studies on the spatiality of regional inequality have flourished and renewed the debate, the examination of space, scale, and locality over a long time period or at the finest level is relatively insufficient. Drawn upon a multi-scale and multi-mechanism framework, this dissertation aims to fill the gap by investigating regional inequality in China for the last sixty years and the patterns and mechanisms based on the county level data.

The first empiric chapter focuses on the long-term pattern of regional inequality and how spatially heterogeneous development processes and policy shocks impact the convergence in China. The findings indicate that the launch of reforms and the entry of WTO have led to the unbalanced redistribution of wealth towards the coastal provinces. While a significant convergence is observed for the eastern and northeastern regions, a divergence trend exists in the central and western regions. The impacts of the transitional processes like globalization, decentralization, and marketization are the most evident in coastal China, and their effects decline or become insignificant in interior China.

The second empiric chapter adopts the finest county level data and investigates how each spatial scale contributes to the pattern and affects the mechanisms of regional inequality. The results observe a plateauing pattern of inequality since the mid-2000s, to which the intra-

provincial inequality and the inter-regional inequality contribute the most. The convergence trend as a whole could mask the tendencies of divergence in each region at multiple scales. The multilevel modeling of mechanisms at the intra-provincial and intra-prefectural level suggests that the role played by spatial scales could not be neglected. The effects of triple processes, i.e. globalization, decentralization, and marketization, may turn from positive to negative or vice versa when inequality at different scales is investigated.

The third empiric chapter conducts an in-depth case study of regional inequality in Zhejiang province, a coastal province leading China's economic growth and reforms. The analyses reveal the importance of local contexts and bottom-up forces in regional development. On the one hand, economic activities are more concentrated due to the Wenzhou model of development and the emergence of new clusters in southern Zhejiang. On the other hand, with the global financial crisis and economic slow-down, the Wenzhou-Taizhou cluster has been challenged by new economic spaces centered on the Hangzhou-Ningbo cluster. The case study suggests the limited efficacy of inequality-reducing policies and the persuasive effects of self-reinforcing agglomeration on economic polarization and income mobility.

In summary, this dissertation comprehensively investigates the spatiality of regional inequality in China. It highlights the role of space, scale, and locality in patterns and mechanisms of regional inequality. Specifically, the spatial heterogeneous development processes, the effects of each spatial scale, and the local context and bottom-up forces are the keys to better understand regional inequality and to further make efficient policies towards balanced regional development.

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Chapter 1 Introduction

1.1 Research Background

Since the late 1980s, the market reform, globalization, and economic transition have contributed to rapid and strong economic growth in several emerging economies (e.g., China). The fruits of economic development, however, have rarely been evenly distributed among regions and individuals in these countries, and intensifying income and regional inequalities have been a central issue in government policy, drawing considerable scholarly attention and public concern (Xie and Zhou, 2014; Wei, 2015). In the aftermath of the global financial crisis in 2008/2009, new normal of economic slow-down and uneven recovery from the recession has created even more complex patterns of inequality, which triggers a new round of rethinking in uneven development (Boushey et al., 2017; Piketty, 2014).

The literature on regional inequality has been mainly focused on changing levels of regional inequality, its underlying forces, and the effect of state intervention (Arestis & Phelps, 2019; Florida and Mellander, 2016; Iammarino et al., 2019; McCann, 2020; Wei, 2017). Geographers and planners are particularly interested in the spatiality of inequality, with key terms such as space, place, location, scale, network, and mobility (Wei, 2015). A hotspot of analysis is China, a country that has recorded spectacular economic growth since the economic reforms launched in the late 1970s and at the same time has been faced with rapidly rising inequality. The Gini coefficient of income inequality in China was as high as 0.42 in 2012, ranking the third highest among the world's 25 largest countries by population (Wildau and Mitchell, 2016; Xie and Zhou, 2014). From the perspective of regional inequality, the coast-interior divide is persisting and has even widened during China's rapid

economic growth. Measured by the GDP per capita indicator, the ratio between the richest provincial economy and the poorest one peaked at 16 in 2002 and remained as high as 3.3 in 2017 (CSB, 2018; Tian et al., 2016). The poorest provinces with interior locations and large numbers of ethnic minorities, such as Gansu, Yunnan, Guizhou, and Guangxi, remain the poorest. At the provincial level, the gap between rich and poor regions within provinces remains evident, and spatial polarization has even intensified in many provinces.

The uneven regional development and concentration of wealth in China are rooted in its historical context and a series of economic transitions in the last four decades. As early as Han Dynasty's rule around 100 B.C., China has already joined the global market by exporting and exchanging silk and other handcrafts in Eurasia. The trade in maritime Silk Road by Zheng He in Ming Dynasty further promoted the development in coastal cities like Suzhou, Hangzhou, Ningbo, and Quanzhou (Frankopan, 2015). In the Age of Discovery, the driver of economic development has shifted to the trade between Europe and America, as China gradually declining from the leading position in the world economy (Broadberry et al., 2018; Pomeranz, 2000). From the first Opium War to World War II, the traditional market in China was forced to open to the western capitalist economy. The imperialistic colony sites along the coastal line, e.g. Hongkong, Macau, Taiwan, and several mainland ports opened by treaties, became the first to be incorporated into the capitalism production and modern industrialization system, with a considerable amount of migrants to start businesses abroad and build cultural and family connections overseas (Arrighi, 2007; Wei and Ye, 2004).

Since the foundation of the People's Republic of China in 1949, the economic system is transformed into a centrally planned one based on a socialist ideology (Wei, 2000). As a historical legacy, the poverty and imbalanced industrialization level between the coastal and interior China has drawn the attention from the Chinese Communist Party and its leaders. In Mao Zedong's discussion of the "Ten Great Relationship" in 1956 and the First Five-Year Plan by the central government from 1953 to 1957, the rebalance of coastal-interior China is one of the major targets in building socialist China and achieving equality in the new society (Mao, 1956). Following the guidelines of developing the interior without neglecting the coastal region at the same time, considerable resources and capital have been transferred to the backward interior China through the state's fiscal and investment systems (Wei and Fan, 2000). However, the efforts to reduce inequality during Mao's period was not as successful as expected due to the inefficiency in utilizing the investment in interior China with a poor endowment for economic growth (Wei 1999; Ma and Wei, 1997). With the political turmoil and social unrest during the Great Leap Forward and the Cultural Revolution, the inequality in China did not report any sign of great improvement during the pre-reform period (Kanbur and Zhang, 2005).

After the politically and economically devastating Cultural Revolution, China under Deng Xiaoping's administration has formally launched the economic reforms in 1978 and embarked on a more pragmatic course of regional development. The country has been transitioning into a "socialism with Chinese characteristics", that shifts the focus from the class and fractional struggle to promoting economic growth based on the market reform and the living standards of people (Gu et al., 2001). Several guidelines and policies under Mao's

period have been altered or modified to serve this purpose. The commune system in rural China has been abandoned by introducing the Household Responsibility System, which decollectivized the power of decision-making and surplus redistribution to rural households. With the rise of agricultural procurement price and gradually lifted limitations on the movement of farmers, agricultural productivity has been improved and a considerable amount of surplus labor has been released from land and flowed into the Township and Village Enterprises (TVEs) (Fan et al., 2011).

The economic autarky has also been deemphasized and replaced with the open-door policy to attract foreign investment. The large market size, due to the amount of population in China, as well as the pool of inexpensive educated labor, has firstly attracted Chinese diaspora capital from Hongkong, Macau, and Taiwan, and then the investors from Japan, Japan, Europe, and United States (Arrighi, 2007). Four special economic zones (SEZs) in southeastern coastal China, i.e. Shenzhen, Zhuhai, Xiamen, and Shantou, were established at the beginning of the reforms, followed by fourteen open coastal cities and three delta areas (Wei, 2000). With the entry to WTO and the establishment of Export Processing Zones (EPZs) nationwide, the export has increased rapidly and made China the world factory of manufacturing goods (Zhao et al., 2012).

The reforms are also reflected in ownership structure change and fiscal decentralization. Despite the TVEs and foreign invested enterprises (FIEs) discussed above, private enterprises (PEs) have also flourished in China, with the diminishing role of State-Owned Enterprises (SOEs) in the economy. To solve employment and productivity problems, the prohibition of

non-state sectors during the pre-reform period has been lifted and the central government has implemented several policies, covering reforms in finance, investment, price, labor and wage, and shareholding, to promote various forms of non-state ownership (Wei, 2000). The local governments have also proactively participated in the ownership structure change to promote economic growth and seize the incentives from the fiscal decentralization. During the fiscal reform from the mid-1980s to 1993, the central government has signed contracts with the local governments as a fixed amount or ratio of tax revenue submitted to Beijing and the rest to local, which provided stimulus to facilitate economic growth within the subnational jurisdictions (Wang, 2010). The sharply declining fiscal capacity during the period has forced the central government to recentralize to a certain degree after 1994. Instead of sharing the general revenue, the revenue has been categorized by tax types and assigned to the central government, the local governments, and shared by the central and local government based on established formulae. Meanwhile, the expenditure has not been centralized and the local governments are still responsible for public good and services within their jurisdictions (Song, 2013).

However, the transition towards a market-oriented economy is geographically uneven in nature and has resulted in increasing inequality in China. Social unrests and struggles have been rising in response to inequality and other issues related to the rapid economic growth like environmental degradation, political corruption, and the failure of social safety net (Arrighi, 2007). Geographic inequality has become a major concern of the central government (Wei, 2002, 1999). The severe regional inequality since the reform has alarmed policymakers into implementing policies aiming to alleviate inequality nationally and

regionally. A series of policies have been implemented to stimulate development in poor provinces since the 2000s, such as the "Western Development Program" (*xibu da kaifa*) in 2000, the "Revival of the Northeastern Region" (*zhenxing dongbei*) policy in 2003, the "Rise of the Central Region" (*zhongbu jueqi*) scheme in 2006, and the most recent "One Belt and One Road" (*yidai yilu*) strategy launched in 2013 to create new growth poles in the western region (Deng et al., 2010; Fan, 2006; Fan and Sun, 2008; Lin, 2015; Yeung, 2005). However, scholars also doubt and debate over whether these policies have had observable effects in alleviating regional inequality and solving the fundamental inequality issue (Chen, 2010; Chen and Groenewold, 2010, 2013).

1.2 Literature review

The central topic of regional development theories is the debate regarding equilibrium or disequilibrium among regions and how it is achieved. After the World War II, the neoclassical convergence school firstly developed based on the assumption of free market (Borts and Stein, 1964; Harris, 1957). Closely related are the inverted-U model and growth-pole theory (Perroux, 1950; Williamson, 1965). However, the modernization paradigm was heavily criticized for the persistence of poverty and inequality in developing countries. In the 1970s and 1980s, the divergence school became an important alternative, including structuralism theory and planned economics theory proposing different explanations of disequilibrium in development (Harvey, 1975; Richardson, 1973). Globalization and reforms in former socialist countries have renewed the debate on regional inequality since the 1990s. Debate over regional inequality was fueled by the rise of the new convergence theory and new economic geography theory (Barro and Sala-i-Martin, 1992; Barro et al., 1991;

Krugman, 1991; Krugman and Venables, 1995). An increasing interest on the role of spatial process and scale in changes of regional inequality also emerged, trying to overcome the limits of traditional regional development theories, which considered space merely as a container or a unit of analysis (Rey and Sastré Gutiérrez, 2015; Soja, 2009; Wei and Ye, 2009).

1.2.1 Convergence and divergence theories

Since the 1950s, there has been a dichotomy between the convergence and divergence schools regarding the long-term trajectories of regional inequality. Heavily influenced by neoclassical economics, the convergence school argues that regional disparity is "temporary" and will be replaced by spatial equilibrium over time under the assumption of free movement of factors and full access to information (Borts and Stein, 1964). In line with this hypothesis, Williamson (1965) argues that regional inequality will rises in the early stage of development when structural change and specialization happen, but tends to fall as the economy matures, characterized by advanced structural change and market integration, as well as increasing capital movement and labor migration between regions, showing an inverted-U pattern along time (Kuznets and Murphy, 1966). Echoing with this "transition theory" (Lipshitz, 1992), the modernization theory assumes that all countries occupy positions on a spectrum from "traditional" to "modern" ones, and nations may move to higher development levels by adopting the characteristics of "modern" countries (Rostow, 1960).

The growth pole theory (Perroux, 1950), the core-periphery model by Friedmann (1966), and the bell-shaped development model (Alonso, 1980) are also related to the convergence

school. Perroux (1950) argues that entrepreneurial innovation and "propulsive industries" serve as growth poles and the engines for regional development. Though polarization because of agglomeration economics and a consequent backwash effect exist in the early phase (Myrdal, 1957), diffusion of technologies and innovations will finally cause redistribution and equilibrium. The core-periphery model points out that though development is led by a few core regions and tends to self-reinforce, the trickle-down effects to peripheries could forge functionally interdependent spatial systems (Friedmann, 1966). Five bell shapes in regional development are summarized by Alonso (1980): development stages, social inequality, regional inequality, geographic concentration, and demographic transition. Theories introduced above could be categorized as top-down development, or by the development from above paradigm (Hansen, 1981).

However, the neoclassical convergence school has been criticized since the 1970s (Krebs, 1982; Stöhr and Tödtling, 1979). Theoretically, the free movement assumption of labor and capital does not hold in most countries (Richardson, 1978). The causes of the inverted-U pattern remain elusive (Kim, 2008). Rising wage and narrowing gap because of out-migration in peripheries are precluded by a high natural population growth rate, and the selective migration of young, skilled, and highly educated groups hampers the potential development of poor regions (Brown and Lawson, 1989). Empirically, though the convergence process is observed in studies (Harris, 1957; Mera, 1978; Tabuchi, 1988; Vining and Strauss, 1977; Barro, 2015), controversial evidences indicate the opposite and the convergence itself may be considered as a "temporary" process if a historical perspective and longer time period is adopted (Breau, 2015; Dorling, 2015; Fabregat & Badia-Miró, 2014;

Geary & Stark, 2016; Magrini et al., 2015; Piketty, 2014; Piketty et al., 2017). The inverted-U pattern is validated (Barrios and Strobl, 2009; Ezcurra and Rapún, 2006; Lessmann, 2014), but empirics also suggest U-pattern of divergence and the market integration and free movement of labor and capital are accompanied with greater regional gaps (Martínez-Galarraga et al., 2015; Monastiriotis, 2014; Peng & Swider, 2017). The neoclassical convergence theory neglects the cultural, institutional, and geographical factors that influence trade, factor mobility, innovation and regional development (Krugman, 1991; Wei and Ye, 2009).

Inspired by the persistent inequality in most underdeveloped countries and the civil rights movement in the United States, the divergence school emerged in the late 1960s and led to new thinking on inequality (Wei, 2015). The divergence school doubts the hypothesis of the free market and emphasizes that capital accumulation and cumulative causation could make regional inequality persistent (Smith, 1984). The divergence school can be further summarized into two theories, one of which is the planned economics theory and the other the radical theory, which agree that free movement of production factors will enhance the spatial disequilibrium but disagree on the effects of government intervention (Lipshitz, 1992). While the planned economy theory postulates that policy intervention is effective in reducing regional inequality, the radical theory, represented by dependency, world-systems, and Marxian/neo-Marxist political economy theories, is mainly based on structuralism, rooted to the works of Marx, and emphasizes spatial disequilibrium. In the Marxist political economy perspective, regional inequality is viewed as a necessary precondition for and unavoidable consequence of capital accumulation (Harvey, 1975).

Within the divergence school, the world-systems theory excels in pointing out the deficiencies in the convergence school and explaining the persistent gap between the developed and developing economies. Inspired by the dualism and dependency theories, the world-systems theory utilizes the positional and relational measurements to reflect not only the economic, but also the social, political, and cultural processes among economic entities under a historical perspective (Wallerstein, 1974; Wallerstein, 1979). A hierarchy structure of core, periphery, and semi-periphery is adopted to summarize the role of countries in a capitalist world economy. Unlike the core-periphery structure by Friedmann (1966), the core-periphery relationship in the world-systems is built by the labor and technology division in the production process, the diversity of trade goods, and capital accumulation and concentration level. Moreover, the active and most mobile semi-periphery is introduced as an intermediate category of economies where the mixture of core and periphery activities take place and the mitigation to the conflicts among the dual core-periphery happens (Chase-Dunn, 1998).

From the world-systems perspective, the inequality among the developed and developing countries is caused by their position in the core-periphery hierarchy and the uneven relationship in the political economy. In contrary to the developmentalism and Rostow's stages of development theory (Rostow 1960), the world-systems theory argues that the futuristic speculation of the peripheries to follow the development ladder like the cores ignores the core- and periphery-producing processes in which the unequal exchange along the commodity chains produces the inequality among states, people, classes, and households (Taylor, 1992). The world-systems perspective has stimulated enormous theoretical and

empirical investigations on the distribution of economies in the hierarchy and dynamics among core, periphery, and semi-periphery, which incorporate and bridge the context of uneven development in both the western and non-western countries (Clark, 2010; Clark & Beckfield, 2009; Dezzani, 2001, 2002; Flint & Dezzani, 2018; Hickel, 2017; Peacock et al., 1988; Rossem, 1996). The evidence is contradictory to the orthodox narratives and suggests divergence between core and periphery. The periphery stagnates since it is chronically deprived of investment and is less favored in terms of human capital and trade (Clark, 2010; Storper, 1989). Successful upward transitions are made along the hierarchy but also balanced with downward transitions, which keeps the structure stable and implies that inertia is the dominant condition in the world-systems (Dezzani, 2001, 2002; Flint & Dezzani, 2018). However, it is also argued that the perspective on the core-periphery structure ignore the interdependence and the dynamics of structure and capital accumulation, and are too strict in practice (Corbridge, 1986; Duncan, 1989; Knox et al., 2014).

1.2.2 New convergence theory and new economic geography

Since the 1990s, a renewed interest in regional inequality has been triggered by new round of thinking on the effects of globalization and liberalization, reforms and transitions in former socialist countries, the rediscovery of regions and geography in social science, and new developments in the disciplines of economics and geography (Wei, 2015; Wei and Ye, 2009). Two influential theories, the new convergence theory and the new economic geography, are put forward to respond to the critiques of neoclassical economics and provide more explaining power with relaxed economic assumptions (Barro and Sala-i-Martin, 1992; Barro et al., 1991; Krugman, 1991, 2011; Krugman and Venables, 1995).

The new convergence theory identifies two concepts of convergence, namely σ-convergence and β-convergence. The most-often studied convergence measure, σ-convergence, refers to the declining dispersion of income or outputs per capita across regions over time (Rey and Janikas, 2005). In empirical studies, σ-convergence is usually measured by the coefficient of variance (CV), the ratio between standard deviation and mean value. A decreasing trend indicates that regional inequality is declining. To test σ-convergence, regression of the standard deviation over the time trend will be conducted, in which a significant and negative coefficient indicates σ-convergence (Barro and Sala-i-Martin, 1992).

Differing from the aggregated perspective in σ-convergence, β-convergence refers to the process that poor economies grow faster than wealthy economies, which will ultimately lead to convergence among economies (Barro and Sala-i-Martin, 1992; Barro et al., 1991). In addition to absolute convergence, the conditional convergence and club convergence theories are also proposed (Quah, 1997; Sala-i-Martin, 1996). Conditional β-convergence holds that regions tend to converge conditionally on endowments of regions such as the investment return rate, human capital, population growth rate, technology advancement, and capital depreciation rate (Barro, 2015; Mankiw et al., 1992). Club convergence refers to the convergence process in different geographical regions with similar economic conditions, in which economies converge to multiple steady state equilibrium levels (Lau, 2010).

Though the new convergence theory has fueled fresh debates and empirical testing and deserves a huge credit for revitalizing the study of regional inequality in mainstream economics, it has also received criticism (Wei, 2015; Wei and Ye, 2009). It is argued that by

focusing only on the aggregated level of dispersion, σ-convergence may conceal important geographical patterns over time, mask any mixing and mobility of individual economies, and ignore other aspects of the income distribution such as skewness and modality (Rey and Janikas, 2005; Rey and Montouri, 1999). Exploratory analysis of growth dynamics in the distribution of regional incomes is proposed as an alternative empirical strategy since it does not impose prior restrictive assumptions on the growth processes (Quah, 1993). Methods like stochastic kernel density estimation and Markov transition matrices are widely employed to explore the dynamics of regional inequality (Dezzani, 2001, 2002; Fingleton, 1999; Flint & Dezzani, 2018; Johnson, 2000; Magrini, 1999; Quah, 1996).

Without asserting a convergent or divergent trend of regional inequality, the new economic geography (NEG) has been proposed to explain regional development by integrating traditional location theory, new internal trade theory, and transportation costs, forming a set of analytical approaches in economic geography (Fujita et al., 1999; Krugman, 1991). It adopts a microeconomic lens to consider the effects of imperfect competition in which increasing returns of scale, agglomeration economies, and geographical factors are emphasized (Krugman, 1997, 2011). The new economic geography serves the significant purpose of bringing geography and economics together and provides insights about how falling trade costs will increasingly integrate the core and peripheral regions but also foster a greater concentration of economic activities in the core (Armstrong et al., 2000; Krugman and Venables, 1995).

Under the new economic geography framework, centripetal and centrifugal forces will be generated between core and periphery, which will eventually determine the spatial distribution of economic activities (Krugman 1991; Krugman and Venables 1995). The centripetal forces originate from the advantages of larger cities in which a greater variety of intermediate inputs will provide the efficiency-scale effects in production. Factors will collocate together and the rate and scale of collocation of factors depend in part on the mobility of the factors (Puga, 1999). Meanwhile, the iceberg transport cost and localized congestion effects will provide centrifugal forces because of the increasing marginal distance cost and agglomeration diseconomy (Palivos and Wang, 1996). The overall observed spatial distribution of economic activities is argued to depend on the balance between the two opposing forces and both regional convergence and divergence are possible.

In new economic geography studies, regionally divergent growth is more often emphasized because the falling trade costs and mutual trade openness in the last twenty years of globalization are seen to generally favor core regions and large urban centers at the expense of other regions (Krugman, 1997; Krugman and Venables, 1995; McCann, 2007). Approaches in NEG are also criticized for being too sensitive to the actual specification employed and small changes in parameters and assumptions will lead to major empirical change (Bosker and Garretsen, 2010). More importantly, agglomeration as the core of NEG theory provide an important explanation for patterns of regional development but do not deliver a complete account (Martin, 2015).

1.2.3 Spatiality and scalarity in uneven regional development

The increasing interest in the role of space since the mid-1980s reflects how human geographers put geography at the center of understanding social, economic, and political processes (Massey, 1985). Spatiality in regional development could be defined as properties relating to or occupying space such as dimensionality, directionality, and spatial configuration (Wei, 2015). In the resurgence of regions and regionalism in development literature, such terms as locality, local context, and scale are associated with local and regional development (Baert, 2017). Hence, local endowments of human capital, institutional qualities, or the innovative capacity of firms and individuals are considered as important factors driving different economic growth rate.

In the view of endogenous growth theory, technological progresses and knowledge spillovers are related to the capital and human investment rather than a component growing exogenously with time, which implies that countries with abundant capital and high proportion of research and development tend to have increasing growth rates (Romer, 1986, 1987, 1994). Unlike the endogenous growth perspective taken by the neoclassical economics theory and new economic geography, the evolutionary and institutional schools focus more on place-based relatedness between regions in technological and institutional terms and how technological “lock-in” and institutional capability affect differential regional growth (Aghion and Howitt, 1992; Boschma, 2005; Porter, 1990; Saxenian, 1994). In empirical models, the evolutionary and institutional schools also capture factors like knowledge spillover, input variety, and human capital, but emphasizes that there is no necessarily preordained growth rate or trajectory to which the economies should converge. It is argued

that the economic growth trajectory of regions depends on how well-positioned an economy is to take advantage of newly emerging technologies (McCann, 2014).

The institutional school argues that institutional profiles of regions also play an important role in economic development and that the historical trajectory of institution and governance systems matters (North, 1990). The ability of an institutional system to facilitate regional growth and development depends not only on its architectural design, but also the interactions between institutional actors, stakeholders, and interested parties. In some cases, the institutional factor is more important than geography or trade (Acemoglu et al., 2002; Rodríguez-Pose, 2013; Wei, 2000). Under a highly centralized state, it will preclude the widespread engagement of local stakeholders and limit endogenous driven local development, while coordination failures, rent seeking, duplication, and absence of coordinated strategies will happen in decentralized systems (Barca et al., 2012).

Empirics show that formal institutional policies, either to the macroeconomic aspect or regional aspect, will impact regional development and inequality. Policies that promote industrialization and foreign investment and trade in developing countries tend to favor development in core regions and exacerbate regional inequality (Gilbert and Gugler, 1992; Lipton, 1977). Political factors like officer assignment, corruption, and instability, will also cause urban primary and regional inequality (Kim, 2008; Wu and Chen, 2016). Since the state is also multi-scalar in nature and embedded with dynamic and shifting development philosophies, the role of local government is complex and non-neglectable. It is suggested that state policies, especially those in developing countries aiming at developing peripheral

regions and reducing regional inequality, only have limited effects and are often offset by macroeconomic realities, forces resulting from foreign direct investment, and local governments in core regions (Wei, 2015).

The impacts from informal institutions are also non-neglectable, of which social capital is the most important one and brought to contemporary economics discussion about urban and regional systems (Putnam, 2001; Putnam et al., 1994; Westlund, 2006). Referring to all types of social norms, social rules, and social conventions that operate within a society, social capital, especially social trust in government institutions, is suggested to be highly correlated with levels of economic activity over time and influence the ability of a region to adapt to changes, therefore implying that the institutional history of the region also determines its long-term development (Putnam, 2001; Putnam et al., 1994). Like the evolutionary school, the institutional school points out that the technological, institutional, and social profile of the region is crucial in understanding its growth pattern and economic development over time beyond the questions of geographical proximity and economic scales and agglomeration (McCann, 2014).

1.3 Research objectives

Given its size, diversity, and profound transformations since the reform, China provides one of the best laboratories to test theories regarding regional inequality, convergence, and uneven regional development in developing and transitional economies (Cavanaugh and Breau, 2018; Herrerías and Monfort, 2015; Wei, 2017; Yao, 2009). The primary objective of this dissertation is to comprehensively analyze evolving multi-scalar patterns of regional

inequality in China and to deepen our understanding of multiple mechanisms in relation to economic transitions and globalization. Conceptually, it is argued that the above-mentioned convergence and divergence theories are overly simplified, masking the complex geographies of regional inequality in China. Therefore, the spatiality of regional inequality deserves special attention, as regional inequality is sensitive to scale, space, and place. The geographic view is more eclectic and provides a middle-ground perspective on regional inequality and uneven development in China beyond the convergence-divergence debate (Wei, 2010).

Specifically, this dissertation attempts to advance the research on regional inequality in China in the following four areas. First, regional inequality evolves with time and context, requiring close monitoring and timely analysis. Although considerable research has been done on regional inequality in China at multiple scales (He, Bayrak, et al., 2017; He, Fang, et al., 2017; Li and Fang, 2014), rich empirics still need to be more systematically analyzed by using longer time-series datasets. It is widely recognized that there are structural breaks in the temporal trend of regional inequality in China, in which policy shocks and changing domestic and global circumstances trigger the redistribution of wealth and change the landscape of regional inequality (Fan and Sun, 2008; Fan et al., 2011; Kanbur et al., 2017; Kanbur and Zhang, 2005). more efforts are needed to couple the spatial and temporal dimensions and consider the impacts of shocks and redistribution effects in the spatiality of regional inequality. In this dissertation, the uneven development and underlying mechanisms both before and after the reform launched in the late 1970s are examined. By extending the study period to the post-crisis and economic slow-down era in the 2010s, this dissertation

also renews our attention to the inequality problem when China's economy entered the "new normal" phase.

Second, regional inequality is sensitive to scale, but the source of such sensitivity remains unexplained. Multi-scalarity is an essential feature of regional inequality. Three major geographical scales have been adopted in the literature, namely the interregional, interprovincial, and intra-provincial ones (Wei, 2017). Recent studies on China have moved from considering interregional and interprovincial inequality to the inter-prefectural and even inter-county inequality, and from the disparities at a finer scale in one province to the gap among prefectures and counties in China as a whole (He et al., 2017; Huang and Wei, 2019; Li and Fang, 2014). Empirics at the regional, provincial, prefectural, and county levels show that multi-scalarity is one of the fundamental features of China's regional inequality, as more profound disparities are corroborated at finer scales (Wei, 2017). However, there are also more discrepancies regarding the trends of regional inequality at the prefectural and county levels, where scale effects become evident and disturb the assessment. Moreover, the underlying mechanisms of the inter-prefectural and inter-county regional disparity should be investigated, which could be interpreted as including the "triple process" of globalization, decentralization, and marketization, as well as rapid urbanization in China (Gao et al., 2019; Li and Wei, 2010; Wei et al., 2017).In this dissertation, the county-level dataset, which reflects the most disaggregated scale of regional inequality in China, is analyzed and the relationships between regional inequality at multiples scales are emphasized. By investigating the multi-scalarity of regional inequality and the underlying mechanisms, this dissertation attempts to

demystify the sensitivity to scales and how the driving forces of regional inequality vary across scales.

Third, the role of place, local context, and locality in uneven regional development deserves more updated scrutinization. Regional development strategies in China vary from place to place and from one political agenda to another. Empirical analyses at the national level could mask the dynamic interplay of the global investors, the central government, and local-level factors that may provide a more nuanced interpretation of regional development in China. Recent studies of regional inequality in China have scaled down to intra-provincial inequality (Dai et al., 2017; Gu et al., 2016). Hotspots of studies include Guangdong, Jiangsu, and Zhejiang, more recently expanding to the interior provinces such as Henan, Guizhou, and Guangxi (Dai et al., 2017; Li and Wei, 2014; Liao and Wei, 2012; Sun et al., 2016; Wei and Ye, 2009; Wei et al., 2011). Bottom-up forces are highlighted in previous studies in determining local economic development, in which the local agents are the key element in line with the global investors and the central government (Wei, 2007). Local development models, supported by locally embedded transitional institutions and developmental governments, are also one of the main causes in shaping the core-periphery divide in provinces like Guangdong, Jiangsu, and Zhejiang (Liao and Wei, 2012; Wei and Ye, 2009; Wei et al., 2011). In the aftermath of the global financial crisis and the slow-down of China's economic growth in the 2010s, the question as to how the local forces can adapt to new circumstances and how regional inequality and the core-periphery structure are changed in such processes need to be answered. In this dissertation, a unique emphasis is placed on intra-provincial inequality with a case study of Zhejiang province, a coastal province that has

been spearheading China's economic reform while recently being hit by a more volatile trade environment in the global economy. The analysis at a finer scale in Zhejiang province shows that regional disparities within provinces are considerable, and the intra-provincial study could present a more thorough examination of development models and local responses to the reform and globalization in transitional China. Therefore, this dissertation scrutinizes the Wenzhou model of regional development in Zhejiang province and emphasizes a more bottom-up approach in understanding regional inequality.

1.4 Data and Methodology

1.4.1 Study area

For the long-term analysis of provincial units in China, the study area includes the provinces and directly administrated municipalities (Figure 1.1). Taiwan, Hong Kong, and Macao are excluded because they are under different political and economic conditions and the data is not available. Chongqing, which has been separated from Sichuan province as a directly administrated municipality since 1997, is treated as a prefecture of Sichuan because separate data for Chongqing before 1997 are largely unavailable. Likewise, Hainan province, which has been separated from Guangdong province after 1988, is merged with Guangdong province since separate data for Hainan before 1978 is not available. In short, there are 29 provincial units in the analysis focusing on the period from 1952 to 2016. For the county-level analysis, since the study period is from 1997 to 2016, the analysis covers 31 provinces with Chongqing and Hainan accounted for. To keep the consistency of spatial units, the county boundaries of 2016 are used and aggregated into the prefectures, resulting in 341 prefectures formed from 2179 counties.

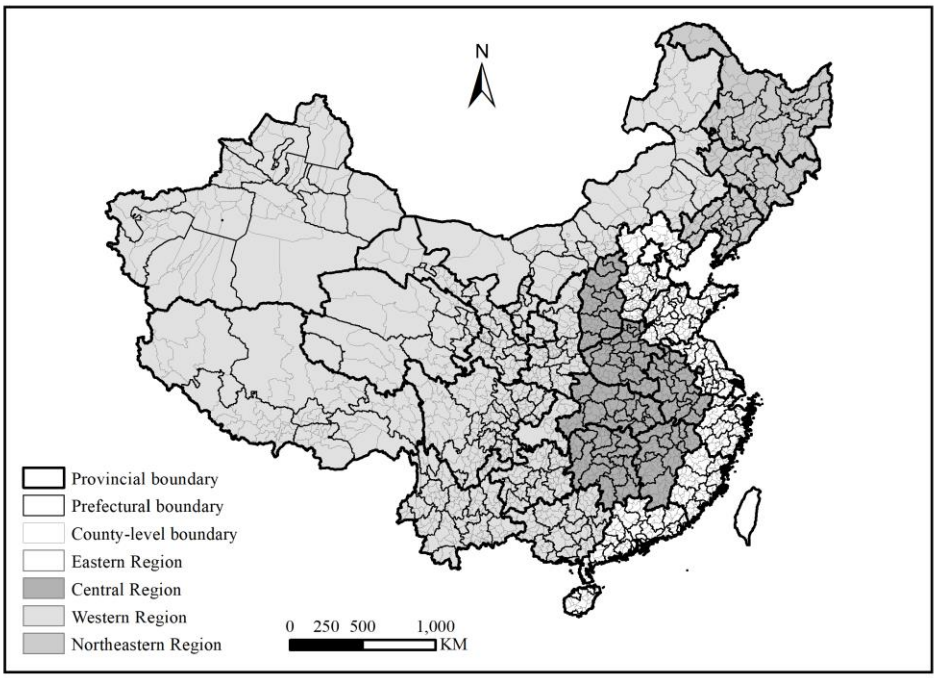

Figure 1.1 The study area: People's Republic of China

The case study of Zhejiang deepens our understanding of regional inequality and further addresses the bottom-up process of regional development in China (Figure 1.2). The province is also known for the Wenzhou model of development driven by the interplay of local contexts, external investment, and thick institutions. In Zhejiang province, multiple forces, especially local or grass-root initiatives or domestic enterprises, are found to be more important (Wei et al., 2007). With respect to the study area, Zhejiang province is traditionally divided into a northeastern part and a southwestern part. Northern Zhejiang includes six prefectures, namely Hangzhou, Ningbo, Jiaxing, Huzhou, Shaoxing, and Zhoushan. Southern Zhejiang contains the other five prefectures, i.e. Wenzhou, Taizhou, Jinhua, Quzhou, and Lishui prefectures. Similar to the analysis of China, seventy-one county level units are aggregated into eleven prefectures and two regions in Zhejiang province. The time span of the study covers the period from 1978 to 2015 (Figure 1.3).

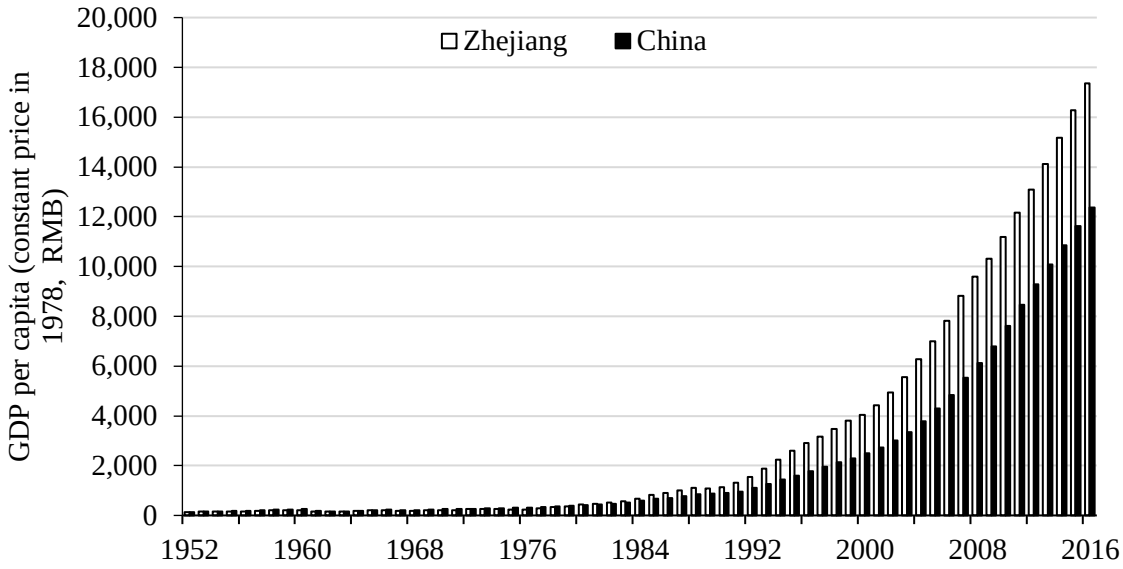

Figure 1.2 GDP per capita in China and Zhejiang province

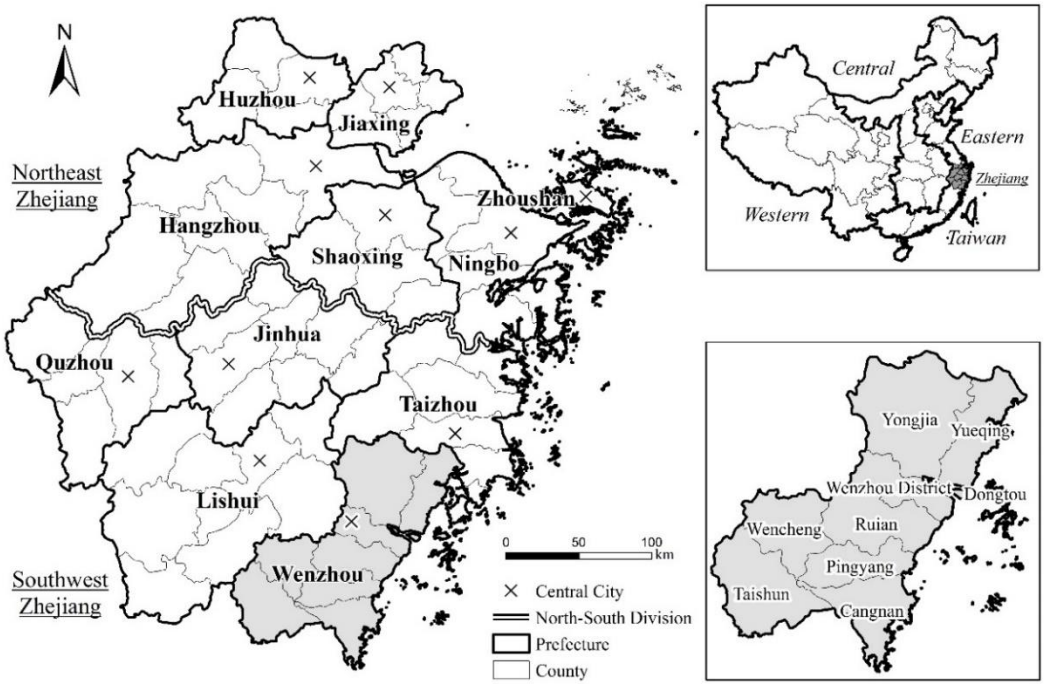

Figure 1.3 The study area: Zhejiang province

1.4.2 Data and methods

The data used in this dissertation includes socio-economic data in China and Zhejiang province, as well as GIS boundary data for spatial analysis. The socio-economic variables are chosen based on the conceptualization of China's economic transition as a triple process of globalization, marketization, and decentralization during the reform era. In order to perform the long-term analysis at various spatial scales, GDP per capita is selected as the indicator due to data availability (He, Bayrak, et al., 2017; Li and Fang, 2014). It is not the best, or even convincible indicator, since many other indicators could be employed to measure the level of economic development, such as the human development index (Li, 2012), disposable household income, wage, and level of consumption (Bin and Fracasso, 2017). But it is also widely used as the economic barometer of China, and it is available and readily collected. The permanent population who lives in a place for more than half a year is used instead of the registration population to calculate GDP per capita given that the considerable amount of migrant labor in total population statistics may be influential in measures of inequality (Li and Gibson, 2013).

Proxies are chosen to represent the three forces of marketization, decentralization, and globalization, as well as other control variables, which is according to the literature and will be discussed in greater details in following chapters (Gao et al., 2019; Li and Fang, 2014; Li and Wei, 2010; Wei et al., 2017). GIS data is collected from China Data Online (http://chinadataonline.org) at various scales, namely the national, provincial, prefectural, and county levels.

In terms of methodology, traditional analysis of regional inequality relies on aspatial indicators and methods such as the Theil index and global regression. In order to understand the spatial and temporal patterns of regional inequality, this dissertation takes full advantage of recent advancements in GIS and exploratory space-time data analysis methods, including Moran's *I*, LISA, spatial and non-spatial Markov chains, spMorph, and space-time path techniques. By applying more rigorous modeling approaches such as spatial regime modeling, multi-level modelling and geographically weighted regression, this dissertation provides detailed analyses of the underlying mechanisms of uneven regional development in China.

1.5 Organization of this dissertation

By integrating a multi-scale and multi-mechanism framework and GIS spatial analysis methods, this dissertation aims to provide a more comprehensive picture of regional inequality in China at multiple levels. It offers rich empirics with respect to spatial inequality in the context of economic transitions in China. After the introduction, Chapter 2 presents a long-term analysis of regional inequality among provinces in China. By adopting newly developed exploratory space-time data analysis (ESTDA) methods, the chapter analyzes the spatial dynamics of regional inequality and investigates how uneven regional development in China changes with policy shocks and different contexts and the mobility of individual provinces. Spatial regime modeling is further used to distinguish spatially heterogeneous development processes and the varying impacts of mechanisms among regions. Chapter 3 furthers our understanding with a multi-scalar perspective and considers the spatial hierarchy embedded in China's regional inequality. The three-stage nested Theil decomposition

method used in the chapter helps to demystify the scale sensitivity of inequality and gauges the contribution of scale under a coherent spatial framework. A Multi-level modeling technique is adopted to make sure that the spatial hierarchy in China is accounted for while investigating the mechanisms of intra-provincial and intra-prefectural inequality. Chapter 4 scales down the study of regional inequality through the case study of Zhejiang province. The aspatial measures and exploratory spatial and temporal data analysis methods used in previous chapters are also employed in this chapter to examine and compare the spatiotemporal dynamics of regional inequality within provinces, with an emphasis on bottom-up forces like the Wenzhou model of development. Chapter 5 discusses and concludes with the findings of the whole dissertation and highlights the research significance and possible pathways for studies in the future.

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Chapter 2 Shocks, Spatial Regime Fades, And Space-Time Dynamics of Regional Inequality in China, 1952-2016

Abstract

This chapter explores patterns of regional inequality in China across provinces during the past sixty years from 1952 to 2016 using exploratory space-time data analysis (ESTDA) methods and spatial econometrics. The chapter firstly applies a novel regionalization technique, spMorph, to identify and investigate the process of spatial regime fades, and its effects on regional inequality. The obtained results indicate that the reform and opening-up since 1978, the rural reform and urban-industrialization in the mid-1980s, the deepening reforms in the early 1990s, and China's integration to the global market since 2001 are decisive factors in the spatial (re)distribution of rich and poor regimes in China. Coastal China has emerged rapidly and the old industrial bases in the northeastern China have declined as the transitions have taken effect. The chapter further scrutinizes detailed dynamics of selected provinces, which contributes to the spatial regime fades in the Chinese regional economy patterns. Results suggest that economic performance of neighboring provinces, as well as institutional forces and poverty alleviation programs, are found to play an important role in the process of spatial redistribution or regime fades. Lastly, drawing upon the conceptual framework of multi-mechanisms, the results of a spatial regime model (SRM) illustrate that differentiated convergence or divergence processes exist among regimes. The underlying mechanisms, mainly represented by the triple transitional forces of globalization, decentralization, and marketization, vary in different regions or spatial regimes.

2.1 Introduction

Regional inequality is not only a central inquiry in the fields of development studies, economic geography, urban and regional planning, and various social-science disciplines, it has also drawn considerable attention from policymakers, since regional inequality is politically hazardous for societal stability and economically negative to regional development and growth (Fan et al., 2011; Ghosh, 2020; Marchand et al., 2020). The renewed debate since the 1990s, represented by the new convergence theory, argues that convergence could be achieved by the poor economies catching up with higher growth rate (Barro and Sala-i-Martin, 1991). However, this strand of studies used to ignore the role of spatial effects and adopt aspatial methods in validation, thus providing poor explanation power to the current divergence and polarization in the world economies (Quah, 1996; Rey & Janikas, 2005; Storper, 2018).

Geographers and planners tend to emphasize the spatiality of regional inequality by utilizing such concepts as scale, space, spatial regime/regions, place and networks. With the aid of more recent developments in GIS and spatial analysis techniques, in conjunction with the availability of geo-referenced economic data, increased efforts have been made to examine the evolving patterns of regional economies over space and time. On one hand, the focus on spatiotemporal dynamics reflects the impacts of policies on local economies, thereby revealing the efficacy of poverty alleviation programs and spatial policies along time and in an exploratory manner. On the other hand, analyzing space-time dynamics could improve our understanding about how individual regions' development paths could essentially change the economic landscape. In general, GIS methods and exploratory space-time data analysis

techniques (ESTDA) provide new assessment approaches to examining changes and bottom-up dynamics of regional inequality.

China's transition from planned to market economy has led to rising spatial inequality among provinces. The gap between the coastal and interior provinces has widened since the reform and opening-up in 1978 (Wei, 2017). Before the reform, interior China was favored in terms of investment and industrialization (Ma and Wei, 1997). But with the reform and opening-up, coastal China has disproportionally benefited from both central government policy and foreign investors and achieved rapid economic growth, leaving interior China lagging behind (Hao and Wei, 2010; Sakamoto and Islam, 2008; Wei, 2007; Yao, 2009). The widening regional gap, which increasingly threatens the social and political stability of China (Howell and Fan, 2011; Knight, 2013), alerts and prompts the Chinese government to implement several inequality alleviation programs like the Western China Development policy (*xibu dakaifa*) and the latest "one belt one road" policy (*yidai yilu*) (Fan and Sun, 2008; Liao and Wei, 2016). To investigate the dynamics of regional development in China, scholars have utilized different ESTDA methods in the previous studies, aiming to analyze the spatial patterns and dynamics of economic development. However, the examination of the spatial redistribution process of regional economies in relation to shocks has been limited, but the issue of spatial regime fades remains important for devising policies to combat unbalanced development.

In this chapter, the concepts of *shock* and *spatial regimes* are introduced through the application of an ESTDA technique, namely SpMorph. *Spatial regime* is defined as a

temporally coherent spatial aggregation of regions and *shock* refers to the structural break wherein one spatial regime fades and another rises (Duque and Hierro, 2016; Duque et al., 2015). The rest of the chapter is organized as follows. The next section presents a brief review of the literature. Then, the data and methods utilized in this chapter are introduced. The results part includes three sections regarding spatial regime fades and shock analysis, the dynamics of individual provinces by using the space-time path method (Gu et al., 2016), and the spatial-regime regression analysis of underlying driving forces of the redistribution process. Finally, this chapter concludes with major findings and implications.

2.2 Literature review

2.2.1 Temporary dimension of regional inequality and shocks

Scholars have long been interested in temporal changes of regional inequality levels. Influenced by the Kuznets inverted-U theory (Kuznets, 1955), the inverted-U model argues that after a certain point, rising regional inequality will eventually fall as the economy matures via structural change, specialization and integration, and increasing capital and labor mobility (Williamson, 1965). Stemming from the new convergence theory, which argues that regional inequality declines because the poor economies grow more rapidly than the rich ones (Barro et al., 1991), stochastic convergence is discussed and differentiated from deterministic convergence to distinguish if the convergence, or catching-up process, is ongoing or completed (Bernard and Durlauf, 1996). The growth pole theory argues that economic growth is spatially uneven and concentrated in engine regions (Perroux, 1950). The backwash and spread effects as well as polarization and trickling-down processes among regions are highlighted (Hirschman, 1958; Myrdal, 1957). Based on the model of the new

economic geography, regional inequality is determined by the dynamics in the core-periphery structure, which is represented by the centripetal and centrifugal forces regarding trade cost and scale economies (Krugman, 1991).

Shock is an important concept that emphasizes the temporary dimension of regional economic pattern. As the trigger towards a new economic landscape, a shock could be the occurrence of any event that fundamentally alters the underlying process and generates a new pattern of regional inequality, such as a new policy (Anagnostou and Gajewski, 2019; Gilmartin et al., 2013), an economic crisis or recession (Đokić et al., 2016; Mazzola et al., 2018), or even climate change (Silva et al., 2015). The recent global financial crisis since 2008-2009 has drawn considerable attention, given its profound impacts and uneven recovery among countries, especially for the developing economies (Wei, 2017). For example, Đokić et al. (2016) find that the economic crisis and downturn has led to a widening regional disparity in Croatia, contradicting the empirics on developed countries that regional inequality tends to decrease during economic recession (Petrakos et al., 2005, 2016; Petrakos and Saratsis, 2000). Gluschenko (2015), found that the global financial crisis hit regions within Russia to varying degrees because of structural differences in regional economic patterns, while pointing out that the global financial crisis might not have had persistent effects.

Regional development in China is closely related to multiple policy shocks over the past decades. In Kanbur and Zhang (2005), six phases of regional development in China are identified, which are closely related to policy shifts in national economic strategies, i.e.

1949–1956 (revolution and land reform), 1957–1961 (the Great Leap Forward and the Great Famine), 1962–1965 (post-famine recovery), 1966–1978 (Cultural Revolution and transition to reform), 1979–1984 (rural reform), and 1985–2005 (post-rural reform, decentralization, and opening up to trade and foreign direct investment). Structural breaks and non-linearities are found in the temporal evolution of regional inequality, which is associated with episodic events in China's economic history (Herrerías and Monfort, 2015; Ho and Li, 2008). The reform and opening-up after 1978 has drawn the most attention because regional inequality has increased rapidly and become persistent with the transitions and a series of policies (Fan and Sun, 2008), which are uneven and preferential in nature. As discussed in Fan et al. (2011), the urban-rural and coastal-interior gaps rise and fall with the central government's focus on economic development, including the rural reforms in the late 1970s, the opening strategy since the 1980s, and the market reforms and decentralization during China's transition to a market economy. By simulating policy shocks in different aspects, a series of works by Chen, Groenewold, and their colleagues identify possible pathways for reducing regional inequality in China, which covers issues about migration costs, agricultural productivity, fiscal redistribution, investment allocation, and the global market (Chen and Groenewold, 2010, 2011, 2013, 2018a, 2018b; Groenewold et al., 2008, 2010). However, the preceding studies of shocks are largely devoid of space and neglect the spatial redistribution process. The redistribution effects associated with shocks not only lead to a narrowing or widening gap in regional inequality but also change the spatial organization of production and income distribution, creating winning and losing regions under specific circumstances.

2.2.2 ESTDA and regionalization approaches in economic geography

The spatial dimension of regional inequality also draws scholarly attention and stimulates debate on the spatial effects of regional development. With more readily available georeferenced panel data, empirical research on the spatial dimension of regional inequality has gradually boomed, covering spatial dependence, heterogeneity, and scale. By detecting patterns of spatial autocorrelation and clustering in economic data, exploratory spatial data analysis (ESDA) is widely used to unfold spatial effects in regional growth processes (Rey and Sastré-Gutiérrez, 2010). Scholars argue that emphasis on the spatial effects helps to avoid biased interpretation in the analysis of economic development, thereby reaching better understanding of the underlying processes (Rey and Janikas 2005). The spatial econometric approach, with many powerful tools accounting for spatial dependence and spatial heterogeneity in inferential analysis, further reveals important processes like technology spillovers, labor migration, commodity flows, and a host of other types of spatial interactions in regional development (Anselin, 2010). Given its large size and diversity in regional development, empirics at various scales and in different study areas confirm that spatial effects should not be neglected when attempting to explain regional inequality in China (He, Fang, et al., 2017; Li and Wei, 2010; Liao and Wei, 2015; Yu and Wei, 2003).

Compared to spatial econometrics and spatial exploratory data analysis, exploratory space-time data analysis (ESTDA) emphasizes the dynamics and mobility in regional development, thereby providing rich detail of the underlying geographical and temporal processes (Ye and Carroll, 2011). Given that regional development is essentially temporal dynamics over space and spatial processes over time, space-time frameworks are required to deal with the spatial

effects and structural breaks in regional inequality, of which ESTDA could be the first move in approaching the coupled dimensions (Ye and Rey, 2013). For example, the utilization of space-time methods in the case of Ohio in the United States finds that competition and unemployment contagion not only occurs over space, but also along the temporal dimension (Ye and Carroll, 2011). From the spatial-temporal perspective, Rey (2018) scrutinizes Alonso's five bells in interpersonal and interregional inequality in the U.S. and finds their space-time coevolution. With the development of space-time methods, the spatiotemporal processes and mobility in China's regional inequality also starts to draw attention (Duque et al., 2015; Gu et al., 2016; Wu et al., 2019; Yu, 2014).

Regionalization of economic data is another aspect that helps to understand the spatial dimension of regional development. The idea of regionalization can be traced back to the ecological fallacy (EF), in which conclusions reached from aggregated data do not reflect the reality of individuals belonging to this aggregation (Robinson, 1950). To reduce the EF effects in economic geography and regional science studies, regionalization is adopted to control the aggregation process thereby minimizing the bias during aggregation, as an alternative to statistical solutions such as sophisticated data transformation or parameterizations (Duque et al., 2006). Analytical regions, or spatial regimes, are the outcome of such controlling processes and are used to replace normative regions or administrative regions since they are less susceptive to the EF effects and better reflect the reality of regional development (Duque and Hierro, 2016). While the results of analytical regions are not free of the EF effects, statistics are also developed to measure error in such spatial aggregation (Bradley et al., 2017).

Regionalization methods are widely used by economic geographers and regional scientists and the empirical studies of various regionalization algorithms and their applications cover the societal and economic aspects of regional development. In Mu et al. (2015), mixed-level regionalization (MLR) is applied to a case study of Louisiana cancer data and shows its strength in aggregating health data. In regional planning, regionalization could also be used to better evaluate regional inequality and support economically weak areas (Flores et al., 2016; Žižka and Rydvalová, 2013). Concerning the "Hu Line", a famous population demarcation line that separates southeast and northwest China (Hu, 1935, 1990), scholars use a GIS-automated regionalization method called REDCAP to further revise and detail the division to fit the population distribution and habitat environment in China (Liu et al., 2019; Wang et al., 2019). But for economic development in transitional economies like China, the rapid growth and profound transformations indicate that the boundary and composition of the regionalization results are unstable and dynamic, depending on the shocks and time period investigated. To deal with this problem, more than one set of spatial regimes and the impacts of shocks and redistribution effects should be considered (Duque and Hierro, 2016; Duque et al., 2015).

Centered on the concepts of spatial regimes, shocks, and regionalization, this chapter therefore seeks to reach a more nuanced understanding of regional inequality in China. Drawing upon the exploratory space-time analysis framework (Ye and Rey, 2013), the empirics answer the following important questions. First and foremost, what are the shocks during the sixty years of economic development in China since its foundation after considering the role of space? And how are the spatial representations or spatial regimes of

economic reality evolving with the shock and redistribution effects? Second, what are the transitional regions after comparing the landscapes of economic development and how do the dynamics and mobility of individual provinces drive such transition? Third, what are the determinants of the space-time dynamics in China after taking the regime effects into account? Finally, what are the implications of these findings for the reduction of regional inequality?

2.3 Methods and data

As mentioned above, in order to research the process of spatial redistribution in China, a newly developed ESTDA method named spMorph is adopted to identify spatial regimes and the redistribution process in China (Duque and Hierro, 2016; Duque et al., 2015). Different from spatial clusters extracted from ESDA methods like LISA, spatial regimes are geographically contiguous units that consider the spatiotemporal dynamics of development and reflect the similarity of observations for multiple years rather than a snapshot of one year. In spMorph, intraregional similarity and interregional dissimilarity are maximized among regimes. The Theil index is used as the criterion of similarity because it is readily decomposable into two components of inequality within and between groups (Theil, 1967):

$$T = \sum_{i=1}^{n} y_i \log\left(\frac{y_i}{x_i}\right)$$

$$T = T_{wg} + T_{bg} = \sum_{g=1}^{G} Y_g \sum_{i \in S_g} \frac{y_i}{Y_i} \log\left(\frac{y_i/Y_g}{x_i/X_g}\right) + \sum_{g=1}^{G} Y_g \log\left(\frac{Y_g}{X_g}\right)$$

where T is the overall inequality, T_{wg} and T_{bg} are inequality within and between groups of units, y_i and x_i are the GDP and population share of the ith spatial unit, and Y_g and X_g are the GDP and population share of the gth group of units. The Theil index and its decomposition are also used to analyze multiscale regional inequality and compare normative regions and analytical regions.

The redistribution process occurs when the current spatial regimes do not reflect the economic reality in the study area and a new organization of spatial regimes emerges and replaces the previous one. In spMorph, a minimum number of two sub-periods are needed to achieve a consistent representation of major pattern changes due to at least one shock, to generate the spatial regimes before and after pattern change. Two concepts, "shock" and "regime fade", are introduced (Figure 2.1), where shock is the time when the redistribution process starts, and regime fade is the period of redistribution process until the new regime takes over. By heuristically investigating different numbers of shocks and combinations of when shocks happen, spMorph selects the minimum number of shocks that generates the greatest improvement of the total lower bound (TLB) of the criterion, T_{wg}/T.

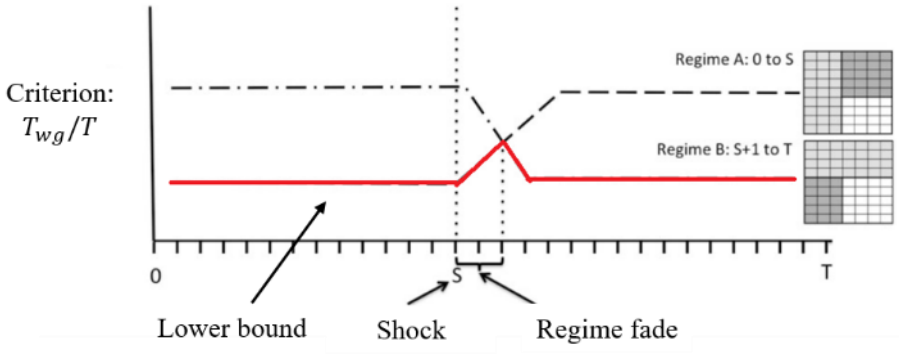

Figure 2.1 "Shock" and "regime fade" in the spMorph method. Adapted from Duque et al. (2015)

Aided by GIS techniques, previous studies on China have revealed the importance of spatially dependent processes by the ESDA methods. Another ESTDA method called "space-time path" is used for selected provinces, adding a temporal dimension to the traditional ESDA methods like the Moran scatterplot (Gu et al., 2016). The space-time path method depicts the trajectory of individual provinces in a two-dimensional economic space, wherein the x-axis represents the relative GDP per capita of the local economy and the y-axis is the spatially weighted GDP per capita of the adjacent regions:

$$R_{it} = \frac{y_{it}}{\sum_{i=1}^{n} y_{it} / n}$$

$$S_{it} = \frac{\sum_{j=1, j \neq i}^{n} \omega_{ij} y_{it} / \sum_{j=1, j \neq i}^{n} \omega_{ij}}{\sum_{i=1}^{n} y_{it} / n}$$

where R_{it} and S_{it} are the X and Y coordinates, y_{it} is the GDP per capita for county i in year t, n is the total number of counties, and w_{ij} is the element of the row-standardized weighting matrix. The path is drawn by coordinates (R_{it}, S_{it}) for $T = 1,2, \dots, t$.

In the space-time path, the pair-wise movement of local and adjacent regions' economic development by temporal order reveals the spatially dependent processes and the evolution of regional inequality over time. Four quadrats and four spatiotemporal trajectories could be summarized (Figure 2.2). Each quadrat refers to the case where the local area and its neighbors are below or above the average level, and each trajectory refers to the situation if the local and neighboring economies are improving or worsening. Taking the Type I pattern (the arrow numbered as 1 in Figure 2.2) for example, the path indicates that the local development level improving and moving from below-average to above-average, and the

development level of its neighboring units are also moving from below-average to above-average. For the Type IV pattern (the arrow numbered as 4 in Figure 2.2), the local economy is moving from below-average to above-average while the neighboring units are moving from above-average to below-average. The method extends the static view of local spatial dependence into the dynamic context. It can be considered as a continuous representation of spatial clustering change and a powerful exploratory tool to understand a local system's stability and dynamics in practice.

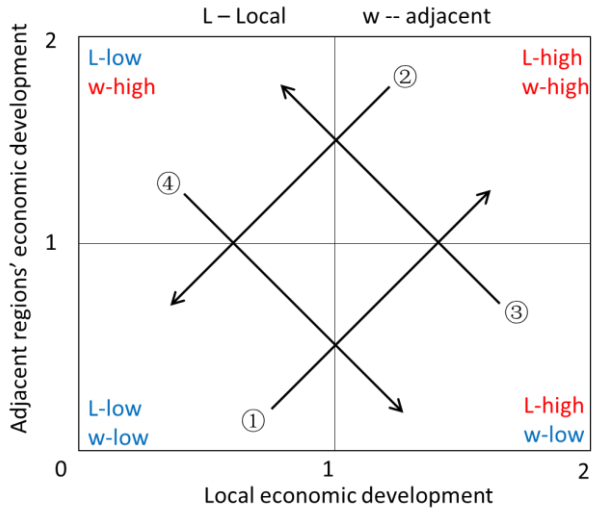

Figure 2.2 Diagram of the space-time method. Adapted from Gu et al. (2016)

This chapter covers study periods from as early as 1952 to the most recent year available, 2016, analyzing the long-term dynamics of regional development in China. GDP per capita by 1978 prices and the residential population in 29 provinces[1] in mainland China is used as the sole measurement of economic development (Fan and Sun, 2008; Sakamoto and Islam,

[1] Chongqing is merged into Sichuan, and Hainan is combined with Guangdong to keep data consistency for the study period.

2008). As shown in Figure 2.3, different normative regions are used in government documents and research by scholars. The “three economic belts” schema, consisting of the eastern, central, and western regions, and its variants are usually used to group provinces, based on the Seventh Five-Year Plan (1986-1990) (Fan and Sun, 2008; Tsui, 2007; Wan et al., 2007; Wang et al., 2016). The coastal-inland division is also employed in studies (Chen and Groenewold, 2011; Fujita and Hu, 2001; Kanbur and Zhang, 2005), together with the four-region division from the Eleventh Five-Year Plan (2006-2010) (He, Bayrak, et al., 2017; Wang, 2007) and a six-region division based on economic linkages and history legacy (Ye and Xie, 2012). The various regions not only bring difficulties in analyzing and comparing the evolution of regional inequality in a compatible way, but also suffer from the ecological fallacy and do not reflect the transformations in regional development. In the spMorph analysis, six spatial regimes are hypothesized in order to compare with previous studies and easily aggregate to two, three, or four regions if necessary (Duque et al., 2015).

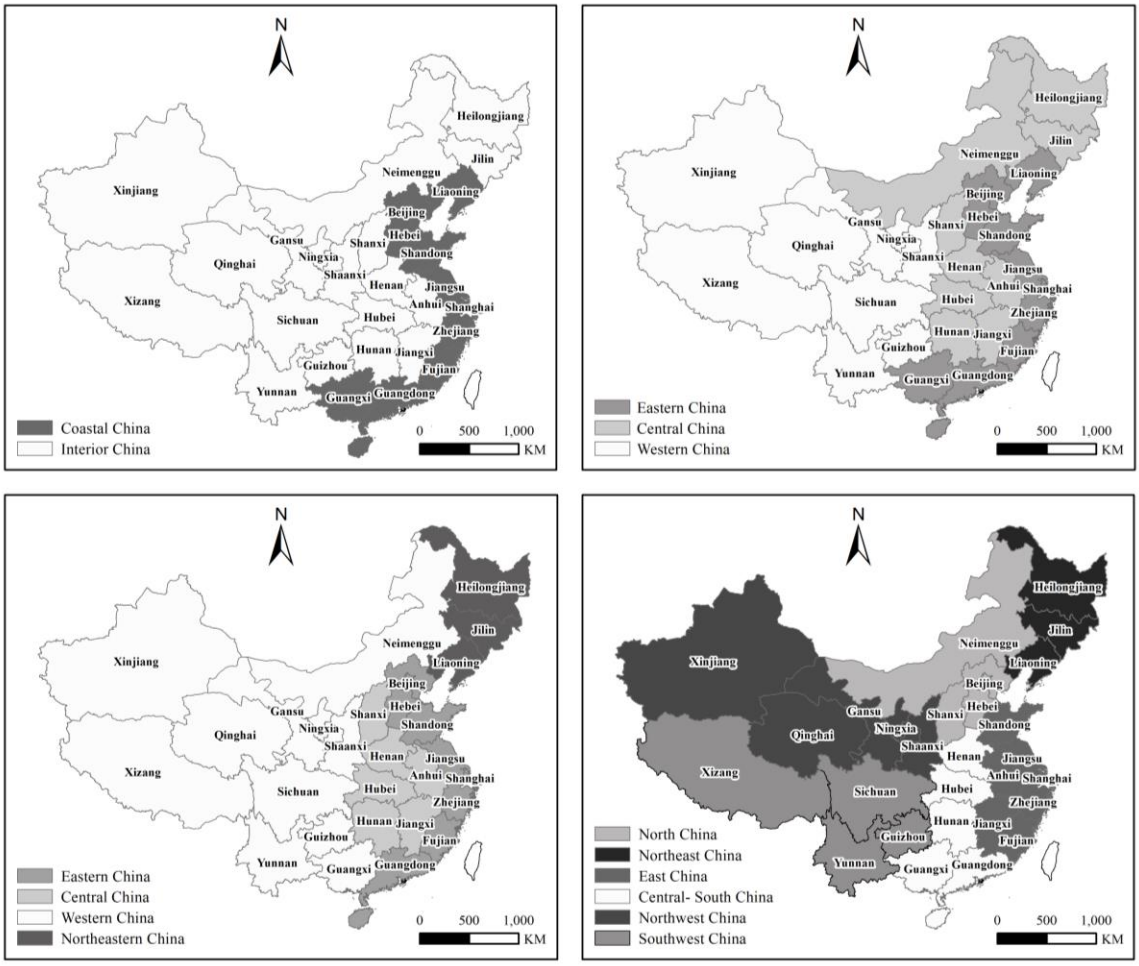

Figure 2.3 Various types of normative regions in mainland China

2.4 Shocks and spatial redistribution processes of regional inequality in China

2.4.1 Temporal dimension of shocks and redistribution processes in China

The results of the spMorph method start with a heuristic search for different hypothesized numbers of shocks (Figure 2.4). The criterion, namely the total lower bound (TLB), shows that the more shocks are assumed, the lower the TLB is. Following the previous empirics (Duque and Hierro, 2016; Duque et al., 2015), the minimum number of shocks with the greatest improvement in the criterion is selected, indicating that it is plausible to assume that there are three shocks during the economic development of China from 1952 to 2016.

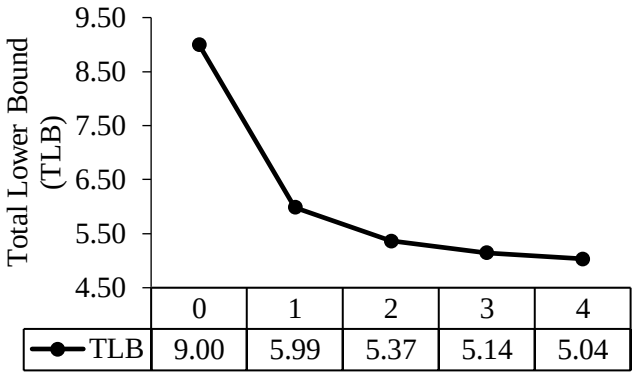

Figure 2.4 Total lower bound (TLB) for different number of shocks

The lower bound curve of different shocks further confirming the selection of three shocks provides additional implications (Figure 2.5). First, the analytical regions generally draw a more realistic picture of economic development than the official regions, with the TLB being significantly lower for the analytical regions regardless of the number of shocks. Second, adding more shocks reduces the TLB and improves the curve by better presenting the economic reality during the sub-periods. Compared to the zero-shock assumption for example, the one-shock assumption significantly lowers the curve from the 1950s to the 1970s and after the 1990s. Third, more shocks and lower TLB do not always mean an improvement in sub-periods. The comparison between the three-shock and four-shock assumption shows that the three-shock assumption is balanced for the whole study period, while the four-shock assumption does not control for intraregional heterogeneity from 1985 to 1992 when China experienced a series of radical political and economic transitions.

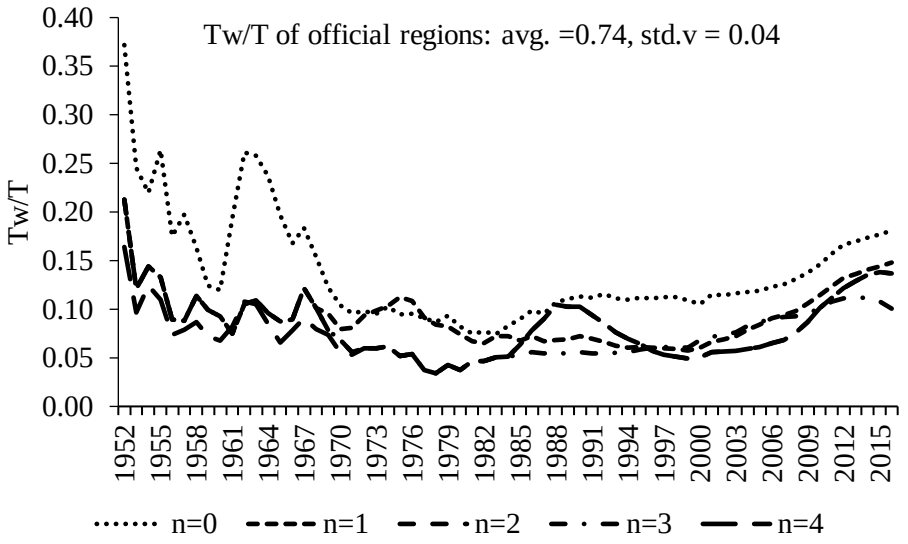

Figure 2.5 Lower bound for different number of shocks

The three shocks separate the study period into four sub-periods: 1952−1979, 1980−1985, 1986−2001, and 2002−2016 (Figure 2.6). Comparing with Kanbur and Zhang (2005), the shocks by spMorph match with it by capturing the reform and opening-up in 1978 and rural reforms in 1995 but fail to further split the pre-reform period into smaller periods. This abnormal situation is largely due to the socioeconomic turbulence during the pre-reform period. Before the reform in 1978, China experienced several historical phases with fluctuating economies, including the Great Leap Forward and the Great Famine in 1957−1961, the post-famine recovery in 1962−1965, and the following Cultural Revolution and transition to reform in 1966−1978. The findings also extend the previous regionalization work on economic development in China. By including the period after the global financial crisis in 2008/09, the entry of WTO in 2001 is identified as an important shock in this study, which is not identified as a shock in Duque et al. (2015).

The Tw/T curve of the other three spatial regimes become normal after 1978, following a "shock to regime fade" order. The second shock happens in 1985 and directly leads to the fade of the second regime based on data from 1980 to 1985 and the emergence of the third regime based on years from 1986 to 2001. It takes three years for the fade of the third spatial regime, which predominates until 2004 and is replaced by the emergence of the latest regime based on the years from 2002 to 2016.

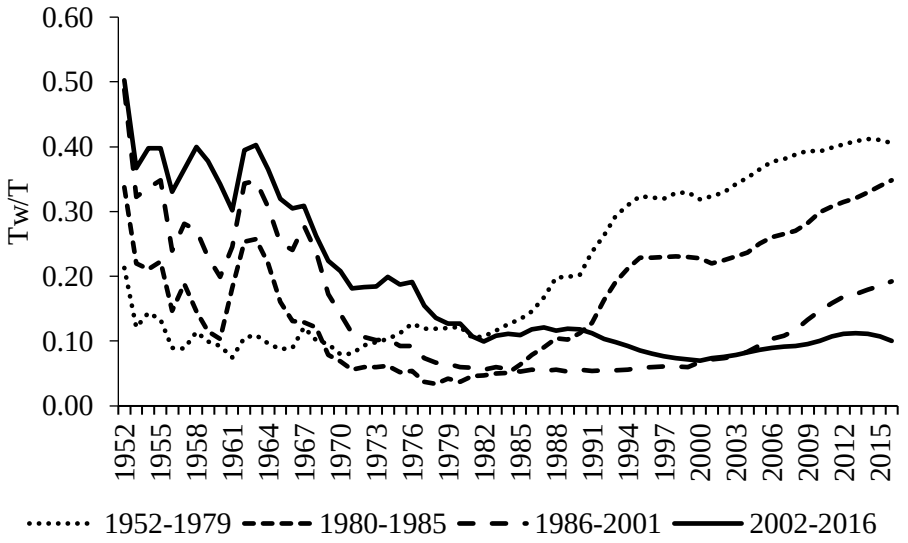

Figure 2.6 Intraregional inequality ratio (Tw/T) in the three-shock assumption

2.4.2 Spatial regime fades and redistribution processes of regional economies in China

The spatial presentation of four spatial regimes implies that there are several fundamental changes during China's transition to a market economy (Figure 2.7). Shanghai, Beijing, and Tianjin rank as the rich and less rich analytical regions because they are three directly administrated municipalities, and more importantly their advanced political, economic, and financial status among provinces (Figure 2.7a). In pre-reform policies, regional development in China followed a Soviet model emphasizing heavy industry and central planning.

Geographically, the northeastern provinces of Liaoning, Jilin, and Heilongjiang, as well as Inner Mongolia, were favored by the central government because of their industrial capacity and proximity to the Soviet Union to get foreign aid. With the national security concerns of the 1960s and 1970s, differentiated regional development policies were implemented in the coastal and interior provinces (Ma and Wei, 1997). In the "Third Front Construction" (*sanxian jianshe*) program, the central government allocated a massive amount of resources to the interior provinces to develop self-sufficient industrial bases in the southwestern and northwestern provinces (Naughton, 1988). Concerning the threat from the Pacific Ocean during the pre-reform period, the coastal provinces were neglected in terms of regional development and industrial agglomeration. Together with socialist China's ideology of equality, the historically less developed and remote interior provinces were promoted, and their economic status was advanced more than their coastal counterparts from 1952 to 1979 (Figure 2.8).

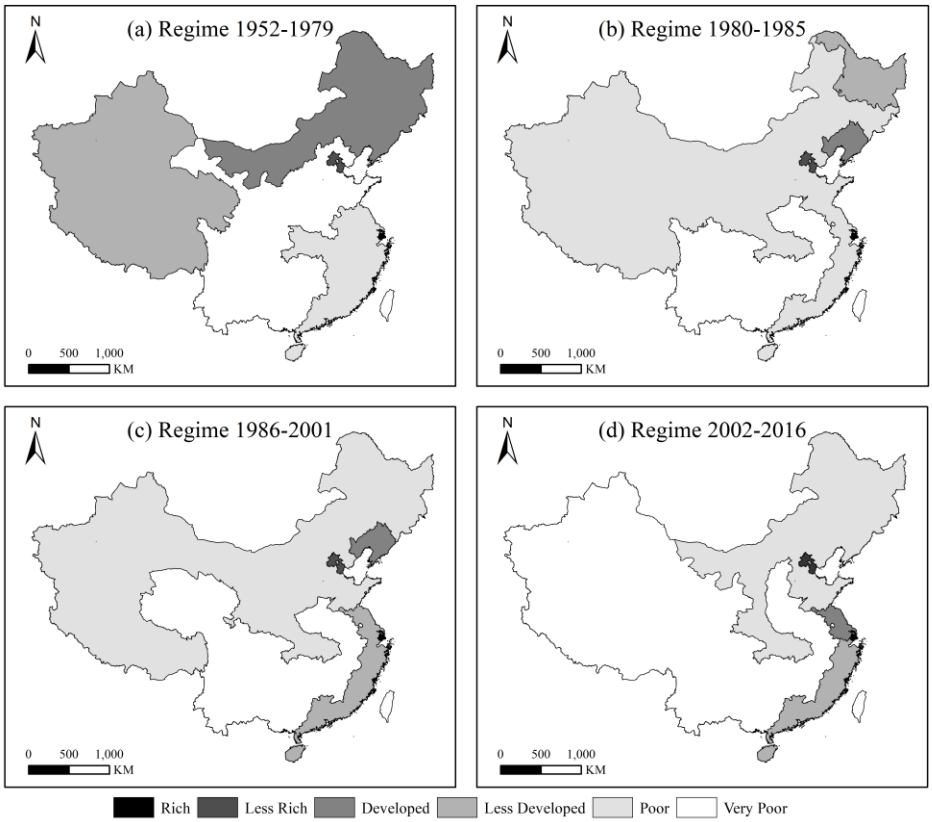

Figure 2.7 Spatial regimes for the four sub-periods

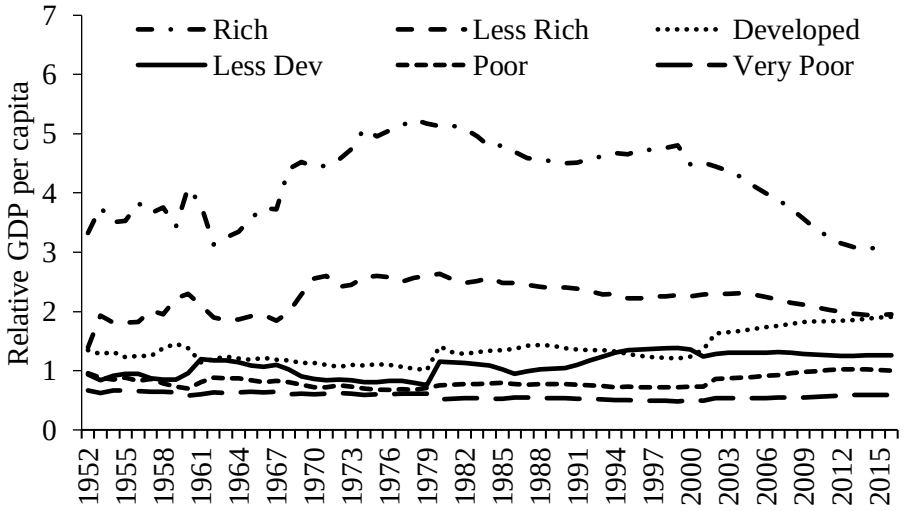

Figure 2.8 Relative GDP per capita of spatial regimes[2]

[2] As shown in Figure 2.7, provinces in regimes are different after each shock in 1979, 1985 and 2001.

The changes to the other three spatial regimes after 1978 help to understand the complexity of the transitions since the reform and reveal several interesting findings. The focus of regional development policies in China depends on the sub-periods and consequently determines the spatial redistribution processes. The mid-1980s witnessed rural reforms in China, which stimulated the productivity of farmers and released surplus labor from the agricultural sector (Fan et al., 2011). As a result, labor-intensive town-village enterprises (TVEs) flourished and the urbanization and industrialization processes accelerated in most regions, especially for the coastal provinces which moved one step ahead in the reform (Figure 2.7b). As shown in Figure 2.8, the three directly administered municipalities of Shanghai, Beijing, and Tianjin remained as leaders in regional development, but the leadership of the old heavy industrial base faded as Inner Mongolia and Jilin provinces transformed into poor regions. Though Liaoning and Heilongjiang provinces were still categorized as developed and less developed regions during the sub-period, they experienced slow growth and their importance in the national economy declined since the 1980s (Fan and Sun, 2008). The coastal provinces started to catch up and emerge as new growth cores during that sub-period while some of the interior provinces continued to lag behind.

The third spatial regime from 1986 to 2001 marks inland and coastal China as two diverging clubs (Figure 2.7c). After the catching-up of the early 1980s, the coastal provinces entered the “fast lane” of economic growth and left the interior provinces behind. The reasons are essentially related to China’s triple processes of globalization, decentralization, and marketization, as well the rapid urbanization and industrialization in the coastal region (Li et al., 2015; Wei, 2000, 2007). During the transitions, several development models have

emerged in the coastal provinces and made them the powerhouses of China's economic growth. For example, the TVE-based Sunan model in Jiangsu (Wei, 2010; Wei et al., 2011) and the Wenzhou model in Zhejiang benefited from marketization and privatization (Wei et al., 2007; Wei and Ye, 2009), and the Pearl River Delta model in Guangdong featured export-oriented industries under globalization (Liao and Wei, 2012; Lin, 1997). The trajectories of different analytical regions show that the less developed analytical region, consisting of Jiangsu, Zhejiang, Fujian, and Guangdong provinces, is the most dynamic one in China since the mid-1980s and its development level has surpassed the developed region (Figure 2.8). Together with the rich region (Shanghai) and the less rich region (Beijing and Tianjin), the divide between the coastal and interior China has become evident during the sub-period.

The latest spatial regime based on years from 2002 to 2016 is fundamentally different from the pre-reform spatial regime (Figure 2.7d). The old industrial base in northern China, which used to be the most developed region after Shanghai, Beijing, and Tianjin in the pre-reform era, has lost its competitive edge and become a poor region in China. The decline of these provinces is related to their limited access to the reform and opening-up policies, the dominance of state-owned enterprises (SOEs) and the heavy burden of tax and social duties associated with them, and outdated industrial infrastructure with concurrent inefficiency in production and management (Hu, 2007; Wei, 2000). After the emergence of the coastal provinces, Jiangsu province to the north of Shanghai further develops after 2000 and stands out from other coastal provinces like Zhejiang, Fujian, and Guangdong provinces to the south of Shanghai (Figure 2.8). However, the interior provinces in the central and western China

have transformed into the most underdeveloped region and lagged behind during the reform era.

A summary of spatial regime changes from 1952 to 2016 helps to identify several focal regions (Figure 2.9). The most evident feature is the rise of coastal China and the fall of northeastern and interior China. Coastal China could be further divided into northern and southern sub-regions considering the different growth poles and agglomerations highlighted. To the south, the rapid growth of Jiangsu and Zhejiang is centered on the financial and economic core in Shanghai, forming the Yangtze River Delta zone, while Guangdong has benefited from the rise of the Pearl River Delta zone and investment from Hong Kong. To the north, the development of Shandong, Hebei, and coastal Liaoning relies on the political and cultural center in Beijing and Tianjin, which is also known as the Bohai Rim or Jing(Beijing)-Jin(Tianjin)-Ji(Hebei) cluster. On the contrary, northeastern China, namely Inner Mongolia, Liaoning, Jilin, and Heilongjiang, has witnessed decline in economic development level, and the interior provinces, such as Henan, Gansu, Guangxi, and Guizhou, remain idle in the spatial redistribution processes.

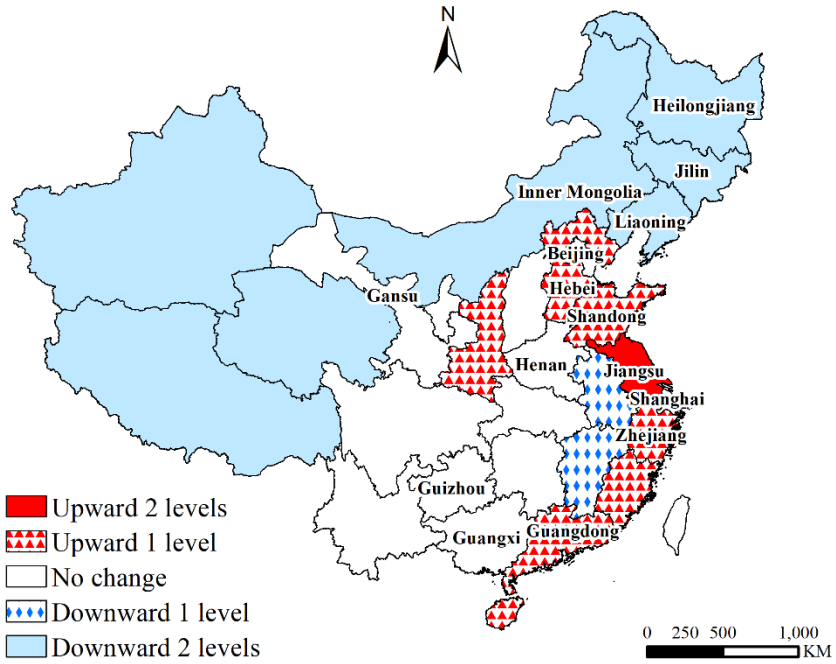

Figure 2.9 Summary of regime change in economic level

2.5 Space-time dynamics of transitional regions

To answer the question of why some provinces have gained upward mobility in China's economic transitions while the others have downward mobility or are stagnant, four aforementioned key regions and their provinces are selected to investigate their space-time dynamics. The location quotient (LQ) method is firstly used to evaluate the trend of regional status in terms of economic development and socioeconomic factors[3]. The results in Figure 2.10 indicate different fortunes of provinces in the four regions. The coastal provinces before the reform were close to the national average but since 1978 their development level has

[3] The LQ measure could be expressed as $\frac{X_i/\sum X_i}{Y_i/\sum Y_i}$, Where X_i and $\sum X_i$ are the regional and total value of the indicator, like GDP, export, fixed asset investment, local fiscal expenditure, and industrial output, and Y_i and $\sum Y_i$ are the regional and total population base. Therefore, LQ over unity means that a region's status is above the average level, while LQ less that unity indicates the opposite.

risen rapidly from the 1980s to 2000, reaching nearly twice the average development level. After 2001, the status of Jiangsu province moves further upward, while the status of Shanghai, Zhejiang, and Fujian provinces converge to the national average. A similar trend is also observed for the Bohai Rim region, with the status of Shandong and Hebei provinces being altered from a below-average level to an above-average one, and Shandong province has further developed during the convergence in the 2000s and 2010s.

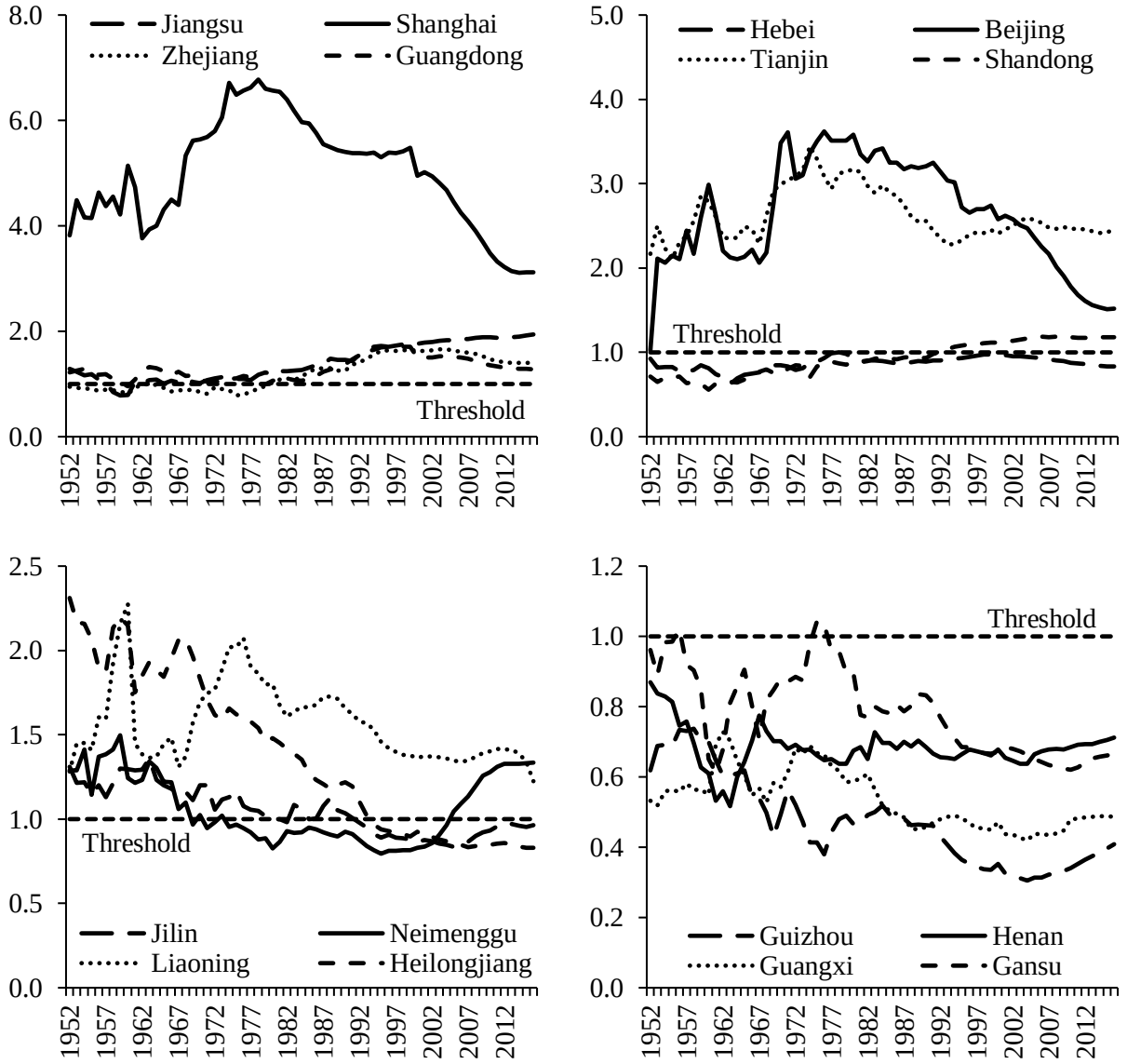

Figure 2.10 Locational quotients of GDP per capita in four regions (threshold is where LQ equals one, meaning national average level)

On the contrary, the northeastern provinces of Inner Mongolia (Neimenggu), Liaoning, Jilin, and Heilongjiang, have declined persistently from an above-average level before the reform to average by 2000, while the status of Inner Mongolia and Heilongjiang has improved since the 2000s. The selected interior provinces remain poor and their status has been slightly improved since the launch of Western Development Strategy and other poverty alleviation programs in the 2000s and 2010s. To further investigate the spatial effects in the dynamics of provinces and regions, another ESTDA method, namely the space-time path introduced before, is utilized in the following sub-sections.

2.5.1 Space-time paths of regional development of provinces in the coastal region

Following Yu and Wei (2003), four coastal provinces, namely Jiangsu, Shanghai, Zhejiang, and Guangdong, are selected to discover their individual development trajectories and patterns during the rise of coastal China using space-time paths (Figure 2.11). The x values of the trajectories of Jiangsu, Zhejiang, and Guangdong provinces are less than 1 before 1980, which implies that their economic performance was below the national average. Since Shanghai is the neighbor for both Jiangsu and Zhejiang provinces, the two coastal provinces have partially benefited from its spillovers and the values of its neighboring provinces were above the national average before the reform. In contrast, Guangdong province is adjacent to either other coastal provinces like Fujian and Guangxi or less-developed interior provinces like Hunan and Jiangxi. Both Guangdong's and its neighbors' relative GDP were below national average before the reform (Figure 2.11).

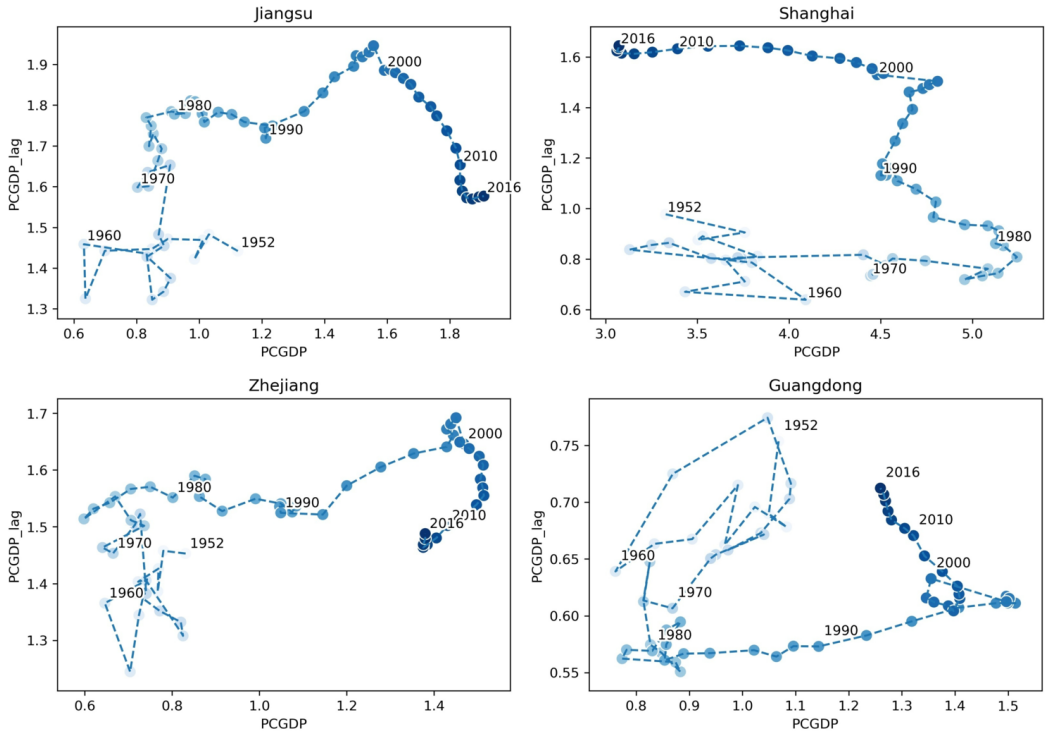

Figure 2.11 Space-time paths of selected coastal provinces

As discussed earlier, the development trajectories since the reform in 1978 indicate that the coastal provinces except Shanghai have moved upward during China's transition to a market economy. The trajectory of Shanghai indicates that its relative advantageous economic status has declined since the reform (Figure 2.11), which is attributed to the rise of Guangdong and other originally poorer coastal provinces (Tian et al., 2016). The regions adjacent to Shanghai experienced a stronger growth before 2000 and stabilized after 2000, reflecting the development of private enterprises in these provinces and the increasingly integrated development of the YRD which comprises of Zhejiang, Shanghai, and Jiangsu. Zhejiang province, known for development of private enterprises, experienced relatively faster economic growth in the first two decades of the reform during the 1980s and 1990s, but its status has somewhat stabilized since 2000 (Figure 2.11). For Jiangsu province, the local

economy consistently outperformed the national average during the reform era, while the adjacent provinces have gone through slight descent, rapid ascent, rapid descent, and slight re-ascent stages in the four decades after 1980. Guangdong province represents a third mode of development trajectory when spatial spillover is considered. While the development of Guangdong experienced a similar ascent-descent process before and after 2000 like Zhejiang, its adjacent regions have consistently moved upward since 1990.

2.5.2 Space-time paths of regional economies in northeastern China

In contrast to the rise of the coastal provinces, northeast China has lost its favored status and declined during the transition (Fan et al., 2009; Kanbur and Zhang, 2005). The three northeastern provinces, Heilongjiang, Jilin, and Liaoning, as well as Inner Mongolia in the western region, are selected to investigate their development patterns before and after reform. The northeastern provinces formed and maintained a developed club before the reform (Figure 2.12). At the beginning of the study period, the economic performance of the four provinces was above the national average, as well as for the provinces adjacent to them. But the four provinces lost their advantageous status before the reform partly due to concerns about national defense. Consequently, Inner Mongolia, Heilongjiang, and Jilin provinces have consistently declined from 1952 to 1980, with Liaoning province the only one managing to achieve growth during the period. The pre-reform policies favored the development of heavy industries and SOEs especially in Liaoning.

During the 1980s and the 1990s, all four provinces experienced a period of stagnation and decline. As discussed before, though the SOEs were still dominant in heavy industries and

capital-intensive sectors at the beginning of the reform in 1978, the supporting pillars, like the trinity system, have gradually collapsed during China's transition from a planned economy to a market economy (Hu 2007; Hu and Lin 2013). However, the issues related to the poor performance of SOEs have remained, which include the insufficient motivation of workers or managers because of ambiguous property rights under socialism, the erosion of SOEs' monopolistic profits, the competition from the non-SOE sectors, and the heavy socioeconomic obligations of SOEs like the tribute revenue transferred to the central government and the housing, medical, pension, and other social welfare to their employees (Hu 2005). As a result, the northeastern provinces, as the most concentrated region of China's old industrial bases and unproductive SOEs, have further declined during the 1980s and 1990s.

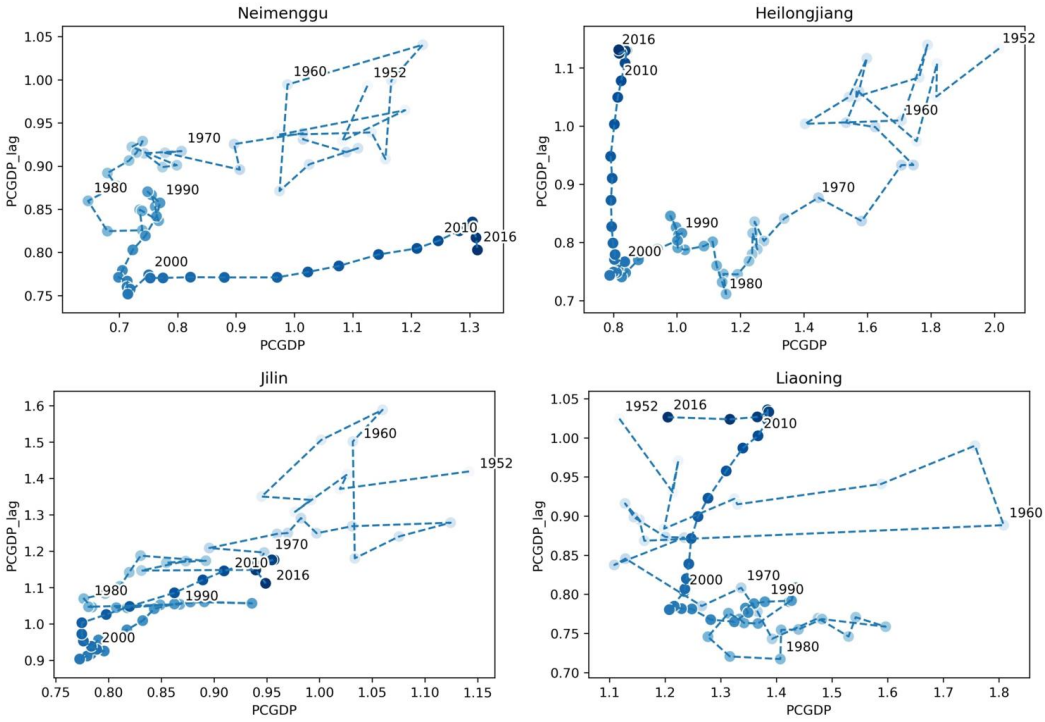

Figure 2.12 Space-time paths of northeastern provinces and Inner Mongolia

This result is consistent with findings about the complex global and domestic contexts, spatial restructuring and transformation in economic activities, and the spatial shifting of favored foreign investment locations (He, Bayrak, and Lin 2017; He, Fang, and Zhang 2017). Together with the revitalization of the old northeastern industrial bases program by the central government, these four provinces have achieved substantial economic growth except for Heilongjiang. Inner Mongolia, Jilin, and Liaoning provinces, as well as their neighbors, have experienced steady growth until the slow-down after 2010.

2.5.3 Space-time paths of regional economies in the Bohai rim region

The individual trajectories of the provinces around Bohai Bay, namely Beijing, Tianjin, Hebei, and Shandong, are also focal provinces for several reasons. First, the Bohai Rim economic zone ranks as the third largest metropolitan region after the PRD and the YRD. Second, the intensifying inequality and core-periphery structure in the greater Beijing area has drawn considerable scholar attentions in recent years (Yu 2006, 2014; Yu and Wei 2008). Third, as two directly administrated municipalities, Beijing and Tianjin show strong economic performance, and their neighboring provinces, Hebei and Shandong provinces, have transitioned from very poor regions to poor regions as in the spatial regime analysis above.

As shown in Figure 2.13, Beijing and Tianjin potentially developed during the pre-reform era when the development policies were urban- and industrial-biased. The relative GDP per capita of Beijing and Tianjin reached as high as 2.5 times the national average on the eve of the reform. In contrast, the economic statuses of Hebei and Shandong provinces remained

stable or declined during the pre-reform period. After the reform, the advantageous status of Beijing faded and converged to the national average, especially after the mid-1990s. The regions adjacent to Beijing were characterized by a rapidly declining phase from 1980 to 1995, a rapidly rising phase from 1995 to 2005, and a stable phase from 2005 to 2016. The trajectory of Hebei province after the reform indicates that the spatial effects are dependent on the study period. From the 1980s to the 2000s, the spatial spillovers from Beijing and Tianjin had positive impacts on promoting Hebei's economic development. But the spillover effects declined since 2000, partially leading to stagnation and a relatively declining status in the 2000s and 2010s. For the case of Shandong, it has achieved a typical win-win mode for economic development of the local and adjacent regions, because it could take advantage of being located in the coastal portion of the Bohai Rim economic zone as well as its geographical proximity to South Korea and Japan (Kim and Zhang, 2008).

The development paths of provinces in the Greater Beijing area, which is consist of Beijing, Tianjin, and Hebei, could be further explained by the core-periphery structure in the region. The diverging trend between Beijing and Tianjin as the core and Hebei province as the periphery in the pre-reform period is attributed to the "urban-industrialization" process under the planned economy, which made the industrialized urban areas in Beijing and Tianjin grow at a relatively high rate while rural Hebei remained less developed (Yu 2006). Since the reform, the economic performance of Hebei province has been promoted as the trickle-down effects and benefits from the reform policies have become evident since the early 1990s (Yu and Wei 2008).

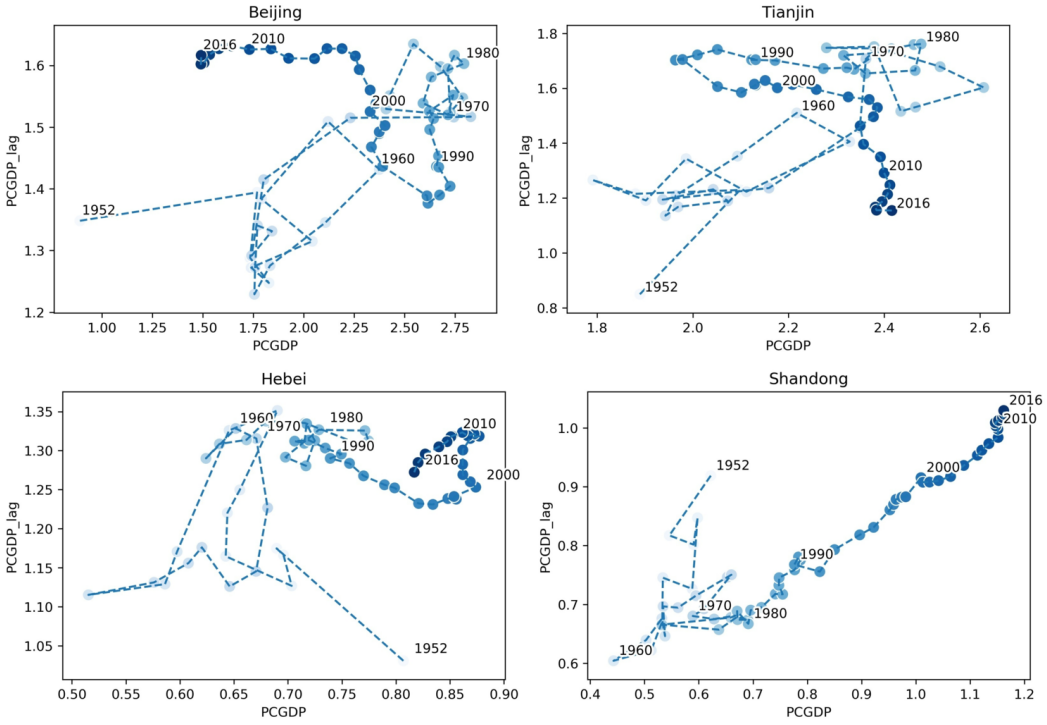

Figure 2.13 Space-time paths of provincial economies in the Bohai-rim region

But the temporary converging trend in the Greater Beijing area has been replaced by a diverging trend after 2000. The different development trajectories are due to the specific geopolitical positions of Beijing, Tianjin, and Hebei as a province geographically surrounding the two. Beijing as China's capital and Tianjin as a centrally administrated municipality are more preferred, not only in the urbanization and industrialization processes, but also with more resources and beneficial policies during China's reform (Wei and Yu, 2006; Yu, 2006, 2014; Yu and Wei, 2008). Beijing and Tianjin took one step ahead of Hebei province to implement the reform policies after their validation in the southern provinces. The governmental supports, fixed asset investment, and capital from foreign investors are all concentrated in Beijing and Tianjin rather than Hebei province. At the same time, Beijing and Tianjin have evident backwash effects on Hebei province since 2000 by drawing labor,

capital, and resources, which has impeded the local economic development. Hebei's support or sacrifice, partly as the political task, has guaranteed the stable economic development in Beijing and Tianjin but also created a "poverty belt" around the country's capital (Sun, Xu, et al., 2016; Yuan and Wang, 2014).

2.5.4 Space-time paths of regional economies in the western and central regions

Two central provinces, Henan and Gansu, and two western provinces, Guizhou and Guangxi, are selected to be compared with the coastal provinces discussed above (Figure 2.14). The four interior provinces share several characteristics in common regarding economic development, including low urbanization level, a dominant SOEs sector as the legacy of "Third Front Construction" program, remote and mountainous geographical locations, and are the target of poverty alleviation policies from the central government (Dai et al., 2017; Li and Wei, 2014; Sun, Lin, et al., 2016; Wei and Fang, 2006). Like the other regions, the trajectory of the interior provinces also shows fluctuating economic development processes during the pre-reform period. A general descent trend is observed for GDP per capita and its spatial lag from 1952 to 1980, indicating that beginning with a relatively low economic status, the four provinces and their adjacent regions further diverged below the national average. Their trajectories in the 1980s and 1990s suggest that the interior provinces and their neighbors experienced stagnation or moderate decline in regional development while the economy in the coastal provinces substantially developed. Since 2000, the trends of the four provinces have been reversed, with both the local and the adjacent economies being promoted to reach or surpass the pre-reform level.

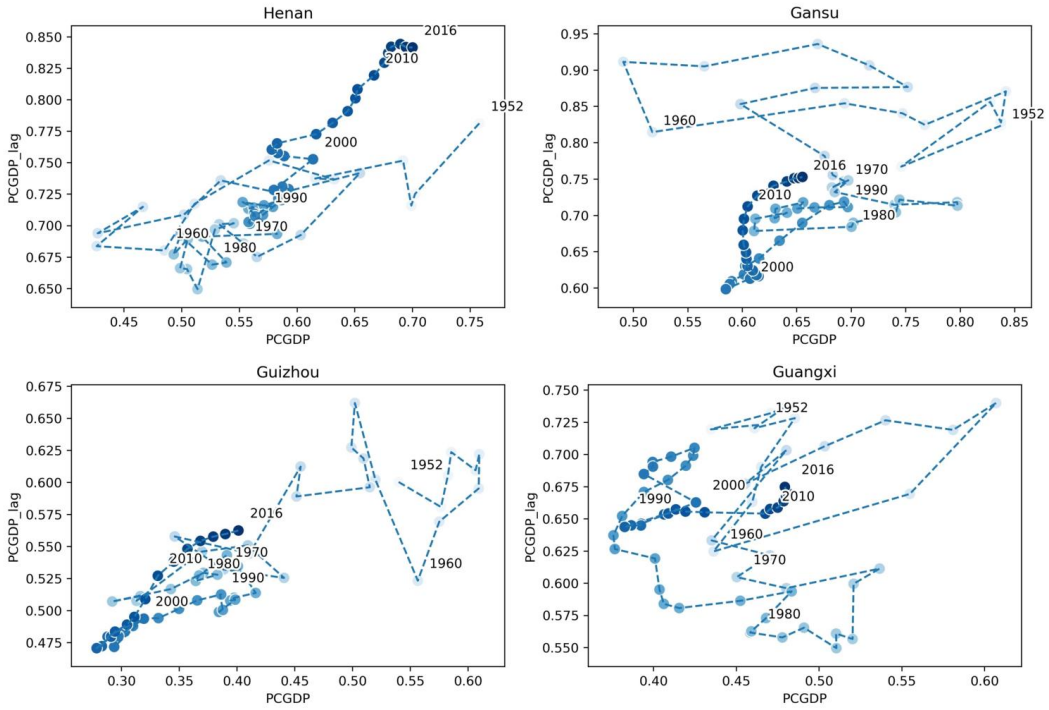

Figure 2.14 Space-time paths of selected interior provinces

Further scrutiny on the regional development processes reveals the underlying forces behind the space-time path trajectory. Driven by the desire to alter the historically uneven spatial pattern of regional development and national security concerns, the central government has allocated considerable investment and resources to the interior provinces, which reached a peak during the “Third Front Construction” program from 1965 to 1971 (Ma and Wei, 1997; Wei, 2000). Consequently, the economic status of the interior provinces has been promoted to a certain degree within the descent trend in the pre-reform period. After the reform, the interior provinces lagged behind in implementing reform policies and were slow to transition to a market economy, resulting in stagnation or moderate decline in the 1980s and 1990s (Wei and Fang, 2006). But the reversed ascent trend since 2000 implies that the poverty alleviation policies, such as the Western Development program and the Rise of Central China

program, have gradually taken effect and promoted the central and western regions in China. However, the relative income level of these selected provinces was still low, with the highest one of Henan at 70% and the lowest one of Guizhou at 40% of the national average in 2016 (Figure 2.14).

2.6 Determinants of uneven regional development

These analyses indicate that regional development in China is a spatially heterogeneous and spatially dependent process, and there have been similarities and dissimilarities in the space-time paths of provinces in the same or different regions. Built on a multi-mechanism framework (Wei, 1999, 2000), the impacts of the triple-process economic transition are further investigated by considering the spatial regimes of the underlying driving forces of regional development in China, with a focus on the reform era. By applying both non-spatial and spatial regression techniques, we quantified the impacts of globalization, decentralization, and marketization processes on the convergence or divergence of provinces, following a beta convergence framework (Zhang et al., 2019).

The annual GDP per capita growth rate is selected as the dependent variable, which is calculated by the constant price GDP and resident population in each province. The initial GDP per capita (y_0), the ratio of fixed asset investment in GDP (K), the ratio of higher education student enrollment in total population (H), and the composite variable of population growth, technology advancement, and capital depreciation rate ($n + g + \delta$) are selected to test the conditional β-convergence using the neoclassical growth model (Barro et al., 1991; Cravo and Resende, 2013; Li and Fang, 2016; Mankiw et al., 1992).

The triple processes of globalization, decentralization, and marketization are represented by the ratio of exports to GDP (EXP), the ratio of SOEs in fixed asset investment (SOE), and the ratio of local expenditure to GDP (LEXP), respectively (Li and Wei, 2010; Liao and Wei, 2016; Yu and Wei, 2003). The pooled OLS model and the spatial regime model (SRM) expansion based on the regional division of the eastern, central, western, and northeastern China could be expressed as follows:

$$\ln\left(\frac{y_{i,t}}{y_{i,0}}\right) = \beta_0 \ln(y_{i,0}) + \beta X_{i,t} + \mu_{i,t}$$

$$\begin{bmatrix} \ln\left(\frac{y_{i,t}}{y_{i,0}}\right), e \\ \ln\left(\frac{y_{i,t}}{y_{i,0}}\right), c \\ \ln\left(\frac{y_{i,t}}{y_{i,0}}\right), w \\ \ln\left(\frac{y_{i,t}}{y_{i,0}}\right), n \end{bmatrix} = \begin{bmatrix} \ln(y_{i,0}), e & X_{i,t}, e & \cdots & 0 & 0 \\ \vdots & & \ddots & \vdots & \\ 0 & 0 & \cdots & \ln(y_{i,0}), n & X_{i,t}, n \end{bmatrix} \begin{bmatrix} \beta_0, e \\ \beta, e \\ \vdots \\ \beta_0, n \\ \beta, n \end{bmatrix} + \begin{bmatrix} \mu_{i,t}, e \\ \vdots \\ \mu_{i,t}, n \end{bmatrix}$$

where $\ln\left(\frac{y_{i,t}}{y_{i,0}}\right)$ is the logarithmic form of GDP per capita growth for province i from the initial year to the next year t and β_0 is the convergence coefficient to be tested. If $\beta < 0$, it implies a convergence trend that the poor provinces develop faster than the rich provinces, and the convergence rate, λ, equals $-\ln(\beta + 1)$. $X_{i,t}$ is $N \times X$ matrices of observations on other explanatory variables and the constant term, and $\mu_{i,t}$ is the error term. The subscripts, e, c, w, and n, indicate the spatial regimes in China.

Table 2.1 reports the Pearson correlation coefficients of the dependent variable and the independent variables. It is not surprising that the fixed asset investment and the educated

labor are positively correlated to the economic growth. The ratio of SOEs in fixed asset investment is negatively correlated to the growth rate. However, the initial GDP per capita, the proxy of globalization, and the proxy of decentralization are insignificantly correlated to the growth of GDP per capita, and the composite variable, $n + g + \delta$, is negatively correlated to the dependent variable. Furthermore, the correlation between initial economic status and human capital is as large as 0.8 and significant, indicating the existence of a potential multicollinearity problem. In the following pooled OLS regression and SRM, the human capital variable, H, is not included.

Table 2.1 Correlation coefficients among dependent and independent variables

	1	2	3	4	5	6	7	8
1. y	1							
2. y0	-0.05	1						
3. K	0.12***	0.37***	1					
4. H	0.08**	0.80***	0.58***	1				
5. $n + g + \delta$	-0.44***	0.07**	-0.15***	0.01	1			
6. SOE	-0.24***	-0.57***	-0.44***	-0.65***	0.19***	1		
7. EXP	0.05	0.52***	-0.10***	0.34***	0.26***	-0.23***	1	
8. LEXP	-0.04	0.06*	0.53***	0.09***	0.02	0.16***	-0.18***	1

Note: ***, p-value < 0.01; **, p-value <0.05; *, p-value < 0.1.

Table 2.2 presents the results based on the pooled OLS regression and SRM. After excluding the human capital variable, the multicollinearity problem is controlled as the VIF values are less than 5.0 for all explanatory variables. The ANOVA test and Chow test are both significant at 0.01 level, indicating that the SRM improves the modeling performance comparing with the pooled OLS regression. While the pooled OLS regression only explains 19% of the variance in economic growth, the SRM reaches as high as 27%.

Table 2.2 Results of the spatial regime model (SRM) and pooled OLS regression

Variables	Pooled OLS		Spatial regime model (SRM)			
	coefficients	VIF	Eastern	Central	Western	Northeastern
ln(y0)	-0.0082***	4.44	-0.0158***	0.0139*	0.0143***	-0.0426***
ln(K)	0.0356***	3.39	0.0204**	0.0188	-0.0037	0.0195
ln(H)	-	-	-	-	-	-
$\ln(n+g+\delta)$	-0.0376***	1.06	-0.0705***	-0.0649***	-0.0246***	-0.0901***
ln(SOE)	-0.0017	2.58	-0.0098*	0.0172	-0.0096	-0.0620**
ln(EXP)	0.0078***	2.08	0.0194***	0.0170**	0.0057**	0.0127**
ln (LEXP)	-0.0165***	2.12	-0.0310***	-0.0430***	-0.0040	-0.0052
Convergence rate	0.8%		1.6%	-1.4%	-1.4%	4.4%
Adjusted R^2	0.1853		0.269			
Observations	899		279	186	341	93

Note: ***, p-value < 0.01; **, p-value <0.05; *, p-value < 0.1.

The pooled OLS regression implies that Chinese provinces have slowly converged during the period of 1978-2016, with a convergence rate less than 1%. Also, fixed asset investment has significant positive impact on economic growth; as a developmental state, China uses the allocation of fixed asset investment as a key instrument to promote industrialization and regional development (Li and Wei, 2010; Ma and Wei, 1997; Yu and Wei, 2008). However, the independent variable regarding population growth has a negative impact on economic growth, which is in line with previous convergence test empirics on China (Lau, 2010). While high population growth provides more potential labor and a larger consumer market for economic development, it also limits income per capita and leads to agglomeration diseconomy. Under industrial restructuring and transformation, economic growth in China relies less and less on cheap labor (Li and Fang, 2016). Among the triple processes of decentralization, globalization, and marketization, the ratio of exports to GDP is significant in explaining economic growth in provinces, but the ratio of SOEs to fixed asset investment is insignificant and the ratio of local expenditure to GDP has a negative impact on regional development.

The SRM results reveal more interesting findings that are not covered by the pooled OLS regression. First, the national trend has masked the different convergence and divergence trends within spatial regimes. The convergence among the eastern provinces corroborates the consensus that coastal Chinese provinces have formed a convergence club since the reform (Tian et al., 2016; Wei, 2017; Zhang et al., 2019). Moreover, northeastern China has experienced a strong β-convergence. It is argued that the gap in northeastern China has been narrowed significantly and the poor regions have converged rapidly since the implementation of the revitalization of northeastern old industrial bases program (Huang et al., 2018). In comparison, central and western China showed a divergence trend during the post-reform period.

Second, the insignificant coefficient with respect to the proxy of the marketization force, proxied by the ratio of SOEs to fixed asset investment, becomes significantly related to economic growth rates in northeastern provinces. It indicates that the heavy burden of SOEs may impede economic development, and on the contrary, if a province implements marketization policies and reinforces the non-SOE sector, it will experience higher economic growth if the other conditions are identical, which is particularly applicable to the northern region.

Third, the proxy of globalization is also significantly related to economic growth rates, regardless of the regions. However, the effects are dependent on the geographical location of the provinces. The positive impact of globalization is strong within the eastern provinces, followed by central and northeastern China, and the effect in the western provinces is the

weakest. It is discussed that the coastal provinces have locational advantages to the global market and foreign investors from Taiwan, Hong Kong, and western countries (Yu and Wei, 2003). The opening-up of coastal cities at the beginning of the reform and their deepening integration into the global market since China's entry into the WTO has further benefited the eastern provinces by attracting FDI, developing export-oriented industries, and cultivating specific local development models as discussed above (Li and Wei, 2010; Liao and Wei, 2012; Wei and Ye, 2009; Wei et al., 2011).

2.7 Conclusion

This chapter investigates the impacts of shocks, spatial regime fades, and spatial redistribution processes on regional development in China from 1952 to 2016. The findings suggest that three shocks, or development policy shifts, has caused spatial redistribution of wealth in China, namely the reform and opening-up, the rural reform, and the entry to WTO. As a result, the rich and poor regional club have changed correspondingly in terms of member provinces and the club's boundary, as illustrated by the spatial regime fades. The space-time path of individual provinces reveals that different regions have various patterns of development in response to the policy shocks and redistribution processes. The investigation of mechanisms indicates that the convergence trend and the driving forces vary significantly across regions, implying spatially heterogeneous processes underlying the uneven regional development in China.

The utilization of spMorph, a newly developed ESTDA method, uncovers structural breaks in the temporal dimension and the redistribution and changes of regimes in the spatial

dimension. The segregation of the evolution of regional inequality in China highlights three shocks and four spatial regimes in the last sixty years, one in the pre-reform period and three since the reform. The reform in 1978 marked the end of the planned economy and the decline of traditional rich clusters benefited from it, namely, the interior provinces and the northeastern industrial base. The redistribution processes in the reform era is more complex because of the ever-changing focus of the central government in economic development strategies. The emergence of coastal China due to the triple transitional process of globalization, decentralization, and marketization is confirmed, echoing previous literature (Fan and Sun, 2008; Sakamoto and Islam, 2008). The analysis also provides more detail that is not easily revealed by solely depending on the structural break or the spatial analysis. For example, the decline of northeastern China is uneven and lasts until the 2000s, with Liaoning being the last northeastern province with a falling economic status. Within the coastal-interior divide, the coastal club further contains three small groups, with Jiangsu province as the most developed one, followed by the coastal provinces to the southeast like Zhejiang, Fujian, and Guangdong, and the northern Shandong and Hebei as the least developed one.

The results of the space-time path method reveal the mobility and dynamics of individual provinces in regional development, further corroborating the results of spatial-regime analysis (Gu et al., 2016; Wu et al., 2019). Strong spillover effects are found among provinces and the effects are heterogeneous among regions in China. For example, the spillovers from the strong economic performance of rich regions such as Shanghai in the YRD and Guangdong in the south have been more evident. By scrutinizing the growth trajectory of individual provinces, these spillover effects are also found to be intertwined

with the institutional forces and inequality alleviation programs such as the Western Development program or the Rise of Central China program. Our results also corroborate previous studies which emphasize the role played by the state in China's regional development. During the reform era, the major political goal of the central government in the 1980s and 1990s followed a "getting rich first" philosophy, with Guangdong province being the exemplary case, whereas political administration since 2000 has transitioned to and emphasized "common prosperity", "a harmonious socialist society", and a "war on poverty" (Fan, 2006; Fan et al., 2011; Graeme, 2018). The results have shown individual provinces have interacted with these top-down policies in very different ways and a bottom-up approach is more powerful in making connections between the micro-scale process and the multi-scalar pattern of regional inequality in China.

Investigation of the underlying driving forces in the spatiotemporal dynamics validates the importance of spatial regimes in regional development and uncovers spatially heterogeneous mechanisms within regimes. The comparison shows that the spatial regime model (SRM) outperforms the pooled OLS regression, indicating the existence of spatial heterogeneity in the economic growth of provinces. While a weak but significant β-convergence trend is observed for all the provinces, both convergence and divergence trends are identified in different regions. A strong and significant convergence trend is found for the eastern and northeastern provinces due to the rising of originally less developed regions (Huang et al., 2018; Wei, 2017). However, a moderate divergence trend is observed in both central and western China. The modeling results suggests that various spatially differentiated instruments should be used to promote economic growth and alleviate regional inequality. Though the

pooled OLS regression result shows that economic growth in China is heavily driven by fixed asset investment, this developmental instrument is only significant within eastern China as indicated by the SRM results. For the triple processes of marketization, globalization, and decentralization, only the models focusing on eastern and northeastern provinces confirm the significant impacts from the emergence of the private and other ownerships and the diminishing of the SOEs sector. Similarly, the globalization effect gradually fades from coastal China to central, northeastern, and western China in promoting regional development.

The investigation in this chapter only covers part of the whole picture of regional inequality and regional development in a transitional economy like China. In the following chapters, the empirics resulting from county-level analysis and a more in-depth case study of Zhejiang province further reveal the scales, hierarchy, and agglomerations in uneven regional development by a multi-scalar and multi-mechanism framework.

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Chapter 3 A Spatial Decomposition of County-Level Inequality in China Under A Multi-Scalar and Multi-Mechanism Framework

Abstract

Drawing upon a national county-level economic dataset, this chapter examines the multi-scalar regional inequality across regions, provinces, prefectures, and counties in China. The study utilizes a novel nested Theil decomposition method to compare and analyze the contribution made by each scale under a coherent spatial hierarchy. The obtained results demonstrate that the between-prefecture inequality contributes most to the overall inequality at the county level, followed by the within-prefecture, between-region, and between-province inequality. The results also find evident differences in terms of the trends and contribution of each scale across regions. Based on a multi-mechanism framework, results of multilevel modeling indicate that globalization, marketization, urbanization and economic development play an important role in shaping the bulk of regional inequality. While globalization and relative development level have positive and negative effects on intra-provincial inequality respectively, their effects are opposite on intra-prefectural inequality, suggesting that scale effects and spatial hierarchy should not be neglected in analyzing the underlying mechanisms.

3.1 Introduction

Regional inequality is an intensively debated topic in academic inquiry and governmental policy (Boushey et al., 2017; Piketty, 2014; Stiglitz, 2012). It is a problem manifested from the macro to the micro scales. Fruitful studies are interested in regional inequalities at the international, national, sub-national, and household levels (Cavanaugh & Breau, 2018; Iammarino et al., 2019; Mykhnenko and Wolff, 2019; Paredes et al., 2016; Rey and Sastré Gutiérrez, 2015). However, contradictory evidences of convergence and divergence are found at every focused scale and there is no formal consensus reached. While the orthodox neoclassical theory supports convergence globally or within developed countries (Barro, 2015; Barro and Sala-i-Martin, 1995), empirical results demonstrate that they have failed to explain the persistent and intensifying inequality, especially in the underdeveloped countries (Kanbur et al., 2005; Ravallion, 2014; Stiglitz, 2012; Wei, 2017). In addition to the disagreement on regional inequality at an individual scale, scholars also find that inequality across spatial scales vary differently, which highlights its sensitivity to scale and suggests a multi-scalar perspective in study (Arestis & Phelps, 2019; He et al., 2017; Paredes et al., 2016; Wei, 2015).

With the transformation of former socialist countries, globalization, and liberalization since the late 1980s, regional inequality in transitional economies has drawn considerable attention (Chapman and Meliciani, 2018; Rodríguez-Pose and Krøijer, 2009; Wei, 2007; Wei et al., 2017). China as a rising transitional economy, as well as its unique political and administrative system, provides an ideal laboratory to investigate the multi-scalar inequality under transformations. Since the reform and opening-up in 1978, China has undergone

tremendous transitions towards a market economy with socialist characteristics. The rapid economic growth in China, with an annual average rate at 9.6% from 1978 to 2016, is accompanied with persistent and intensifying inequality, with the Gini index increasing from 0.32 in 1990 to a peak of 0.44 in 2010, remaining high since then, dropping slightly to 0.39 in 2015 (World Bank, 2018). The widening inter-regional and inter-provincial gap, mainly between the coastal and interior provinces in China, has bred numerous empirical examinations since the 1990s (Chen and Fleisher, 1996; Kanbur and Zhang, 2005; Li and Wei, 2010; Tsui, 1991; Wei, 1999). Alarmed at the negative impacts on social and political stability and unity, the central government has put forward several inequality alleviation programs like the Western Development Strategy to promote the poor and interior provinces (Fan and Sun, 2008). Scholars also debate that spatial inequality is alleviated while the ethnic inequality is increasing due to urban-rural gap and migration in the western China (Howell, 2017; Howell & Fan, 2011).

While most studies focus on the regional or provincial scale of regional inequality, only a small amount of research has been carried out recently to comprehensively analyze nationwide inequality at the prefectural or county scale in China (He, Bayrak, et al., 2017; He, Fang, et al., 2017; Huang and Wei, 2019; Li and Fang, 2014). The sensitivity to scales is confirmed by conducting analysis as fine as the county level, but the relative importance of each scale, namely which scale is more decisive in the evolution of regional inequality in China, remains understudied, not to mention the driving forces behind it (Fan and Sun, 2008; Kanbur and Zhang, 2005; Liao and Wei, 2012; Wei and Ye, 2009; Wei et al., 2011).

Therefore, this chapter aims to demystify the sensitivity to scales in China's regional inequality and quantitatively measure the contribution of each scale by applying a spatial decomposition approach to the county-level economic dataset from 1997 to 2016. Specifically, the novel method, called as the three-stage nested Theil decomposition, takes the spatial hierarchy in China, namely the region-province-prefecture-county administrative structure, into consideration and investigates the contribution of scales within a coherent analytical framework (Akita, 2003; Paredes et al., 2016). Drawn upon a multi-mechanism framework, the triple processes of globalization, decentralization, and marketization, as well as the urbanization process in China, are used to explain the underlying forces of inequality at different scales (Wei, 2000, 2007).

The rest of the chapter is organized as follows. The second section presents a brief review of literature on regional inequality in China. The third section introduces the research setting, including the study area, data, and analytical methods. The fourth and fifth sections examine the multi-scalar characteristics of regional inequality in China through the applications of nested spatial decomposition and Markov Chain methods. The sixth section investigates the underlying forces of intra-provincial and intra-prefectural inequality by the multilevel modeling method. The final section concludes with findings and policy implications of the results.

3.2 Literature review

The literature on regional inequality is centered on three major objectives: the magnitude and temporal evolution of regional inequality, the mechanisms and driving forces underlying the

pattern of regional inequality, and the developmental policies and strategies to reduce regional inequality (Li and Fang, 2014; Li and Wei, 2010; Lipshitz, 1992).

According to one neoclassical perspective, regional inequality will firstly increase as a county's development level rises and finally decrease because of structural change and equilibrium forces on labor and capital, indicating an inverted-U pattern or "Kuznets curve" (Kuznets, 1955; Williamson, 1965). But the empirics are controversial and dependent on the study area and study period, implying the existence of both inverted-U and U-shaped patterns, mostly convergence for the core economies and divergence for the peripheral countries (Fan and Casetti, 1994; Kim and Margo, 2004; Lessmann, 2014; Monastiriotis, 2014). With regards to the determinants of regional inequality, scholars argue that the globalization since the 1990s has led to a widening gap among countries while the impact of political and fiscal decentralization varies among the developed and underdeveloped countries (Ezcurra and Rodríguez-Pose, 2013a, 2013b; Lessmann, 2009, 2012; Rodríguez-Pose and Ezcurra, 2011). Other factors like human capital, economic structural, and transportation also contribute significantly to uneven regional development (Cuaresma et al., 2014; Jiang and Kim, 2016; Petrakos et al., 2011). Government intervention and development of growth poles, which is also known as the top-down developmental strategy, are suggested by the planned economics theory to narrow the gap among regions (Friedmann, 1973; Hirschman, 1958; Perroux, 1950). However, studies on the governmental and inter-governmental policies suggest that treatment of regional disparity should take the heterogeneous development path of regions into consideration (Charron, 2016; Dunford and Perrons, 2012; Iammarino et al., 2019).

Stemming from the literature of uneven regional development in western capitalist countries, studies on China have revealed unique characteristics and developed their own analytical frameworks to better understand regional inequality in a transitional economy (Wei, 1999, 2000). Previous studies are mainly concentrated on three aspects of regional inequality in China (Wei, 2017). First, more attention is paid to the spatiality of inequality, which involves the role of scale, hierarchy, and geography in regional disparity. Second, more nuanced understanding of regional inequality has been reached by interpreting the transitions as the triple processes of globalization, decentralization, and marketization, as well as the rapid urbanization in China. Third, more vigorous spatial analysis methods are implemented to highlight the spatially dependent and heterogeneous processes of regional development in China.

Regional inequality in China is sensitive to scale, with both convergence and divergence trends observed along the spatial hierarchy and across regions in China. The studies on inequality at regional and provincial scales have reached a consensus that the gap among the coastal and interior regions and provinces has been widening since the reform (Chen and Fleisher, 1996; Hao and Wei, 2010; Sakamoto and Islam, 2008). Under the divergence trend among regions in China, various empirics indicate that there are two convergence clubs within regions, one high-income club residing within the coastal region and another low-income club consisting of the remaining provinces (Lin et al., 2013; Tian et al., 2016; Zhang et al., 2019). Scholars argue that the widening coastal-interior gap is attributed to the preferential policies during China's reform, which helps the coastal provinces to move one step ahead of the interior counterpart in globalization, decentralization, and marketization,

and gain benefits from leaned government investment and infrastructure construction (Démurger, 2001; Fujita and Hu, 2001; Hao and Wei, 2010; Yao, 2009).

Recent comprehensive assessment of disparities at the prefectural and county levels further reveals the multi-scalar nature of regional inequality in China (Wei, 2017). In Huang and Wei (2019), it is observed that the gap among prefectural cities has enlarged and shows a diverging trend, while the interregional inequality has firstly increased and then decreased from 1990 to 2010, indicating an inverted-U pattern. The study by He et al (2017) has found the inverted-U curve at the regional, provincial, and prefectural levels, and the county level inequality shows an upward divergence trend from 1997 to 2010. But the findings in Li and Fang (2014) imply that intercounty inequality increased from 1992 to 2002 and then declined until 2009. Discrepancies of regional inequality across scales could be observed among empirics, which could be ascribed to the indicator, methods, or data used in the studies. But more importantly, it implies that more vigorous assessment approaches and more serious treatment of scales and hierarchies should be applied in examining China's regional inequality.

To investigate the underlying forces of uneven regional development in China, scholars are interested in the effects of various determinants, including population and human capital (Fleisher et al., 2010; Li and Wei, 2010), fiscal decentralization (Chen and Groenewold, 2013b; Liu et al., 2017; Wang, 2010), foreign investment (Greaney and Li, 2017; Huang and Wei, 2016; Li and Haynes, 2012; Yao et al., 2010; Yu et al., 2011), trade openness and globalization (Fujita and Hu, 2001; He et al., 2008; Wan et al., 2007; Zhang and Wei, 2017;

Zhang and Zhang, 2003), government investment (Chen and Groenewold, 2013a; Yu and Wei, 2003), state-owned enterprises (SOEs) (He, Zhou, et al., 2017; Shen, 2004), urbanization (Wei et al., 2017; Yu and Wei, 2008), economic structure (Kanbur and Zhang, 2005; Li and Haynes, 2011), agglomeration economies (Ge, 2009; Ke, 2010), transportation (Chen and Haynes, 2017), and biased policy and political forces (Démurger et al., 2002; He, 2016; Ho and Li, 2008). In particular, Wei (1999) proposes the multi-scale and multi-mechanism framework to generalize and better understand the transition after the reform as a triple process of globalization, decentralization, and marketization. Recent studies further develop the multi-mechanism framework and include urbanization, a profound process that is spatially biased in China, in the investigation of regional inequality and rapid urban expansion over the past decades (Gao et al., 2019; Wei et al., 2017).

Under globalization and liberalization in China, a series of reforms were implemented in foreign investment and trade to provide more deregulated and open policies for the coastal region (Yao, 2009). Special economic zones (SEZ), coastal open cities/zones, and numerous economic and technological development districts were established along the coastal provinces, within which the export-oriented and foreign-invested firms could gain comparative advantages regarding ownership, tax, wage, land use, and financial support (Yeung et al., 2009). Besides preferential policies from the central government, the coastal regions are also advantageous in location, infrastructure, and labor supply with the support of local developmental institutions and business network linking with foreign investors (Huang and Wei, 2016; Wei, 2007). Empirics reveal that globalization contributes significantly to the

widening regional inequality in China (Greaney and Li, 2017; Lessmann, 2013; Wan et al., 2007; Zhang and Zhang, 2003).

Meanwhile, the decentralization process gives the local authorities considerable power in decision making, enterprise management, and tax revenue collection and allocation (Qiao et al., 2008). Local governments constantly bargain with the central government in revenue sharing, expenditure responsibilities, and investment (Chen and Groenewold, 2013b). Rich coastal provinces are usually more influential in such bargaining process and able to finance their rapid economic growth, which results in rising regional inequality (Liu et al., 2017; Song, 2013). Decentralization also tends to intensify the interregional competition because economic achievements weigh heavily in the measure of political performance and bureaucratic promotion (He and Zhu, 2007). The competition produces duplicate industries and imitation of successful development strategies in other regions, which leads to local protectionism and spatially fragmented economies in China (He and Pan, 2010; Poncet, 2005). On the contrary, the effects of equalization policies, such as revenue transfers between rich and poor provinces, are found to be limited, or even counter-productive, in alleviating regional inequality (Huang and Chen, 2012).

China's transition to a market economy is accompanied by the marketization process and the diminishing role of state-owned enterprises (SOEs) in economic development (Fujita and Hu, 2001; Wei, 2002). As a legacy of the Soviet-model of industrialization from the pre-reform era, the SOE sector has been challenged by the non-SOE sectors because of its fading advantages in productivity, subsidies, and policies, as well as the heavy burden in tax

responsibility and social welfare (Cao et al., 1999; Xiao and Weiss, 2007). As a result, regions with a high percentage of SOEs in economic components, like the old industrial bases in northeastern China and the interior provinces targeted by the "third front project" during Mao's era, are slow to adapt to the reform and are now lagging behind the coastal region (Hao and Wei, 2010; He, Zhou, et al., 2017).

Besides the triple processes of globalization, decentralization, and marketization, the urbanization process also has an evident impact on regional inequality in China. In order to reallocate the abundant rural labor force, the central government has gradually reformed the household registration system (*hukou* system) to ease the constraints on labor migration (Fang, 2010; Zhang and Tan, 2007). There is a total of 274 million rural migrant workers (*nongmingong*) in urban China to date, which has fundamentally altered the income structure in both urban and rural regions (Gao et al., 2019). Population urbanization plays an important role in reducing regional inequality in China by transferring non-*hukou* migrants from the poor interior provinces to the rich coastal provinces (Li and Gibson, 2013).

Based on the above review, there are two areas which deserve more research efforts. First, the comprehensive analysis of multi-scalar regional inequality in China needs to be further studied. As aforementioned, the literature suggests that there is no formal consensus about regional inequality at the prefectural and county level in China. It is partially because the lower level scale is examined without separating the embedded effects from the higher level. That is, counties from different prefectures or prefectures from different provinces are pooled and assessed together. Conventional methods like one-stage Theil decomposition is capable

to deal with spatial hierarchy involving two levels but is limited when the region-province administrative hierarchy is extended to the region-province-prefecture-county one. Moreover, the sensitivity to scale is depicted with intensifying magnitude at finer scales, but without quantitatively explaining the source of such sensitivity, which leaves the relative importance of each scale neglected.

Second, the multi-mechanism framework is widely used to investigate uneven socio-economic development in China (Gao et al., 2019; Huang and Wei, 2019; Li and Fang, 2014; Li and Wei, 2010; Wei et al., 2017). However, most of the studies focus on the determinants of economic development level or differentiated economic growth rate. The driving forces, as well as the role played by the multi-scalar effects and spatial hierarchy, of regional inequality remain understudied, which is more closely related to policy implications for inequality reduction. This chapter aims to fill the gaps by introducing a three-stage nested Theil decomposition method to multi-scalar regional inequality and analyzing the mechanisms of intra-provincial and intra-prefectural inequality in China by the multilevel modeling method.

3.3 Research setting

3.3.1 Study area and data

The study area covers the regional, provincial, prefectural, and county level scale units in China. For the regional scale, this chapter uses the four-region division, namely the eastern, central, western, and northeastern regions of China (Figure 3.1). Though the eastern-central-western division and the coastal-inland division have been used in previous studies (Fan and Sun, 2008; Kanbur and Zhang, 2005), the four-region description is adopted in recent studies,

which reflects the macroeconomic linkages and the development policy of the central government (He, Bayrak, et al., 2017; Zhang et al., 2019). The provincial scale contains 31 provincial level units in mainland China. Hong Kong, Macau, and Taiwan are not included due to data availability and different political and economic systems. The administrative boundary changes are salient at the county level and thus may affect the prefectural units and inequality measures (He et al., 2018). The county level boundaries of 2016 are used and aggregated into the prefectural one to ensure consistency, following the statistical units issued by the National Bureau of Statistics (http://www.stats.gov.cn). As a result, this chapter covers four regions, 31 provinces, 341 prefectures, and 2179 counties during the period of 1997-2016.

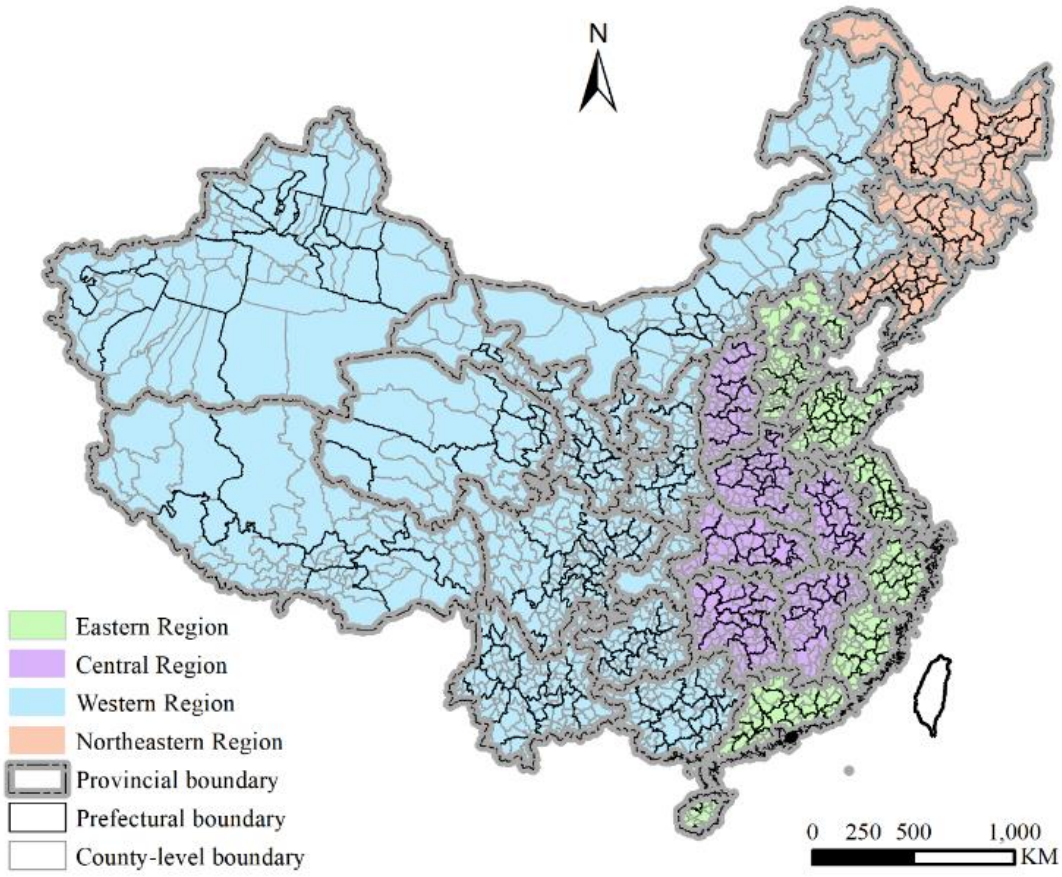

Figure 3.1 The multi-scalar boundaries in China

The primary data used this chapter are the county level GDP, population, and shapefile, which is extracted from China Data Online (http://chinadataonline.org) and aggregated to the higher levels. The GDP per capita is used to represent economic development level of counties, which is calculated based on constant price GDP in 1997 and the resident population estimated from the censuses of 2000 and 2010 (He, Bayrak, et al., 2017; Liao and Wei, 2012). The mechanisms of intra-provincial and intra-prefectural inequality involve data of exports, fixed asset investment, urban population, industrialization, transportation, and human capital for the provinces and prefectures of China, which are primarily extracted from the China Statistical Yearbook and China City Statistical Yearbook in various years.

3.3.2 Analytical methods

For the regional inequality measures, they could be categorized into three types: dispersion indices, Lorenz Curve indices, and entropy or information theoretic indices (Gaile 1984). The dispersion indices include mean deviation, standard deviation, and coefficient of variation. They are straightforward and easy to be computed, but since the absolute (in)equality is measured, they are scale-dependent and sensitive to outliers. The Lorenz curve indices are associated with Gini coefficient and most frequently used by economists and geographers, but they are difficult to compute and unduly influenced by high values at the upper end of Lorenz curve. Compared to the dispersion indices and Lorenz Curve indices, the entropy indices are reasonably tractable and not affected by extreme values. Besides, the indices, like Theil index, are readily decomposable into components that measure the inequality between and within groups of observations by regions.

This chapter uses the Theil index (T), a commonly used measure of regional inequality, to explore the multi-scalar regional inequality in China (Fan and Sun, 2008). As an entropy-based method, it satisfies several properties like mean independence, population-size independence, and the Pigou-Dalton principle of transfers (Shorrocks, 1980). More importantly, the Theil index is readily decomposable into within-region inequality, T_{wr}, and between-region inequality, T_{br}, thus makes it possible to measure the contribution of the two (Theil, 1967):

$$T = \sum_i \sum_j \frac{y_{ij}}{y} \log \left(\frac{y_{ij}/y}{x_{ij}/x}\right)$$

$$T = \sum_i \frac{y_i}{y} \sum_j \frac{y_{ij}}{y_i} \log \left(\frac{y_{ij}/y_i}{x_{ij}/x_i}\right) + \sum_i \frac{y_i}{y} \log \left(\frac{y_i/y}{x_i/x}\right) = T_{wr} + T_{br}$$

where y and x are total GDP and population in China, y_i and x_i are GDP and population in region i, and y_{ij} and x_{ij} are GDP and population of province j in region i.

In Akita (2003), the decomposable advantage of Theil index is improved by developing the one-stage decomposition into a two-stage one, which includes finer scale at the prefectural level, k:

$$T = \sum_i \sum_j \sum_k \frac{y_{ijk}}{y} \log \left(\frac{y_{ijk}/y}{x_{ijk}/x}\right) = \sum_i \frac{y_i}{y} T_i + T_{br}$$

$$T_i = \sum_j \sum_k \frac{y_{ijk}}{y_i} \log \left(\frac{y_{ijk}/y_i}{x_{ijk}/x_i}\right)$$

$$T_i = \sum_j \frac{y_{ij}}{y_i} \sum_k \frac{y_{ijk}}{y_{ij}} \log\left(\frac{y_{ijk}/y_{ij}}{x_{ijk}/x_{ij}}\right) + \sum_j \frac{y_{ij}}{y_i} \log\left(\frac{y_{ij}/y_i}{x_{ij}/x_i}\right) = T_{i\_wp} + T_{i\_bp}$$

$$T = \sum_i \frac{y_i}{y} T_{i\_wp} + \sum_i \frac{y_i}{y} T_{i\_bp} + T_{br} = T_{wp} + T_{bp} + T_{br}$$

where y_{ijk} and x_{ijk} are GDP and population of prefecture k in province j, region i. For each region i, T_i is the overall inequality measure based on prefectural units, and T_{i_wp} and T_{i_bp} are within-province inequality and between-province inequality components in region i. T_{wp} and T_{bp} are weighted sum of within-province inequality and between-province inequality for all regions.

Akita's idea is further expanded into a three-stage decomposition including the county scale by Paredes et al. (2016). The three-stage decomposition is more relevant for policy issues in China because it fits the region-province-prefecture-county hierarchy in China and is not constrained to any specific scale level. After integrating the county level, c, the overall inequality is measured as:

$$T = \sum_i \sum_j \sum_k \sum_c \frac{y_{ijkc}}{y} \log\left(\frac{y_{ijkc}/y}{x_{ijkc}/x}\right) = \sum_i \frac{y_i}{y} T_i + T_{br}$$

$$T_i = \sum_j \sum_k \sum_c \frac{y_{ijkc}}{y_i} \log\left(\frac{y_{ijkc}/y_i}{x_{ijkc}/x_i}\right)$$

$$T_i = \sum_j \frac{y_{ij}}{y_i} T_{ij} + T_{i\_bp}$$

$$T_{ij} = \sum_k \sum_c \frac{y_{ijkc}}{y_{ij}} \log\left(\frac{y_{ijkc}/y_{ij}}{x_{ijkc}/x_{ij}}\right)$$

$$T_{ij} = \sum_k \frac{y_{ijk}}{y_{ij}} \sum_c \frac{y_{ijkc}}{y_{ijk}} \log\left(\frac{y_{ijkc}/y_{ijk}}{x_{ijkc}/x_{ijk}}\right) + \sum_k \frac{y_{ijk}}{y_{ij}} \log\left(\frac{y_{ijk}/y_{ij}}{x_{ijk}/x_{ij}}\right) = T_{ij\_wm} + T_{ij\_bm}$$

$$T = \sum_i \frac{y_i}{y} \sum_j \frac{y_{ij}}{y_i} T_{ij\_wm} + \sum_i \frac{y_i}{y} \sum_j \frac{y_{ij}}{y_i} T_{ij\_bm} + \sum_i \frac{y_i}{y} T_{i\_bp} + T_{br}$$

$$T = T_{wm} + T_{bm} + T_{bp} + T_{br}$$

where y_{ijkc} and x_{ijkc} are GDP and population of county c in prefecture k, province j, region i. For each province j in region i, T_{ij} is the overall inequality measure based on county units, and T_{ij_wm} and T_{ij_bm} are within-municipality[4] inequality and between-municipality inequality components. T_{wm} and T_{bm} are the weighted sums of within-municipality inequality and between-municipality inequality for all provinces in each region.

Markov chain is widely used to investigate the shape change of the income distribution and the long-term convergence or divergence trend (Dezzani, 2001, 2002; Fingleton, 1999; Quah 1993). The Markov chain method begins with the discretization of income distribution into non-overlapping and exhaustive intervals. The relative GDP per capita is pooled and equally divided into k different state-space. For time t, the discretized distribution F_t is a $n \times 1$ vector, where n is the number of units. For its future time $t + 1$, there is F_{t+1} with the same length. The Markov transition matrix M is a n by n matrix that governs the transformation from F_t to F_{t+1}:

[4] Municipality and the abbreviation m are used equivalently with prefecture to avoid ambiguous abbreviation for province and its abbreviation p.

$$F_{t+1} = M' \cdot F_t$$

where each element $m_{i,j}$ in M indicates the probability for a unit in state-space i at time t ends up in state-space j at time $t + 1$.

If transition probabilities are stationary, that is if the probability are time-invariant, then

$$F_{t+s} = (M^s)' \cdot F_t$$

Under the assumption of time-invariant matrix ($t \to \infty$), the properties of this Matrix can be further examined to determine the Ergodic distribution of F_t to indicate if the regional inequality will be converging or diverging after compared with the initial and final (sample) period distributions. Such a comparison can provide a full picture of regional inequality dynamics.

To better understand the driving forces of regional inequality in China, multilevel modeling is used. Intra-provincial inequality and intra-prefectural inequality are selected as the dependent variable. The triple processes of globalization, marketization, and decentralization, as well as the urbanization process and other control variables are used (Table 3.1). The single-level, two-level, and three-level models are designed. The single-level model is a pooled regression. The two-level model adds the four-region as the dummy variable and the control group into intra-provincial inequality and intra-prefectural inequality, respectively. And the three-level model is fledged with the region-province effects considered:

$$y_{ijts} = \beta_0 + \beta_1 x_{ijts} + \mu_{oj} + \vartheta_{ojt}$$

where y_{ijts} is the dependent variable in province/prefecture i that belongs to region j, x_{ijts} are the independent variables in province/prefecture i that belongs to region j, μ_{oj} is the error term in region j, and ϑ_{oij} is the error term of province/prefecture i that belongs to region j.

Table 3.1 Independent variables

Category	Abbr.	Definition	Data source
Intra-provincial level			
Globalization	EXP	ratio of export in GDP	CSY
Marketization	SOE	ratio of SOEs in fixed asset investment	SYCIFA
Decentralization	LEXP	local fiscal expenditure in GDP	CSY
Urbanization	URB	urban population ratio	CCSY
Control variable			
Development	PGDP	GDP per capital	CSY
Investment	FIX	ratio of fixed asset investment in GDP	SYCIFA
Industrialization	IND	ratio of secondary sector in GDP	CSY
Transportation	TRS	ratio of highway length to territory area	CSY
Human capital	EDU	ratio of higher education student to total population	CSY
Intra-prefectural level			
Globalization	FDI	ratio of foreign direct investment in GDP	CCSY
Marketization	SOE	ratio of SOEs in urban employed population	CSYRE
Decentralization	LEXP	local fiscal expenditure in GDP	CCSY
Urbanization	URB	ratio of population in city district	CCSY
Control variable			
Development	PGDP	GDP per capita	CCSY
Investment	FIX	ratio of fixed asset investment in GDP	CCSY
Industrialization	IND	ratio of secondary sector in GDP	CCSY
Transportation	TRS	ratio of passenger to and population	CCSY
Human capital	EDU	ratio of middle and high school students to total population	CCSY

Note: CSY: China Statistical Yearbook; SYCIFA: Statistical Yearbook of the Chinese Investment in Fixed Assets; CCSY: China City Statistical Yearbook; CSYRE: China Statistical Yearbook for Regional Economy.

3.4 Decomposition analysis of multi-scalar regional inequality

The multi-scalar Theil indices from 1997 to 2016 provide several implications about the evolution of regional inequality in China (Figure 3.2). First, regional inequality in China is sensitive to scale, manifested by the increasing levels of inequality, measured by the values of Theil index, when moving from the coarse scales to the finer scales. The average Theil index is 0.07, 0.1, 0.19, and 0.25 at the regional, provincial, prefectural, and county level, respectively. Second, an overall inverted-U pattern is observed across the four scales in China, showing that regional inequality firstly increased from the late-1990s to the mid-2000s and then declined continuously until the mid-2010s. The temporal trend provides updated empirical evidence and corroborates previous findings which suggest a turning point of regional inequality in China around 2005 (He, Bayrak, et al., 2017; Kanbur et al., 2017; Li and Fang, 2014).

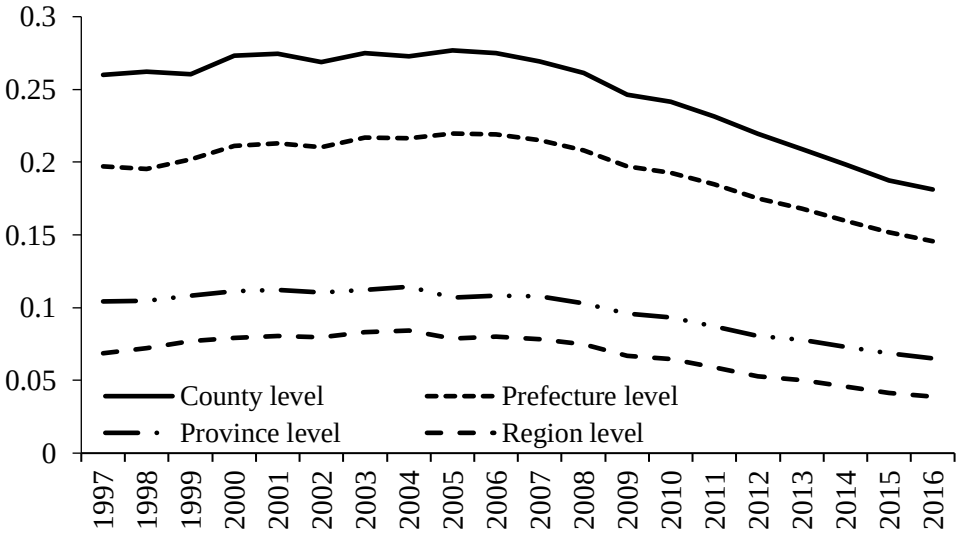

Figure 3.2 Values of the Theil index at multiple scales from 1997 to 2016

The reasons for declining regional inequality since 2005 are complex, which could be associated with the outcomes of economic restructuring, global market, and government policy. Since the 2000s, besides regional development policies such as the Western Development Plan, the Revitalization Program of Northeast China's Old Industrial Base, and the Rise of Central China Program (Fan and Sun, 2008), the central government has also launched several development policies, like the Enhancing County-Level Economy Plan and the Belt and Road Initiatives, to support economic growth in the disadvantaged interior, especially the county economies in rural China (Chen and Groenewold, 2010; Groenewold et al., 2010; Hong, 2018). Moreover, rising production costs in the coastal region and improving consumption levels in the interior have also resulted in new investment in the interior, including some industries relocated from the coastal region.

A further investigation through the nested Theil decomposition method reveals more nuanced patterns of regional inequality by comparing the contributions of different sources, including the between-prefecture, within-prefecture, between-region and between-province components (Figure 3.3). First, the inequality among prefectures, i.e., the between-prefecture component, contributes the most in overall inter-county inequality, followed by between-region inequality, within-prefecture inequality, and the inequality among provinces within each region. It should be noted that if between-region and between-province level inequality are accounted for, the inequality at the prefectural and county levels contributes more than half of the overall inequality across counties. Meanwhile, between-province inequality occupies the smallest share among the four components. The comparison was made possible by using the 3-stage decomposition technique, which confirms the importance of analyzing

regional inequality below provinces (Dai et al., 2017; Liao and Wei, 2012; Wei and Fang, 2006; Wei and Ye, 2009; Wei et al., 2011; Ye et al., 2017).

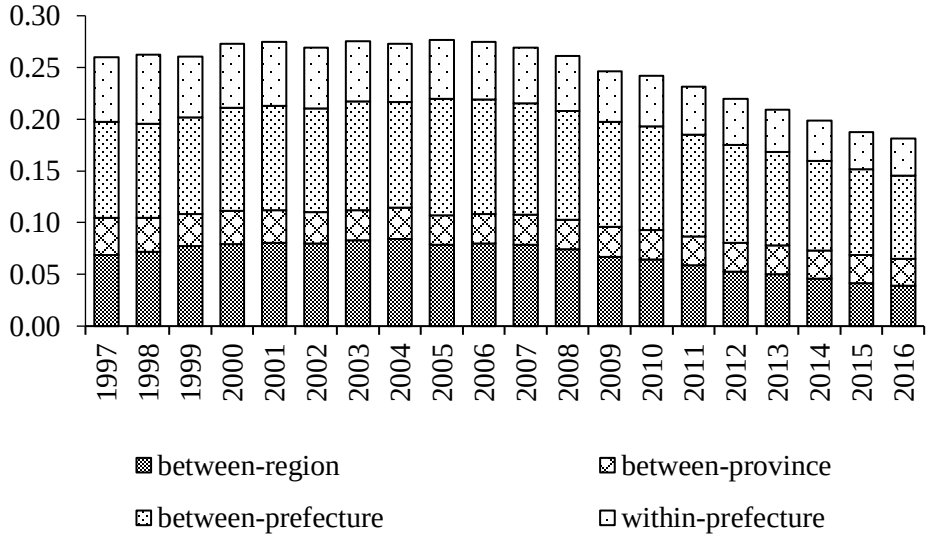

Figure 3.3 Three-stage nested decomposition of Theil index

Second, the change of the between-region component is identical to the regional-level inequality (see Figure 3.2). The inequality among the four regions first increased from 1997 to 2005 and then declined, confirming previous studies about the inward and northern-ward shift of economic gravity (He, Bayrak, et al., 2017; Ng and Tuan, 2006). Regional development in the last decade has witnessed an inward and northward shift due to rising labor costs in the coastal and southern regions and relatively low capital price in inland and northern China (Wu et al., 2018; Ye, 2012). The spatial agglomeration of economic development in northern China has been strengthened because of the rise of Beijing and the Bohai Rim region in recent years and other major economic centers in the northern part of China (He, Fang, et al., 2017). While the high-tech and capital-intensive industries remain in the coastal region, some labor-intensive and resource-based sectors have moved toward the

Chinese periphery (Wu et al., 2018). The global financial crisis of 2008 has dampened export-oriented industry, triggering slower economic growth in the coastal cities and strengthening the tendencies of convergence across regions.

Third, the decline of overall inequality after 2005 is mainly attributed to the change in the between-region and within-prefecture components, as compared to the contributions derived from the between-province and between-prefecture components. The between-region component has declined from 0.069 to 0.039 during the period and the within-prefecture one has decreased from 0.063 to 0.036, while the between-province one only decreased from 0.036 to 0.026 and the between-prefecture one dropped from 0.093 to 0.081 during the study period of 1997-2016. It implies that the economic restructuring and urbanization at the national level has narrowed the gap among regions and among urban-rural counties within prefectures in recent years. However, the divide between provinces in each region and the gap between prefectures within each province persists or remains salient. Furthermore, the convergence trend is observed for all the four scales, but between-prefecture inequality, which is the largest source of regional inequality in China across counties, has only declined by 13%, as compared to between-region inequality by 44%, between-province inequality by 26%, and within-prefecture inequality by 43%.

As the largest component of overall inequality, between-prefecture inequality is further decomposed into the contribution of each province based on the average value of the between-prefecture components from 1997 to 2016, which considers both their weight in

China's economy and the gap among prefectures within each province (Figure 3.4 and Figure 3.5).[5]

Three coastal provinces, i.e. Guangdong, Jiangsu, and Shandong, are the three most important contributing provinces to between-prefecture inequality when their economic sizes are considered. The three provinces are not only important sources of uneven development in China, but they are also characterized by internal unevenness of regional development (e.g., Guangdong). Furthermore, the prefectural-level inequality within several interior provinces, e.g. Xinjiang, Gansu, Heilongjiang, and Yunnan, is also large (Figure 3.4), which is greatly attributed to the geographical conditions and structural constraints of regional development within these inland provinces (Wei and Fang, 2006).

[5] Four directly administrated municipalities, namely Beijing, Tianjin, Shanghai, and Chongqing, are not included because as a special provincial unit, they are also considered to be consisted of only one prefecture in analysis. For their role in regional inequality in China, see (Li and Wei, 2010).

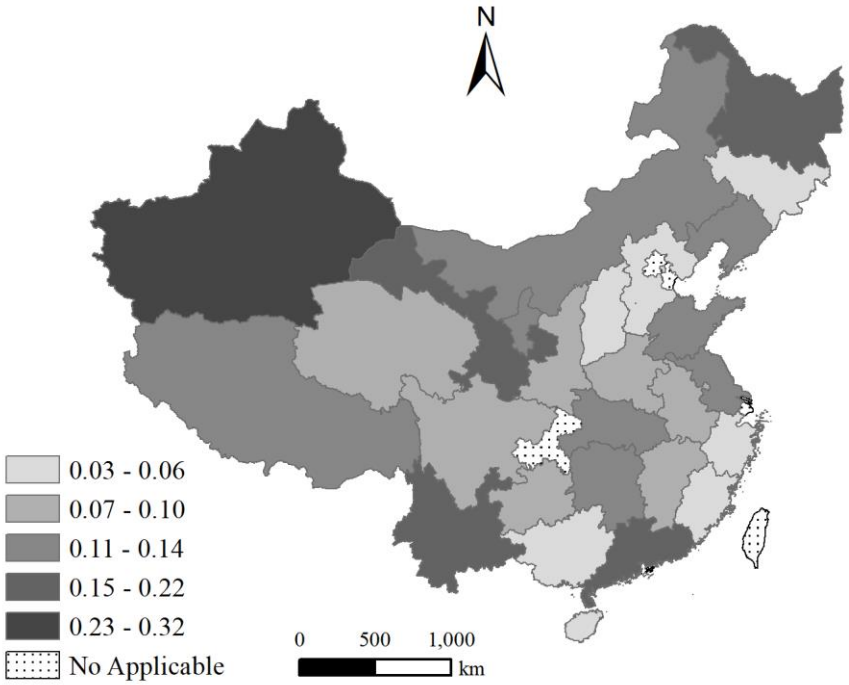

Figure 3.4 Spatial distribution of between-prefecture Theil values (average of the period of 1997 to 2016)

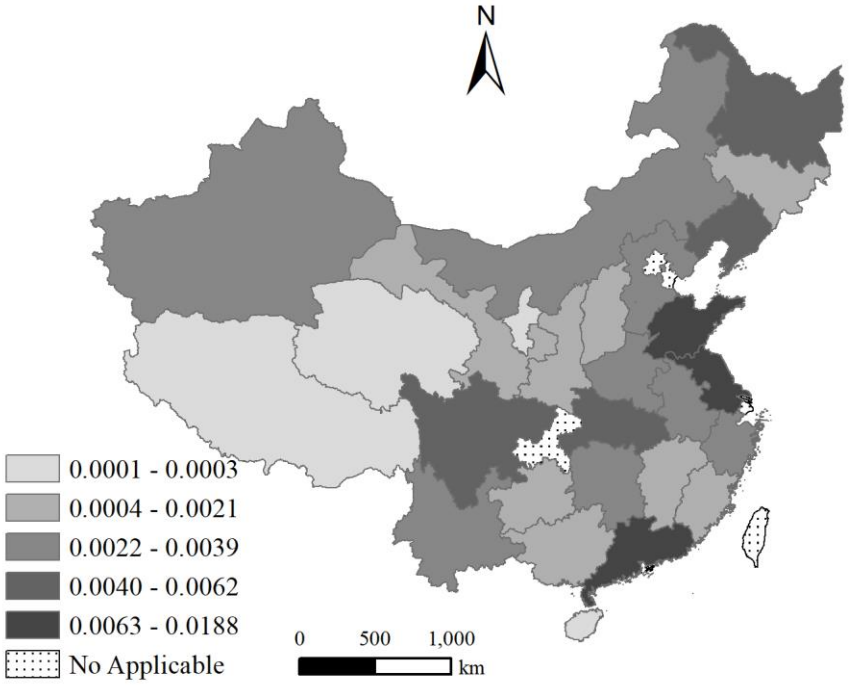

Figure 3.5 Spatial distribution of between-prefecture Theil values weighted by GDP (average of the period of 1997-2016)

As shown in Figure 3.6, the nested spatial decomposition method is applied to each region to quantify the relationship between inequality across scales in different geographical contexts. Specifically, the contribution is decomposed into the inequality among provinces in each region, the inequality among prefectures in each province within specific regions, and the gap among counties in each prefecture (Figure 3.6). Several interesting patterns are found regarding multi-scalar characteristics.

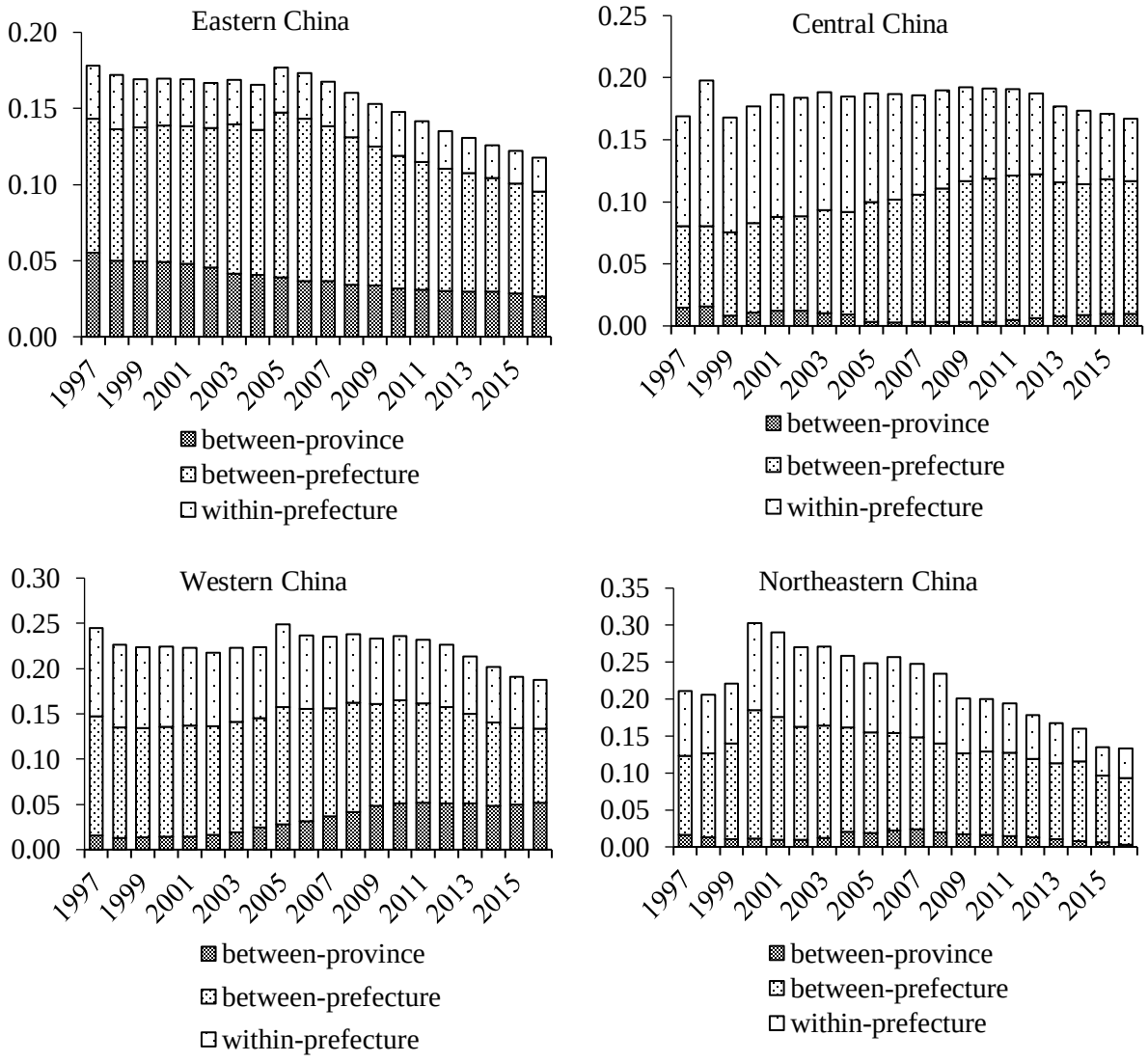

Figure 3.6 Three-stage nested decomposition of the Theil index in each region

First, like multi-scalar inequality in China, inequality in the four regions is also sensitive to scale, manifested by increasing inequality as the focusing scale changes from the provincial level to the prefectural and county levels, regardless of regions. However, different temporal patterns are observed in four regions, which may be masked by the analysis of China as a whole. For example, even though regional inequality in China exhibits an inverted-U pattern across different scales, there are differentiated trends or magnitudes of changes in the four regions.

Regional inequality in the eastern region has decreased regardless of spatial scales. In other words, convergence in the eastern region is not only the result of a narrowing gap among the coastal provinces, but also can be attributed to narrowing gaps among the prefectures and counties in the region (Zhang et al., 2019). However, similar to other regions, the between-prefectural scale in the eastern region remains the largest source of regional inequality and its decline is less evident as compared to the between-province and the within-prefecture components. Researchers have found several core-periphery structures in the coastal provinces, like the coastal-inland divide in Zhejiang (Wei and Ye, 2009; Yue et al., 2014), the Sunan-Suzhong-Subei gradient in Jiangsu (Liu et al., 2018; Wei et al., 2011), and the gap between the Pearl River Delta and peripheral Guangdong (Liao and Wei, 2012; Zhang et al., 2018). The concentration of resources, i.e. labor, fixed investment, foreign capital, and technology and information, in the core prefectures, has been reinforced and generated a counter effect on the overall trend of convergence in the eastern region (Liao and Wei, 2015).

For the central region, the changes in regional inequality across counties have remained stable from 1997 to 2016. There has been a U-shaped pattern when focusing on provincial level inequality, while its contribution is very small. However, the most important source of regional inequality, i.e., the between-prefecture component, has exhibited a diverging trend. This finding indicates that the divide between the prefectures in central China has been widening from 1997 to 2016, while there have been narrowing gaps among counties within each prefecture. Hence, the overall inter-county inequality has remained stable. Recent studies of regional development and inequality in the central region indicates that provincial-level regional development strategy tends to favor the provincial capital and gradually cultivate the growth pole around the capital city (Ke and Feser, 2010). Meanwhile, the rapid urbanization in China and in the region has played an important role in narrowing the vast gap between the urban and rural counties, leading to the decline of within-prefecture inequality.

As shown in Figure 3.6, the between-province component has made a larger contribution to the overall county level inequality in the western region, as compared to the other three regions. There has been declining inequality across counties and prefectures, when between-province component is controlled for. In contrast, between-province inequality has increased by almost 200%. As discussed in He et al. (2017), the Western Development Program since 2000 aims to enhance infrastructure construction and industrial modernization in the western provinces. But the development strategy is geographically uneven, favoring those provincial economies with rich resources. Provinces like Inner Mongolia have achieved rapid economic growth during the period, but provinces with geographic constraints, poor natural resources,

and low-skilled human capital have been lagging behind. Hence, the decline of overall county-level inequality in the western China is greatly attributable to a narrowing gap among prefectures and counties within each province rather than the gaps among provinces.

Unlike in the western and eastern regions, the between-province component in the northeastern region has made less of a contribution to overall county-level inequality. The inter-county inequality is mainly determined by the within-province inequality, namely the between-prefecture and within-prefecture components, which both have increased rapidly from 1997 to 2001 and gradually decreased from 2002 to 2016. These results suggest that despite the implementation of the Revitalization of the Northeastern Old Industrial Bases Program, industrial restructuring in the northeastern region has suffered from the decline of the original leading industrial cities in the Chinese rust belt, which are burdened with the inefficient SOEs (Huang et al., 2018), resulting in convergence among counties and prefectures in the region.

3.5 Distributional dynamics of regional inequality at multiple scales

The analyses so far have revealed a temporal pattern of regional inequality by the administrative hierarchy and a multi-scalar perspective. In order to investigate the long-run properties of regional income distribution, the Markov chain method is used in this section. As in Chapter Two, four classes, namely poor (P), less-developed (L), developed (D), and rich (R), are adopted to represent different development levels. The results of the Markov method contain a gridline of development level, transition probabilities among classes and

long-run ergodic distribution, which provides a holistic picture of the development processes at three scales (Table 3.2).

Table 3.2 Markov chain transition probability at three scales from 1997 to 2016

Scale	Grid line [upper bound]			
Province	P [0.612]	L [0.727]	D [1.337]	R [3.495]
P (150)	0.940	0.060	0.000	0.000
L (149)	0.040	0.899	0.060	0.000
D (142)	0.000	0.021	0.944	0.035
R (148)	0.000	0.000	0.027	0.973
Ergodic	0.081	0.121	0.346	0.451
Prefecture	P [0.541]	L [0.811]	D [1.198]	R [8.099]
P (1634)	0.947	0.050	0.002	0.001
L (1619)	0.043	0.904	0.053	0.001
D (1615)	0.003	0.048	0.901	0.048
R (1611)	0.001	0.000	0.047	0.953
Ergodic	0.217	0.242	0.263	0.278
County	P [0.492]	L [0.766]	D [1.246]	R [15.69]
P (10439)	0.923	0.072	0.004	0.001
L (10310)	0.068	0.856	0.075	0.001
D (10304)	0.003	0.074	0.869	0.054
R (10348)	0.002	0.003	0.049	0.946
Ergodic	0.237	0.252	0.25	0.26

The gridline, which is used to divide the ratio of the income level to the national average of each county into four development levels, indicates the gap across the spatial units and how it changes with scales. At the provincial level, the variance of GDP per capita is relatively small, with the highest one 3.5 times the national average and the lowest one less than 0.6. As it moves to finer scales of the prefectural and county ones, the disparity becomes evident and the richest county could be 15 times more than the national average and the poorest one

be less than half. Since the quantile division is used in the Markov method, the number of spatial units within each development level, listed after the abbreviation, is similar.

The transition matrix implies the probability of certain spatial units to stay in the current class or move towards other classes in the diagonal and non-diagonal values, respectively. Together with the long-run ergodic distribution, it indicates how regional inequality evolves and the convergence/divergence trend if the current development process sustains. The sensitivity to scale is also observed in the long-run income distribution (see Table 3.2). While the ergodic distribution at the provincial level implies a strong convergence trend within the developed and rich classes, the prefectural and county level indicates a more even distribution in the long term. This observation also coincides with previous studies suggesting that convergence among provinces may mask the consistent or widening disparity within provinces and among prefectures and counties (Zhang et al., 2019).

A closer look at the matrix reveals that the probability of a spatial unit, either a provincial, prefectural, or county one, staying in its current class is relatively high in general. The highest diagonal value is 97.3% for rich provinces, and the lowest one is 85.6% for less-developed counties, indicating the probability of remaining in the same class during the transition. At the provincial level, no leap-frog, e.g., from poor to developed or from developed to poor, is found. The probability of upward movement is more possible than the downward one since the upward probabilities are slightly larger than their counterparts for all transitions, which could be attributed to the recent convergence trend at the provincial level. For the prefectural and county levels, the upward probabilities are only slightly higher than

their counterparts, implying a stable economic structure and persistent inequality in the long run (He, Bayrak, et al., 2017).

Table 3.3 further depicts the distributional dynamics in different regions. It shows that upward mobility at the county level is highest in the eastern region, followed by the northeastern region. This is consistent with the previous discussion on the convergence of county-level economies within the eastern region. In contrast, upward mobility is much lower for counties in the western region, even showing some inclination toward downward movement. The result implies the declining regional inequality at the national level might be attributed to convergence among counties in the coastal region, characterized by a trend of club convergence. Localities in inland provinces still face challenges of catching up, and spatial inequality or the formation of poverty traps therein should warrant more attention.

Table 3.3 Markov chain transition probabilities in different regions from 1997 to 2016

Scale	P (-INF., 0.492]	L (0.492, 0.766]	D (0.766, 1.246]	R (1.246, 15.69]
Eastern region				
P (381)	0.850	0.142	0.008	0.000
L (1465)	0.051	0.872	0.076	0.001
D (3046)	0.001	0.048	0.902	0.050
R (4874)	0.000	0.000	0.034	0.965
Ergodic	0.067	0.188	0.304	0.441
Central region				
P (2455)	0.918	0.079	0.002	0.000
L (3619)	0.066	0.873	0.061	0.001
D (2823)	0.001	0.092	0.866	0.041
R (1895)	0.001	0.003	0.068	0.929
Ergodic	0.283	0.347	0.232	0.138
Western region				
P (7301)	0.934	0.062	0.003	0.001
L (4610)	0.074	0.850	0.075	0.000
D (3266)	0.004	0.080	0.858	0.059
R (2303)	0.004	0.004	0.056	0.936
Ergodic	0.310	0.254	0.224	0.212
Northeastern region				
P (302)	0.778	0.169	0.04	0.013
L (616)	0.071	0.766	0.156	0.006
D (1169)	0.010	0.081	0.825	0.083
R (1276)	0.006	0.010	0.067	0.916
Ergodic	0.091	0.200	0.341	0.368

3.6 Modeling of Intra-provincial and Intra-prefecture level inequality

The multi-scalar regional inequality analyzed above reveals that inequality below the provincial level contributes the most to overall inequality. In order to investigate the underlying mechanisms, multilevel modeling is used in this section to quantify the effects of economic transition on spatial inequality within the provinces and prefectures of China. The results of single-level, two-level, and three-level models regarding inequality among prefectures and counties in each province from 1997 to 2016 are reported in Table 3.4. The

VIF value of nine independent variables is below 5, indicating that the model is free of a multicollinearity problem. Multilevel models improve single-level models by an increased R^2 value, which implies that like the multi-scalar inequality, the mechanisms of regional inequality in China is also sensitive to spatial hierarchy.

These results have several implications for the relationship between the intra-provincial inequality at different levels and transitions in China. First, the impacts of globalization, proxied by export ratio to GDP, are significant and positively related to the intra-provincial inequality at both prefectural and county levels. While globalization promotes regional development of provinces and prefectures in China (Huang and Wei, 2019; Li and Wei, 2010), the spatial distribution of factors like FDI and export-oriented industries is uneven and concentrated, which further causes rising regional disparities (Ge, 2009; Huang and Wei, 2016). Provinces in which exporting occupies considerable share in local economies, e.g. Guangdong, Jiangsu, and Zhejiang, are also featured as evident regional gaps within provinces (Liao and Wei, 2012; Wei and Ye, 2009; Wei et al., 2011).

Table 3.4 Determinants of intra-provincial inequality

Variable	VIF	Single-level		Two-level		Three-level	
		Coefficient	p-value	Coefficient	p-value	Coefficient	p-value
between-prefecture inequality							
EXP	2.67	0.17	0	0.167	0	0.167	0
LEXP	3.31	-0.012	0.66	0.001	0.96	0	0.99
SOE	4.19	0.129	0	0.059	0.08	0.064	0.05
URB	4.9	-0.003	0.95	-0.048	0.36	-0.044	0.4
PGDP	4.28	-0.054	0	0.006	0.76	0.001	0.96
FIX	4.2	0.004	0.87	-0.025	0.29	-0.023	0.32
IND	1.6	0.207	0	0.13	0	0.136	0
TRS	2.86	-0.057	0	-0.031	0.01	-0.032	0.01
EDU	4.61	2.916	0	2.2	0.01	2.258	0.01
Intercept	NA	-0.009	0.77	-0.018	0.56	0.022	0.53
Central	NA	NA	NA	0.045	0	NA	NA
Western	NA	NA	NA	0.08	0	NA	NA
Northeastern	NA	NA	NA	0.047	0	NA	NA
Adjusted R^2		0.18		0.24		0.32	
Observations		540		540		540	
between-county inequality							
EXP	2.67	0.13	0	0.162	0	0.158	0
LEXP	3.31	0.009	0.79	0.011	0.73	0.011	0.73
SOE	4.19	0.235	0	0.158	0	0.165	0
URB	4.9	-0.03	0.61	-0.134	0.03	-0.125	0.05
PGDP	4.28	-0.1	0	-0.038	0.09	-0.044	0.05
FIX	4.2	-0.043	0.11	-0.048	0.09	-0.048	0.09
IND	1.6	0.401	0	0.311	0	0.319	0
TRS	2.86	-0.061	0	-0.032	0.03	-0.034	0.02
EDU	4.61	4.292	0	3.239	0	3.331	0
Intercept	NA	-0.001	0.98	0.003	0.93	0.052	0.22
Central	NA	NA	NA	0.054	0	NA	NA
Western	NA	NA	NA	0.082	0	NA	NA
Northeastern	NA	NA	NA	0.079	0	NA	NA
R^2		0.33		0.37		0.34	
Observations		540		540		540	

Second, since a higher share of SOEs in fixed asset investment in provinces is associated with a widening gap among prefectures and counties, it implies that the marketization process aiming to promote non-SOE sectors has positive effects in reducing regional

inequality. As discussed in He et al. (2017), the marketization reforms provide an even and transparent playground for firms with different ownerships and thus improve the productivity of both SOEs and non-SOEs via a competitive market economy. At the same time, the marketization process also gradually lifts the barriers to labor and capital mobility and local protections for industries, which further alleviates regional inequality by efficiently redistributing resources between rich and poor regions.

Third, the decentralization process, proxied by the ratio of local expenditure to GDP, is not significant in impacting intra-provincial inequality, which is not consistent with the studies by Huang and Wei (2019) on economic development at the prefectural scale and Gao et al. (2019) on rural inequality. For the urbanization process, it is significantly related to between-county inequality when the spatial hierarchy is accounted for, providing more evidence that multilevel models improve our understanding of the underlying mechanisms. Demographic urbanization, especially migration from the periphery to core regions in provinces, is found to have an alleviating effect on income and regional inequality, which is in line with previous studies (Chen et al., 2016; Zhang et al., 2018).

Two findings are noteworthy for the control variables. First, the development level has an impact on the intra-provincial inequality. GDP per capita is negatively related to between-county inequality and the interior regions are characterized by more evident spatial inequality of economic development as indicated by the region factors in Table 3.4, both implying that regional development within poor provinces tends to be geographically more uneven when other conditions are the same. It is also in line with previous analysis that the between-

prefecture and within-prefecture inequality is more evident in the interior regions than the coastal region (see Figure 3.6). Second, like the urbanization process, the investment factor, measured by the ratio of fixed asset investment to GDP, is negatively related to between-county inequality when multilevel models are adopted. It confirms that as a key instrument used by the central and provincial government to promote regional development and cultivate new growth poles, fixed asset investment is also effective in mitigating regional disparities (Chen and Groenewold, 2013a; Yu and Wei, 2008).

A further investigation of intra-prefectural inequality from 2000 to 2010 reveals several interesting findings about the underlying forces (Table 3.5). The effects of some mechanisms on intra-prefectural inequality are consistent with intra-provincial inequality. The marketization process is proofed to be negatively related to intra-prefectural inequality. Urbanization is also found to have negative impacts on intra-prefectural inequality. Industrialization is significantly associated with widening economic disparities within prefectures, which is in line with previous studies (Cheong and Wu, 2014; Li and Haynes, 2011). The transportation factor is also negatively related to intra-prefectural inequality, implying that improvement in infrastructure helps to achieve a more balanced regional development (Chen and Haynes, 2017; Jiang and Kim, 2016).

Table 3.5 Determinants of intra-prefectural inequality

Variable	VIF	Single-level		Two-level		Three-level	
		Coefficient	p-value	Coefficient	p-value	Coefficient	p-value
FDI	1.26	-0.481	0.01	-0.303	0.08	-0.381	0.04
LEXP	2.96	0.165	0.08	0.074	0.43	0.056	0.53
SOE	1.94	0.077	0	0.068	0.01	0.05	0.07
URB	1.27	-0.073	0	-0.099	0	-0.122	0
PGDP	2.08	0.006	0.46	0.016	0.05	0.014	0.08
FIX	3.21	-0.026	0.33	-0.033	0.21	-0.013	0.61
IND	1.68	0.193	0	0.178	0	0.216	0
TRS	1.31	-0.001	0.03	-0.001	0.07	0	0.48
EDU	1.24	-0.29	0.27	-0.08	0.76	-0.21	0.43
Year_2010	4.23	-0.013	0.33	-0.003	0.83	-0.016	0.23
Adjusted R^2		0.11		0.21		0.34	
Observations		484		484		484	

Moreover, the driving forces are found to be sensitive to scale as well, after comparing this to the regression results focusing on the drivers of intra-provincial inequality. While the globalization process has positive impacts on intra-provincial inequality, the effects are negative when it moves to the intra-prefectural level. It could be explained that the intra-prefectural inequality is mainly about the gap between city-district and surrounding county units, namely the urban-rural inequality. Previous study has found evidence that globalization, represented by the multinational enterprises, reduces the urban-rural income gap (Greaney and Li, 2017). It is also argued that foreign investment is more embedded not only in urban areas but also in rural China, resulting in a narrowing urban-rural disparity (Gao et al., 2019). The development indicator implies that prefectures with higher level of economic development tend to have larger intra-prefectural gaps, which is in contrast with previous analysis that richer provinces have lower intra-provincial inequality. It could be explained that increased GDP per capita would strengthen geographical concentration of resources in the core areas like the city district and upgrading the non-agricultural sector,

while this may leave the agricultural sector in rural counties behind (Li, 2012; Li et al., 2013).

3.7 Conclusions

This chapter investigates the multi-scalar and multi-mechanisms of regional inequality in China by county-level data from 1997 to 2016. The nested decomposition of regional inequality into the regional, provincial, prefectural, and county level confirms its sensitivity to scales and quantifies the contribution of each scale to the overall inequality. Further decomposition of inequality within each region finds the regional heterogeneity regarding temporal trends of regional inequality at scales. The Markov chain analysis results reveal that long-term pattern of regional inequality is different both by scales and by regional context. The regression modeling of sub-provincial level inequality suggests that the triple processes of globalization, marketization, and decentralization, as well as urbanization, in China play different roles in determining intra-provincial and intra-prefectural inequality.

County-level inequality is built at the current most disaggregated level administrative unit in China and contains four components after the spatial nested decomposition, namely between-prefecture, between-region, between-province and within-prefecture inequality. The between-prefecture inequality, which measures the disparity among prefectures within each province, contributes most to the overall county-level inequality, followed by the between-region, intra-prefecture and between-province inequality. Notably, inequality at the prefectural scale, after separating the embedded effects from the regional and provincial scales, is the sole largest contributing factor to the evolution of regional inequality in China,

which involves gaps between the urban and rural counties within specific prefectures and between the rich and poor prefectures within certain provinces. When considering the gap among prefectures within each province, the interior provinces are in general higher than the coastal provinces.

The heterogeneous spatial development processes are identified. The overall convergence trend across scales in China may mask the detailed geographies of inequality in regions, especially when focusing on the contributions of different components. For instance, counties in the eastern region have experienced convergence whereas downward mobilities of counties in the western and central regions are relatively higher, contributing to the persistent coastal-inland inequality in China. Furthermore, the between-prefecture component has been the major contributor to county-level inequality in the eastern region, but their contributions are smaller in the western region, in which the between-province component should warrant more attention, if compared to the other three regions.

Among the underlying forces, the marketization process, proxied by the share of SOEs in fixed asset investment, is found to have negative impacts on sub-provincial regional inequality in China. The urbanization process is also negatively related to the intra-provincial and intra-prefectural inequality. However, the globalization and development level show different impacts at the provincial and prefectural levels. The economic reliance on the global market exacerbates regional divides within provinces but alleviate the urban-rural gaps. The result of intra-provincial inequality implies that wealthier provinces tend to have narrower economic development gaps among prefectures and counties, while the results of intra-

prefectural inequality suggest that with economic development, concentration of resources and industrial upgrading might have caused intensified inequality between urban districts and rural counties.

The findings by this chapter further help to guide and provide suggestions for policymakers to reduce poverty by considering scales and hierarchy in regional inequality. While the coastal-interior gap has drawn the most attention before, the disparities within prefectures and among prefectures in provinces also need be considered in government policy when it is scaled down to the county-level. The uncoordinated distributional dynamics among the coastal and interior regions suggests that more efforts and resources should be devoted to the disadvantageous provinces and regions. To achieve the alleviation of sub-provincial inequality, several practical tools or instruments are identified by the regression on intra-provincial and intra-prefectural inequality, such as deepening reforms in marketization, promoting population urbanization, and more opening-up policies by the central and local governments.

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Chapter 4 Regional Inequality and Spatiotemporal Dynamics in Provincial China: A Case Study of Zhejiang Province

Abstract

This chapter investigates the spatial-temporal dynamics and bottom-up process of regional inequality in provincial China through a case study of Zhejiang province from 1978 to 2016 with a multi-scale and multi-mechanism framework. The study has identified an evolving core-periphery structure of economic development at the regional scale in Zhejiang, and a transition from a north-south divide to a coastal(north)-inland(south) structure. Moreover, despite some signals indicating convergence among counties in the province, the results of spatial Markov chains and exploratory data analysis (ESDA) confirmed the effects of self-reinforcing agglomeration and suggest newly emerged clusters or the existence of "poverty traps" in Zhejiang. Results of geographically weighted regression (GWR) further suggest investment and industrial agglomeration are the most important underlying forces of uneven regional development. Drawing upon a more bottom-up approach, the chapter further updates our understanding of the Wenzhou model, known for development based on private enterprise and rural industrialization, and discusses its effects on regional inequality in relation to globalization, localities, and the state.

4.1 Introduction

The uneven recovery from the recent global financial crisis, as well as the "New Normal" of China's economy, namely the slowdown of the economic engine and economic restructuring and rebalancing, has renewed the debate on regional development and inequality (Chen and Groenewold, 2018; Stiglitz, 2012). The political and economic turmoil in the aftermath of 2008/2009 calls for rethinking and prioritizing local and regional development under the context of how globalization spatially unfolds and impacts in various ways (Pike et al., 2016). The role of local institutions and place-based policies are hotly debated by scholars in understanding different development trajectories and divergence among regions (Iammarino et al., 2019; Rodríguez-Pose, 2013). Researches on regional inequality in Asian economies have drawn considerable attention given the developmental governments and complex political-economic processes interlinked globally and locally in the continent (Kanbur et al., 2005; Wei, 2017).

With the transitions to a market economy, China has achieved unprecedented economic growth for three decades after the opening-up and reform in 1978. Meanwhile, rapidly rising inequality during this period has drawn considerable scholarly and government attention due to the negative impact on social and political stability (Fan and Sun, 2008; Knight, 2013). It is argued that regional development in China could be interpreted by transitional mechanisms involving globalization, state, and localities (Li and Fang, 2014; Wei, 2007). Studies on inequality in provincial China is a research frontier given China's vast size and complex landscape of regional development. Aided by the development of GIS and spatial analysis methods, rich empirics on economic powerhouses in China, like Zhejiang, Jiangsu, and

Guangdong provinces, have highlighted the role of local developmental models in regional inequality and their impacts on the spatial pattern of regional development (Liao and Wei, 2012; Wei and Ye, 2009; Wei et al., 2011). However, the studies are mostly dated to the pre-crisis era before the 2010s, thus do not reflect the transformations and policy shifts of recent years (Kanbur et al., 2017). More importantly, the changing role of locality and local developmental models in the post-crisis era deserve detailed and updated investigation (Shen and Tsai, 2016).

This chapter investigates regional inequality in provincial China through a case study of Zhejiang province, a coastal province that has been spearheading the reform and known for the Wenzhou model of development based on private enterprise, drawing upon a multi-scale and multi-mechanism framework (Wei, 2000). It contributes to the regional inequality literature on provincial China in a threefold way. Firstly, by investigating the multi-scale pattern from 1978 to 2015, it reveals how inequality evolves with changing domestic and global contexts by comparing the pre-crisis and post-crisis eras. Secondly, by utilizing spatiotemporal data analysis methods, it uncovers the spatial redistribution processes in regional development and deepens our understanding of the locality and the role of the local development model in shaping regional dynamics. Lastly, it takes into account spatial heterogeneous processes in regional development and deepens our understanding of the mechanisms in the triple transitions of globalization, marketization, and decentralization.

The rest of this chapter is organized as follows. The second section presents a brief review of the literature on regional inequality in provincial China. The third section introduces the

background of regional development in Zhejiang province and the research setting. The fourth section analyzes the multiscalar regional inequality pattern in Zhejiang. The fifth section presents the comprehensive regional dynamics by several exploratory spatiotemporal data analysis methods. The sixth section adopts geographically weighted regression and reveals the spatially heterogeneous processes underlying the uneven regional development. The seventh section focuses on the local development model and compares the bottom-up forces in Wenzhou and other regions in Zhejiang. The last section discusses and concludes with major findings.

4.2 Literature review

The early debate between the convergence and divergence schools is centered on whether the equilibrium or disequilibrium process determines the long-run trend of regional inequality (Lipshitz, 1992). Since the late 1980s, the negative impacts of globalization and transitions in the former socialist countries has renewed the debate. Theories like the new convergence and new economic geography are proposed to explain differentiated economic growth among regions and stimulate intensive empirical validations (Barro, 2015; Barro and Sala-i-Martin, 1995; Barro et al., 1991; Gumpert, 2019; Krugman, 1991, 2011). Meantime, the role of locality, or local contexts and institutions, in regional development is highlighted in the research agendas of the evolutionary and institutional school (McCann, 2014). However, these theories are also criticized for being insensitive to scale, neglecting the importance of space and time, and more importantly, do not fully reflect the underlying processes and bottom-up forces within transitional economies (Petrakos et al., 2005; Wei, 2015; Wei and Ye, 2009).

Ever-increasing income inequality since China's economic reform in 1978 has reached a new high level and drawn considerable scholarly attention (Xie and Zhou, 2014). Scholars agree on the fact that the coastal-interior gap has been widening since the reform but debate intensely over the recent trend of regional inequality during the 2000s and 2010s (Wei, 2017). While some studies show that inequality in China exhibits an upward trend since the mid-2000s (Piketty et al., 2017; Xie and Zhou, 2014), several other empirics indicate that interprovincial inequality has plateaued or decreased during the period (He, Zhou, et al., 2017; Kanbur et al., 2017; Poon and Shang, 2012). Scholars argue that the declining regional inequality is attributed to spatial and industrial restructuring, as well as shifts of policy and political focus, under China's economic slowdown and global recession since 2008-2009 (Chen and Groenewold, 2018; He, Bayrak, et al., 2017). Given that the recent trend of interregional and interprovincial inequality is hotly discussed, a following investigation of intra-provincial inequality is also needed, which could contribute to the inquiry by providing complementary empirics at a finer scale and understanding the forces operating at the local level.

Studies on regional inequality in provincial China have boomed in recent years and become a research frontier, revealing the diversity, dynamics, and transitions in local development (Wei, 2017). Scholars have been mostly interested in the economic powerhouses of coastal China, such as Zhejiang (Wei and Ye, 2009; Yue et al., 2014), Guangdong (Liao and Wei, 2012; Zhang et al., 2018), Jiangsu (Liu et al., 2018; Wei et al., 2011), and Beijing (Chu et al., 2018; Yu, 2006). However, the focus has gradually shifted to interior China and the regional dynamics in underdeveloped provinces like Gansu (Wei and Fang, 2006), Guizhou (Sun et

al., 2016), Chongqing (Ye et al., 2017), and Guangxi (Dai et al., 2017). With respect to the temporal change of intra-provincial regional inequality, both divergence and convergence trends are observed, regardless of the coastal or interior region, which reflects the complexity of patterns and underlying mechanisms of regional development in China (Dai et al., 2017; Liao and Wei, 2015; Sun et al., 2016; Yu and Wei, 2008).

The inquiry of spatiality in regional inequality by scholars, mainly geographers, acquires fruitful empirics regarding scales, agglomerations, and spatial effects in provincial China. In line with findings about regional inequality in China (He, Bayrak, et al., 2017; Li and Wei, 2010), regional inequality in provincial China is also found to be sensitive to geographic scale. The magnitude of inequality increases at the scalar level, moving from regions to prefectures and counties within provinces (Dai et al., 2017; Yue et al., 2014). The contribution of each scale depends on the case province and a convergence trend may be observed at one scale and divergence at another one (Sun et al., 2016; Wei et al., 2011).

Despite the various trend of regional inequality, the spatial concentration of wealth and the core-periphery structure is intensifying in provincial China. For developed coastal provinces, the region with locational advantages and favored by global investors has developed rapidly and left the periphery behind, e.g. the southern part of Jiangsu province and the northern part of Zhejiang province close to Shanghai, the Pearl River Delta in Guangdong near Hong Kong and Macau, and coastal Fujian near Taiwan (Liao and Wei, 2015; Lyons, 1998; Wei et al., 2011; Yue et al., 2014). For the interior provinces and Beijing, political forces play a more important role and the core-periphery structure is centered on the provincial or national

capital, such as Guiyang in Guizhou province, Lanzhou in Gansu province, and Beijing in the Beijing-Tianjin-Hebei area (Li, 2012; Sun et al., 2016; Wei and Fang, 2006).

The bottom-up forces from local government and agents operates in parallel with global investors and the central government in creating uneven regional development. Three local development models, namely the Sunan model in Jiangsu province, the Pearl River Delta (PRD) model in Guangdong province, and the Wenzhou model in Zhejiang province, are highlighted in previous studies and show distinguishing institutional embeddedness (Wei, 2007). Benefiting from the development of township and village enterprises (TVEs) and transitions towards hybrid economies, the inequality between Sunan (southern Jiangsu), Suzhong (central Jiangsu), and Subei (northern Jiangsu) has continuously increased (Wei et al., 2011; Yuan et al., 2014). Driven by external capital and investment from Hong Kong, the PRD region has moved "one step ahead" in reform and economic growth, leading to a widening gap with peripheral Guangdong (Gu et al., 2016; Lin, 1997). Centered on family-owned small businesses embedded in local institutions, the Wenzhou model has gradually formed and scaled up the spatial agglomeration of specialized industrial clusters (Bellandi and Lombardi, 2012; Wei et al., 2007; Wei and Ye, 2009).

With the aid of GIS and spatial analysis methods, scholars have reached a deeper understanding of spatial effects in provincial China. The efforts of scholars involve empirics by techniques such as Moran's *I*, spatial Markov chains, spatial econometrics, and geographically weighted regression (GWR), and find three points in common (Dai et al., 2017; Liao and Wei, 2012, 2015; Wei et al., 2011; Yu and Wei, 2008; Yue et al., 2014).

First, the spatial concentration of regional development is found to be persistently increasing in provinces, echoing the intensifying core-periphery structure aforementioned. Second, spatial spillovers are evident in determining the mobility of regions as neighboring a rich county is more advantageous than being proximate to a poor county for local development. Third, the impacts of underlying forces are not constant over space, which implies spatial heterogeneous processes in regional development.

The widening gap between the developed and underdeveloped regions has alarmed and stimulated the central and provincial governments to carry out a series of policies to alleviate regional inequality. State strategies like the Western Development Program and the Belt and Road Initiative are carried out to motivate the economic development of remote and poor provinces in interior China (Fan and Sun, 2008; Hong, 2018). At the provincial level, policies are designed to balance the disparity between the core and periphery regions. The policy instruments aim to encourage the economic cooperation between urban and rural by the transfer of fiscal resources, relocation of industries and labor, and corresponding administrative assessment (Graeme, 2018). However, while these policies have successfully reduced regional inequality in some provinces, they have failed in others (Gu et al., 2016; Ye et al., 2014).

The concern about regional development in China under the “New Normal” and aftermath of global financial crisis raises several questions regarding inequality in provincial China, calling for an updated view on trends, agglomerations, and underlying mechanisms. First, while the interregional and interprovincial inequality is experiencing “great turnaround”

featured as a plateaued or decreased trend in the 2000s and 2010s (Kanbur et al., 2017), would the intraprovincial inequality, as at the scales of regional, prefectural, and county, follow a similar or different trend? Second, while the local development models are reacting or adapting to such contexts (Shen and Tsai, 2016), how would the associated spatial agglomeration and core-periphery structure evolve and what are the impacts on uneven regional development? Third, while the spatial-temporal perspective is drawing more attention and beyond the conventional spatial perspective (Gu et al., 2016; Ye and Rey, 2013; Yu, 2014), how would the development of exploratory space-time data analysis (ESTDA) methods help to further our understanding about dynamics and mechanisms in provincial China and the role of local forces in it? Drawing upon a multi-scale and multi-mechanism framework (Wei, 1999; Wei and Fan, 2000), this chapter tackles the questions through the case study of Zhejiang province.

4.3 Research setting: Zhejiang province

Zhejiang is a coastal province located to the south of Shanghai (Figure 4.1). As one of the core provinces in the Yangtze River Delta (YRD) region, Zhejiang is the smallest coastal province, only covering 1.1% of China's territory but home to 4.1% of the nation's population. Zhejiang has been spearheading China's economic growth and privatization since the reform. The annual growth rate of GDP and GDP per capita in Zhejiang is 12.2% and 11% respectively from 1978 to 2015, which is much higher than the national average (9.6% and 8.5% respectively). The industrial output of state-owned enterprises (SOEs) has dropped from 61% in 1978 to 4.7% in 2015, while the share of private enterprises (PEs) and foreign invested enterprise (FIEs) are 41.2% and 21.8% in 2015. The private sector in Zhejiang is

featured as clusters of small scale, family-owned, light industries, which are deeply integrated with the global economy (Wei, 2009, 2011). In 2015, Zhejiang accounts for 13% and 14% of China's exports and foreign direct investment (FDI), of which the major investors are from Hong Kong, the United States, Singapore, and Japan (NBSC, 2016; ZSB, 2016).

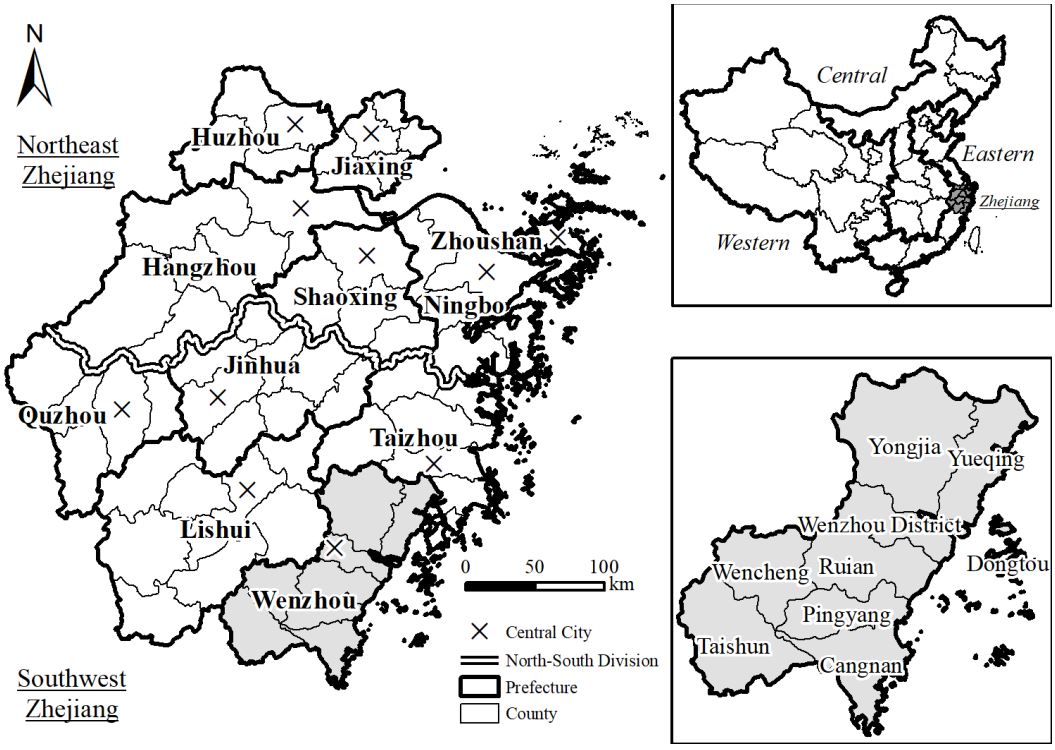

Figure 4.1 Regions in China and regional divisions in Zhejiang province

Regional development in Zhejiang is uneven and has its own unique historical legacy. Traditionally, Zhejiang was divided into a northeastern part consisting of Hangzhou, Ningbo, Jiaxing, Huzhou, Shaoxing, and Zhoushan prefectures, and a southwestern part of Wenzhou, Taizhou, Jinhua, Quzhou, and Lishui (Table 4.1). Northern Zhejiang is part of the flat Yangtze River Delta (YRD) and the start point of the Grand Canal connecting Beijing and Hangzhou. The prosperous trade of handicrafts, tea, and silk beginning during the Ming and

Qing Dynasties has made northern Zhejiang one of the most developed regions in China (Forster, 1998). During Mao's era, economic development in Zhejiang stagnated because the central government shifted allocation of investment and its industrialization policies into the interior provinces (Ma and Wei, 1997).

Table 4.1 Development indicators of Zhejiang province in 2015

	Zhejiang	% of China	NE Zhejiang	% of Zhejiang	SW Zhejiang	% of Zhejiang
Land area, km^2	104,468	1.08%	45,881	43.92%	58,587	56.08%
hukou population, million	48.74	3.55%	24.64	50.55%	24.1	49.45%
de facto population, 2010 census, million	54.43	4.06%	29.73	54.63%	24.69	45.37%
GDP, billion RMB	4,303.84	6.28%	2,921.47	67.88%	1,382.37	32.12%
GDP per capita, RMB	88,302	-	118,566	-	57,360	-
Investment in fixed assets, billion RMB	2,661.91	4.74%	1,769.7	66.48%	892.21	33.52%
Exports, billion USD	276.6	12.17%	186.55	67.44%	90.05	32.56%
FDI, billion USD	16.96	13.43%	16	94.34%	0.96	5.66%
Local fiscal expenditure, billion RMB	581.81	3.31%	381.71	65.61%	200.1	34.39%
Local fiscal revenue, billion RMB	445.69	2.93%	325.76	73.09%	119.93	26.91%

Since 1978, Zhejiang as a coastal province has been favored in the reform and opening-up policies. The entrepreneurship tradition and place-based business networks developed during Zhejiang's trade history have stimulated the rapid economic growth in coastal Zhejiang by channeling the oversea capital, technology, and management into regions like Ningbo and Wenzhou (Wei and Ye, 2004, 2009). The Wenzhou model of development, which is centered on family-owned small businesses embedded in thick local institutions, has flourished in

rural Wenzhou (Wei et al., 2007). As a result, the traditional north-south divide has been gradually replaced by the emerging coastal-interior divide (Ye and Wei, 2005).

Rising regional inequality in Zhejiang has drawn considerable attention from the provincial government and made several poverty alleviation policies possible. In the 2000s, twenty-five counties in Zhejiang were tagged as "underdeveloped regions" by the provincial government and the Underdeveloped Counties Well-off (*Qianfada xiangzhen Benxiaokang*) project was designed to promote their economic development (Wang, 2013). The Coast-Mountain Corporation (*Shan-Hai Xiezuo*) project has been launched since 2003 to pair coastal regions like Hangzhou, Ningbo, and Wenzhou with interior regions like Quzhou, Lishui, and Zhoushan, strengthening economic corporation and the transfer of investment, jobs and fiscal resources among counties (Ma, 2012).

The majority of data in this chapter are extracted from the statistical yearbooks of Zhejiang (ZSB, 2010, 2016), which covers eleven prefectures and seventy-one county level units (e.g. counties, city districts, and county-level cities) in Zhejiang. GDP per capita in constant price is used as the indicator of regional inequality (Fan and Sun, 2008). The de facto population data are estimated by interpolating the ratio between the hukou (household registration) and resident (or *de facto*) population in the 1982, 1990, 2000, and 2010 census, which is used to compare with the *de jure* population in the result (Liao and Wei, 2012).

4.4 Multiscale patterns of regional inequality in Zhejiang

The temporal trend of the multi-scale Theil index provides a holistic picture about the evolution of regional inequality in Zhejiang since the reform, which has several implications regarding the scales and transitions in Zhejiang (Figure 4.2). Regional inequality in Zhejiang is sensitive to scale, which is consistent with previous findings in China and Zhejiang (He, Bayrak, et al., 2017; Yue et al., 2014). Comparing with the inter-regional and inter-prefecture inequality, regional inequality is more salient at the smaller scale like the county level.

Detailed and updated understanding of development processes in Zhejiang could be reached by analyzing regional inequality trend in sub-periods. The comprehensive reform in urban industrial sectors from 1978 to the mid-1980s has led to an increasing inequality at the county scale. The most radical marketization reforms have been implemented since Deng Xiaoping's Southern Tour in 1992. Benefiting from the opening-up and proximity to the global market, the coastal prefectures and counties in Zhejiang have experienced rapid economic growth, which has left the interior region behind and mitigated the divide between northern and southern Zhejiang (Wei and Ye, 2004). Known for its Wenzhou model of development centered on private enterprises, the catching up of the coastal Wenzhou-Taizhou region has altered the traditional north-south divide with an emerging coastal-interior divide (Wei and Ye, 2009).

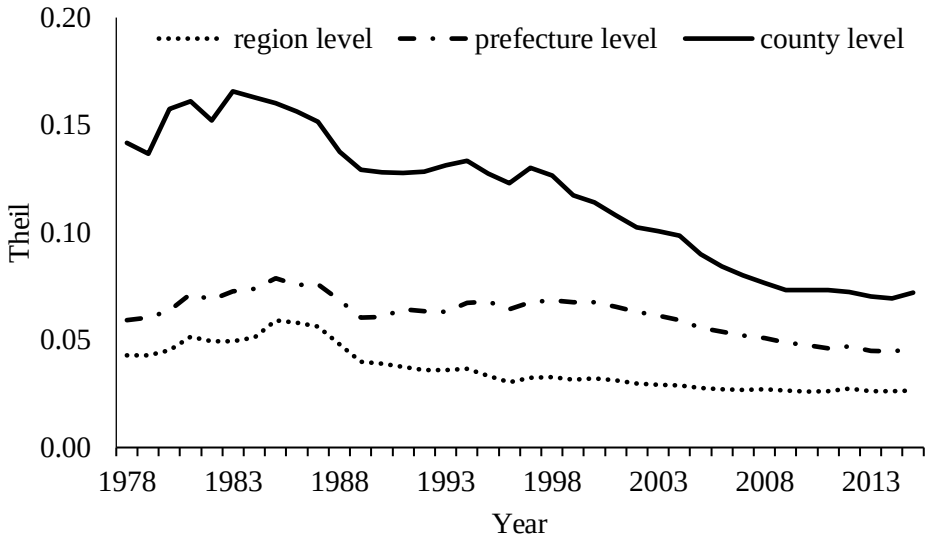

Figure 4.2 Temporal trend of multi-scale regional inequality in Zhejiang province

Following a decline from the mid-1980s to the early 1990s, inequality at the prefecture and county level has increased again, while regional-level inequality has further decreased. A steady decline of inequality at the prefecture and county level is observed since the early 2000s, which is characterized by, to some extent, regional convergence. Like other coastal provinces, China's entry into the WTO in 2001 has led to a new round of inflowing FDI and flourishing export-oriented economies in prefectures and counties in Zhejiang. Fiscal decentralization has linked local expenditure more tightly to local revenue and provided strong stimulus for the local government to improve public services and investment conditions in order to promote economic growth (Brehm, 2013). The development and spatial restructuring of private enterprises and enterprises receiving foreign investment, as well as the greatly loosened *hukou* system, have benefited and spilled over to more prefectures and counties in Zhejiang. In recent years, the regional-level spatial inequality has begun to stabilize. The trend after the mid-2000s supports the argument that Chinese

inequality is plateauing and even starting to fall and is corroborated by observations from other coastal provinces like Guangdong (Kanbur et al., 2017; Zhang et al., 2018).

The impact of population mobility on reducing regional inequality in Zhejiang is evident (Figure 4.3). Since the 1980s, economic growth in coastal Zhejiang has drawn considerable rural migration into urban areas seeking higher wages as manufacturing workers (Lin and Gaubatz, 2015). As a result, the gap between the *hukou* and resident measures has become wider, implying that regional inequality measured by the *hukou* population is distorted and overestimated (Li and Gibson, 2013). It is argued that the greatly loosened *hukou* registration system has helped to achieve more even regional development in China by spatially balancing the capital and human resource among the developed and underdeveloped regions (Chan and Wang, 2008). After 2008, the difference between the two measures has stabilized, which is attributed to the slowing down of the economic engine and the corresponding migration of low-income workers (Chan, 2010).

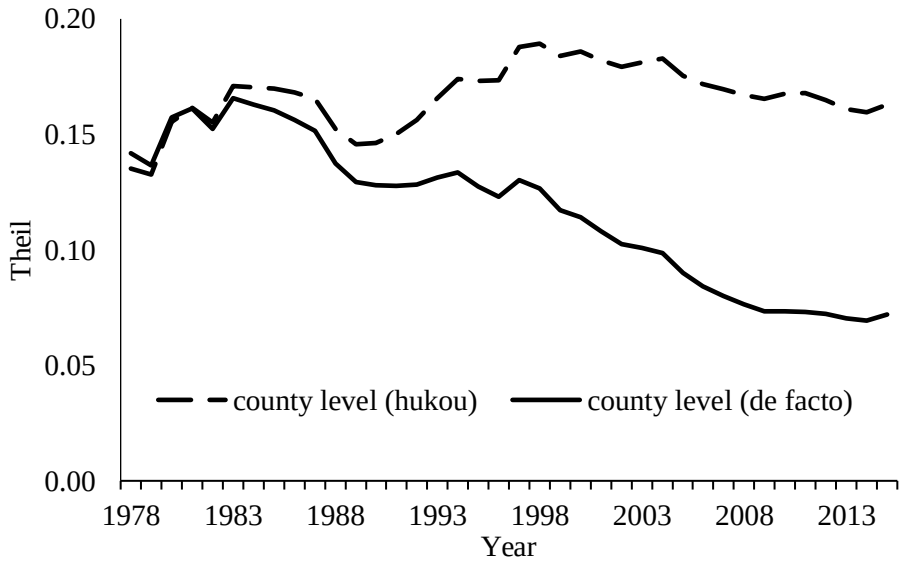

Figure 4.3 Theil index based on *hukou* and *de facto* population in Zhejiang province

4.5 Spatial temporal dynamics of regional development in Zhejiang

4.5.1 Distributional dynamics of regional development and spatial effects

To investigate the disparity and the "long-run" convergence properties among counties in Zhejiang, distributional dynamics and spatial Markov chain methods are used in this section (Quah, 1993). As shown in Figure 4.4, the shape of the distribution has changed considerably over time. The normal distribution in 1978 has converted to a distribution skewing towards the poor in 2000, while fewer counties are concentrated around the average level, indicating a complex divergence process during the period. From 2000 to 2015, a convergence is observed as more counties are close to the provincial average, which is in line with the declining Theil index after the early 2000s.

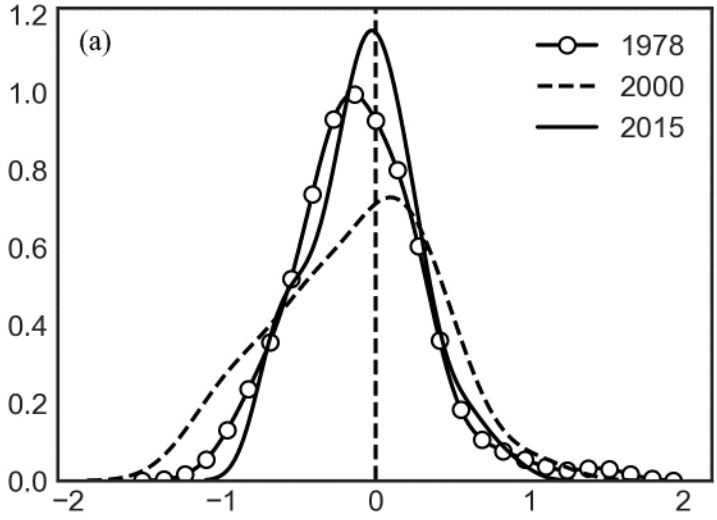

Figure 4.4 Distributional dynamics of GDP per capita in Zhejiang

Table 4.2 contains the transition probability matrices and corresponding ergodic distribution for the whole period of 1978 to 2015 and two sub-periods of 1978 to 2000 and 2000 to 2015. The GDP per capita data is discretized by grid values that split the entire sample uniformly

(Sakamoto and Islam, 2008). Four category groups of poor (P), less developed (L), developed (D), and rich (R) are used to better represent the geographical notion of periphery, semi-periphery, semi-core, and core (Dezzani, 2001, 2002; Wei et al., 2011). The upper bound of each group is given by the value in parentheses. The ergodic distribution indicates an even distribution after an infinite transition time if the current process continues to hold. There are also several findings derived from Table 4.2. First, all the diagonal probabilities in three periods are higher than the non-diagonal ones, indicating that it is more likely for counties to remain in their current status. Within the diagonal probabilities, the two ends of the distribution are higher than the middle ones for 1978 to 2015 and 1978 to 2000, which means that the core and periphery regions are more likely to stay as core or periphery. Second, the off-diagonal probabilities are much lower than the diagonal ones, indicating a relatively stable regional development system with gradual change. Furthermore, the possibility for counties to leapfrog two levels upward or downward is zero.

Table 4.2 Markov transition matrix based on 1-year transition, 1978-2015

Samples	Grid line [upper bound]			
	P [0.668]	L [0.909]	D [1.225]	R [4.409]
1978-2015				
P (671)	0.937	0.063	0	0
L (666)	0.062	0.884	0.054	0
D (658)	0	0.04	0.897	0.064
R (669)	0	0	0.061	0.939
Ergodic	0.206	0.209	0.286	0.298
1978-2000				
P (401)	0.928	0.072	0	0
L (436)	0.085	0.849	0.067	0
D (364)	0	0.063	0.843	0.093
R (383)	0	0	0.076	0.924
Ergodic	0.259	0.221	0.233	0.287
2000-2015				
P (270)	0.952	0.048	0	0
L (230)	0.017	0.952	0.03	0
D (294)	0	0.01	0.963	0.027
R (286)	0	0	0.042	0.958
Ergodic	0.058	0.159	0.475	0.308

Last, the first sub-period is more even in the ergodic distribution, while the ones of the second sub-period and the whole period are biased towards the rich and developed side. It is because the upward movement possibilities are in general higher than the downward ones in the second sub-period and the whole period, which implies a long-run convergence that echoes the Theil index. However, the traditional Markov method treats regions as independent of each other and ignores the spatial effects between regions (Le Gallo, 2004; Rey, 2001). Spatial Markov transition matrices are adopted to reveal the transition probability conditioned on the status of neighbors.

As illustrated in Table 4.3, the spatial effects are found to be salient on the transition matrices. First, as the spatial lag changes from poor to rich, the possibility to remain as a poor county declines, and the possibility to stay in other status increases. Second, the same type of upward movement, e.g. from poor to less developed, will increase as the development level of a county's neighbor improves. Third, the ergodic distribution becomes more biased towards the rich and developed side as the spatial lag condition switch from less developed to developed and rich. The finding confirms the strong spatial effects of neighboring counties in promoting or hampering the local economy.

Table 4.3 Spatial Markov transition matrix based on 1-year transition, 1978-2015

Spatial lag		Grid line [highest point]				
		N	P [0.668]	L [0.909]	D [1.225]	R [4.409]
P	P	470	0.962	0.038	0	0
	L	168	0.113	0.863	0.024	0
	D	17	0	0.176	0.765	0.059
	R	18	0	0	0	1
	Ergodic		0	0	0	1
L	P	174	0.902	0.098	0	0
	L	268	0.049	0.896	0.056	0
	D	160	0	0.05	0.913	0.038
	R	61	0	0	0.098	0.902
	Ergodic		0.163	0.329	0.368	0.140
D	P	22	0.727	0.273	0	0
	L	177	0.051	0.887	0.062	0
	D	306	0	0.033	0.925	0.042
	R	154	0	0	0.084	0.916
	Ergodic		0.046	0.247	0.470	0.237
R	P	5	0.8	0.2	0	0
	L	53	0	0.887	0.113	0
	D	175	0	0.029	0.846	0.126
	R	436	0	0	0.05	0.95
	Ergodic		0.000	0.067	0.267	0.665

Since there is no leapfrog or two-step movement in the spatial Markov transition matrices, the major trend of movements is summarized in Table 4.4 after comparing the symmetric possibilities. For example, when surrounded by poor (P) counties, the possibility of moving from less developed (L) to poor (P) is 11.3%, which is much higher than the possibility from P to L as 3.8%. Thus, the movement trend between P and L is downward if it is conditioned poor spatial lag. When surrounded by less-developed (L) counties, the possibility of rising from P to L, 9.8%, is larger than the possibility from L to P, 4.9%, with an upward movement trend. As illustrated by Table 4.4, the spillover effects from more-developed counties to underdeveloped counties are obvious since rich, developed, and less-developed counties have a positive impact on their poorer neighboring counties catching up with them. However, the backwash effects are also non-negligible. When a less-developed or developed county is surrounded by poor counties or a rich county is surrounded by less developed counties or developed counties, it is more possible for them to move downward than upward.

Table 4.4 Major trend in spatial Markov matrices conditioned on neighbor's state-space

Neighbor county	P ↔ L	L ↔ D	D ↔ R
P	←	←	→
L	→	~	←
D	→	→	←
R	→	→	→

Note: when conditioned on k and state i is lower than j, if the transition probability $p_{i\to j}^{k}$ is smaller than $p_{i\leftarrow j}^{k}$, then the dominating trend is backward movement, or " ← "; if $p_{i\to j}^{k} > p_{i\leftarrow j}^{k}$, then it is " → "; if $p_{i\to j}^{k}$ and $p_{i\leftarrow j}^{k}$ are within 1%, it is "~".

4.5.2 Spatial agglomeration of regional development

As evident from the results of spatial-Markov chain analysis, spatial effects are salient when analyzing regional development in Zhejiang. In this section, Global Moran's *I* is calculated to measure the magnitude of spatial agglomeration during the period (Getis and Ord, 1992). As shown in Figure 4.5, the spatial autocorrelation of GDP per capita has remained at a relatively low level around 0.2 before the mid-1980s, and rapidly increased and stayed at a higher level above 0.3 from 1985 to 1996. A sudden drop of concentration is observed in 1997, possibly due to the Asian Financial Crisis. After then, the spatial agglomeration has continued to increase from 1998 and reached the highest level above 0.5 from 2007 to 2015.

The comprehensive urban industrial reform from 1978 to the mid-1980s has benefited the city districts of prefectures that are sparsely distributed in Zhejiang province. As a result, the spatial concentration has not intensified during the period. But the radical marketization reform since 1992 has geographically disproportional impacts on coastal Zhejiang and leads to the rise of both inequality and concentration (Figure 4.5). The rapid spatial concentration, together with the emerging coastal-interior divide, has not been alleviated with the narrowing gap among counties since the 2000s, which implies that regions are converging in attribute but become more uneven in space. The trend of spatial polarization has only slowed down and slightly declined since the global financial crisis in 2007-2008 when the decrease of regional inequality has been stabilized, indicating the occurrence of spatial restructuring of economies during the period (Wei et al., 2007; Wei, 2012).

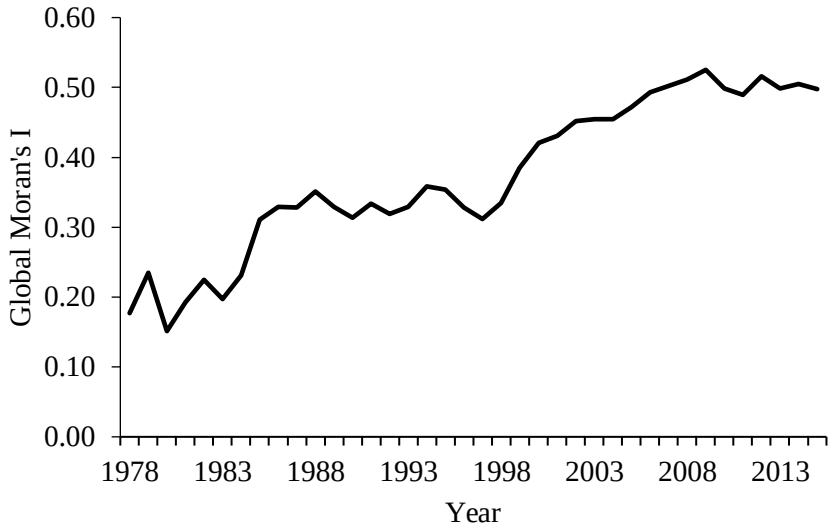

Figure 4.5 Global Moran's I of GDP per capita in Zhejiang province

Local indicator of spatial autocorrelation (LISA) method is used to reveal significant local clusters and outliers that is embedded in the globally intensifying spatial agglomeration in Zhejiang province (Figure 4.6). At the beginning of the reform in 1978, the high-high clusters of economic development are mainly concentrated in the developed city districts in northern Zhejiang or the surrounding areas, e.g. Xiaoshan and Yuhang around Hangzhou city district, Yinzhou around Ningbo city district, and the city districts of Shaoxing and Zhoushan, while the low-low clusters are mostly located in the southern Zhejiang. Wenzhou city district stands out as a high-low outlier because the surrounding counties are poor and their economic development was suppressed before the reform (Wei and Ye, 2004).

In 1992, the northern high-high clusters have expanded into Fuyang in Hangzhou and Cixi in Ningbo that were low-high outlier previously. The low-low clusters have shifted into the interior mountainous areas of Zhejiang, most of which are in Lishui prefecture. The city

district of Taizhou also stands out as a new high-low outlier. The northern clusters have further expanded in 2005, covering the counties along the city district axis of Hangzhou-Shaoxing-Ningbo, which has become fully-fledged in 2015. The southern clusters have become stabilized and gradually expanded to more interior counties in Jinhua and Quzhou prefectures from 1992 to 2015. The transition and mobility of spatial clusters is attributed to different development processes and fortunes between the northern and southern Zhejiang, as well as the coastal and interior Zhejiang. In contrast, the surrounding counties near Shanghai, Hangzhou and Ningbo greatly benefited from globalization, state investments, and local institutional forces promoting industrialization and urbanization. Specifically, in recent regional development, Hangzhou has emerged as a center of high technology and high-end service industries, and Ningbo benefitted as a core harbor for chemical industries and logistic services relying on its deep-water ports (Zhu, 2006) (Figure 4.6).

The emergence of the coastal counties of southern Zhejiang is mainly due to the rise of non-state sectors and the importance of entrepreneurship. The Wenzhou model of development, centered on small scale, private enterprises, and trading networks, has spread beyond Wenzhou to Taizhou and Jinhua and cultivated agglomerations of specialized light industries (Ye and Leipnik, 2013). Consequently, the rapid economic growth in Wenzhou, Taizhou, and Jinhua has transferred counties from low-low clusters to insignificant spatial clusters and maintained the high-low outlier of Wenzhou city district. Because of the mountainous location, outdated infrastructure, heavy burden of problematic SOEs, and lack of investment from the state and the global market, interior, southwestern Zhejiang, including Lishui and

Quzhou prefectures, is lagging behind and shows a local concentration of poor economies (Wei and Ye, 2009; Yue et al., 2014).

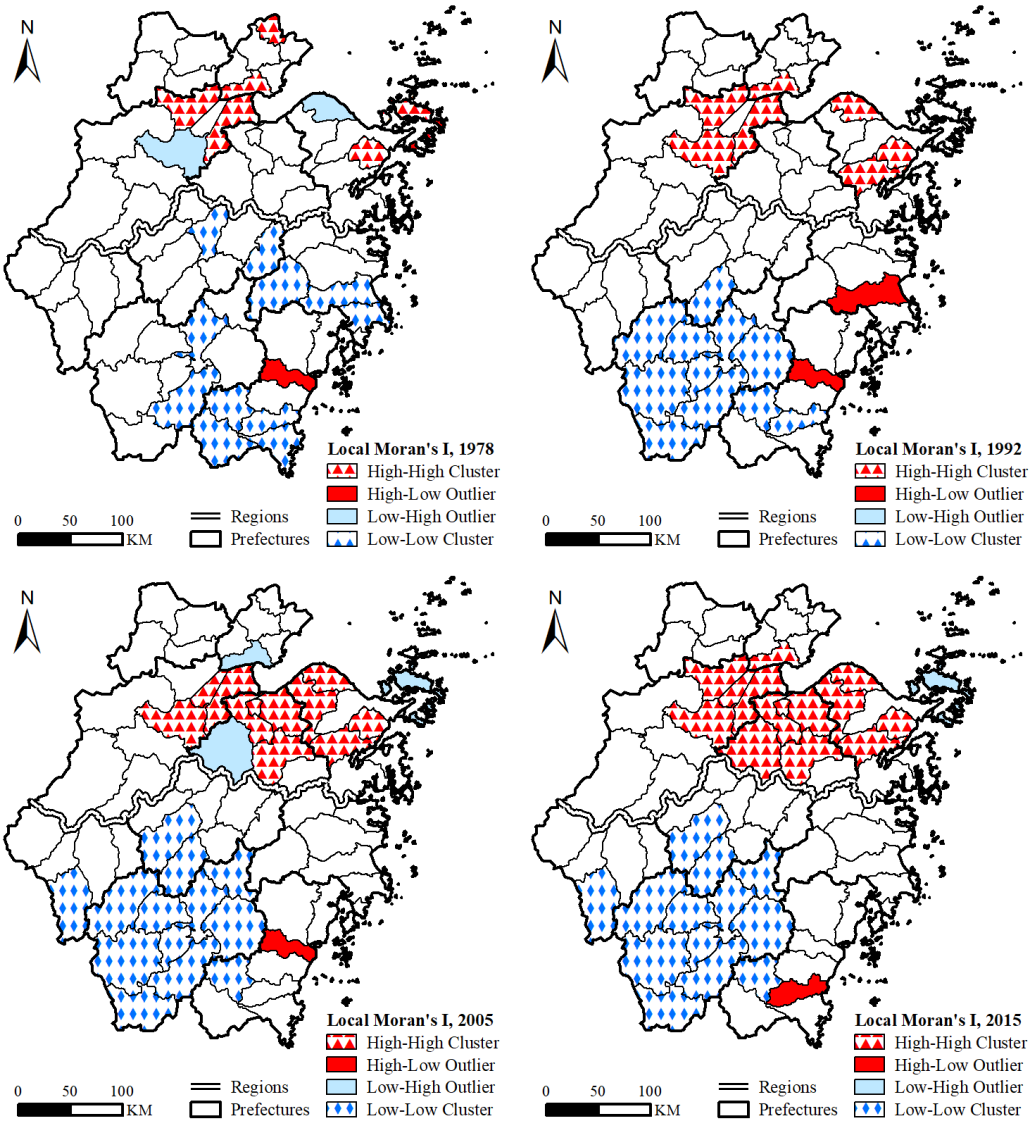

Figure 4.6 LISA map of county level GDP per capita in Zhejiang

To quantify the dynamics of spatial agglomeration, LISA Markov is used to explain the transitions of "pockets of local non-stationarity" (Gallo and Ertur, 2003). As shown in Table 4.5, the possibility for counties to stay or convert to the high-high or low-low cluster is

generally higher than staying or converting to the low-high or high-low outlier. It means the concentration of counties with a similar economic level, demonstrating the effect of spatial clustering on regional income mobility.

Table 4.5 LISA Markov-chain transition matrices for county level GDP per capita

	HH	LH	LL	HL
1990-2007				
HH	0.973	0.017	0.002	0.007
LH	0.085	0.881	0.025	0.008
LL	0.002	0.009	0.972	0.017
HL	0.056	0.000	0.077	0.866
Ergodic distribution	0.488	0.097	0.340	0.075
2008-2015				
HH	0.955	0.028	0.000	0.017
LH	0.042	0.896	0.063	0.000
LL	0.000	0.009	0.978	0.013
HL	0.021	0.000	0.043	0.936
Ergodic distribution	0.164	0.094	0.578	0.164
1990-2015				
HH	0.969	0.020	0.002	0.010
LH	0.075	0.884	0.035	0.006
LL	0.001	0.009	0.975	0.015
HL	0.046	0.000	0.067	0.887
Ergodic distribution	0.396	0.098	0.411	0.094

Note: HH, High-High cluster; LH, Low-High cluster; LL, Low-Low cluster; HL, High-Low cluster.

When comparing the results before and after 2008 or the most recent global economic recession, some interesting findings can be derived. On the one hand, from 2008 to 2015, the transition possibility from other types to a low-low cluster is higher than other transitions, which explains the radical change in LISA maps in Figure 4.6. The Wenzhou city district has even lost its advantageous status as a growth pole in the southern Zhejiang. More interior counties in northern Zhejiang moved toward rich clusters because they are more favored in economic development due to their advantageous location in proximity to Hangzhou and

Ningbo and new infrastructure development. As a result, the north-south divide in Zhejiang has become evident again.

4.5.3 Evolving core-periphery structure in Zhejiang

In order to reveal the spatial extent of agglomerations and their temporal change, spMorph, a novel exploratory spatiotemporal analysis method used in previous chapter, is adopted here to investigate the redistribution process of wealth across regions (Duque et al., 2015). Spatial regimes are divided into four to represent the core, semi-core, semi-peripheral, and peripheral regions in Zhejiang (see Chapter 2 for detailed discussion of the spMorph technique and application in interprovincial inequality). As shown in Figure 4.7, when the shock number equals three, the TLB will not be improved significantly with more shocks. The three-shock TLB is calculated from spatial regimes based on four sub-periods, i.e. 1978-1990, 1991-1998, 1999-2007, and 2008-2016 (Figure 4.8). It could be observed that each spatial regime has the lowest intraregional inequality ratio in the corresponding sub-period, which means the current spatial regime outperforms others in reflecting temporally coherent and spatially meaningful clusters.

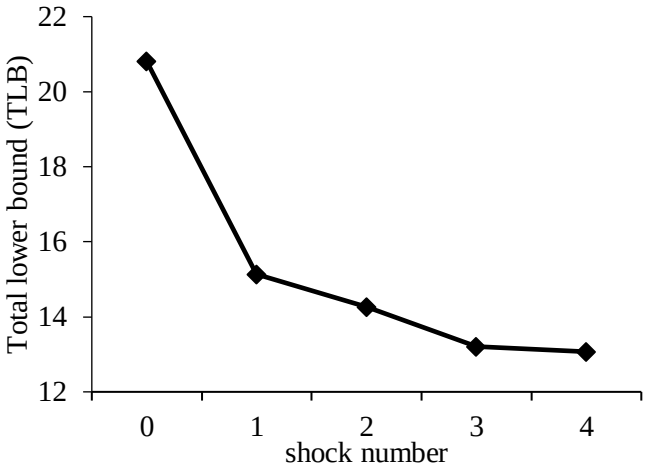

Figure 4.7 Total lower bound (TLB) for different number of shocks

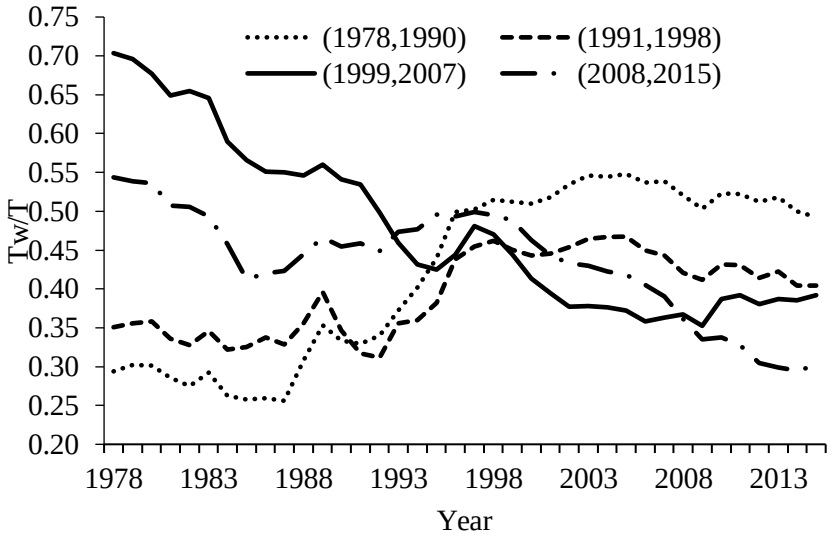

Figure 4.8 Intraregional inequality ratio (T_{wg}/T) for different regimes

The spatial representation of regimes and its transition have implications for the evolution of the core-periphery structure in Zhejiang (Figure 4.9). During the first sub-period from 1978 to 1990, the spatial regime follows the traditional north-south division (Figure 4.9-a). All the counties in southern Zhejiang are classified as periphery while northern Zhejiang is further divided into core, semi-core, and semi-periphery. Hangzhou city district, where the provincial capital is located at, is the sole core in Zhejiang, and Shaoxing city district in the

nearby prefecture is the only semi-core area. Other counties proximate to Shanghai or in the coastal area are less developed, while the interior or rural counties in the region are lagging behind. The spatial regimes during this sub-period mainly reflect the legacy of regional development before the reform in 1978. Hangzhou, Shaoxing, and Ningbo, especially their city districts, have already been the leading regions in Zhejiang. In contrast, other regions in Zhejiang have lagged behind historically during Mao's era because of their poor natural resources, disadvantageous location, and backward infrastructure (Wei and Ye, 2004).

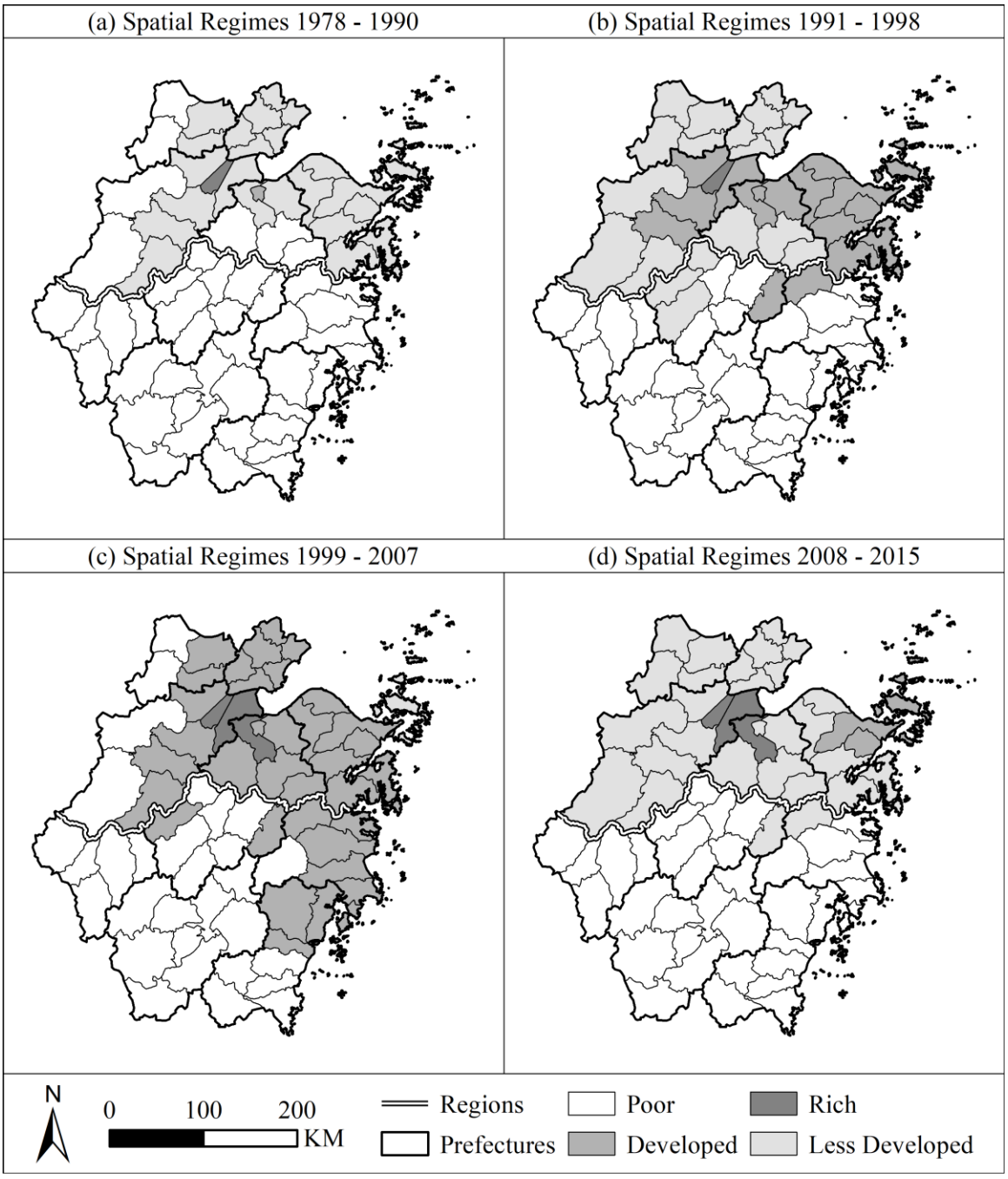

Figure 4.9 Spatial regimes obtained by spMorph in the four sub-periods

The first spatial regime fade takes place during the early phase of reform (Figure 4.9-a and Figure 4.9-b). The implementation of reform in urban industrial sectors in the 1980s has benefited the city districts and neighboring counties in China. Ningbo was selected by the

central government in 1984 as one of the fourteen coastal open cities, aiming to encourage foreign investment and technology transfer. As a result, city districts and nearby counties in northern Zhejiang, especially coastal Ningbo, have been greatly favored in economic development and promoted from being semi-peripheral regions to semi-core regions. Rural reform of the agricultural sector during the period has granted farmers the right to make production decisions, which has become an incentive for production and stimulated rural development. Consequently, the gap between urban and rural and between regions in general has narrowed in China (Fan et al., 2011). It explains the transition of the former peripheral regions in interior and rural northern Zhejiang to semi-peripheral regions.

The second transition of spatial regimes has essential impacts on regional inequality in Zhejiang (Figure 4.9-b and Figure 4.9-c). The spatial regimes fade for 1991-1998 to 1999-2007 is mainly featured as the emerging coastal-interior divide to replace the traditional north-south divide, which is in line with previous studies but more explicit in the spatial extent and temporal duration (Wei and Ye, 2004, 2009; Yue et al., 2014). Besides the top-down forces like the radical marketization and opening-up during the period, the bottom-up forces, such as the flourishing of the private sector and the Wenzhou model of development, have also contributed significantly in the catching-up of the coastal counties in Wenzhou and Taizhou to join the semi-core regions.

The last spatial regimes indicate a transition from the coastal-interior divide back to a north-south divide, which is new to our understanding of regional development in Zhejiang (Figure 4.9-c and Figure 4.9-d). Featured as the fall of the Wenzhou model of development, the

north-south divide after 2008 is fundamentally different from the traditional one and has its roots in new global, domestic, and local contexts. Relying heavily on specialized export-oriented manufacturing, the Wenzhou model of development in the Wenzhou-Taizhou region helps to achieve rapid economic growth under globalization but also creates a dependence on foreign demand and investment, of which the vulnerability is revealed with dropping demand abroad since the global financial crisis (Liu et al., 2019). Under the "New Normal" of China's economy, several transitions, like the restructuring towards high-tech and innovation-led industries and the rebalancing from export- and investment-oriented GDP growth to one relying on domestic consumption, are adopted by the central government to sustain economic growth during its slowdown, which puts the Wenzhou model of development in a disadvantageous location (Chen and Groenewold, 2018; Zhang and Chen, 2017).

The regional lock-ins in relational, interregional, and structural terms have further hampered the sustainability of the Wenzhou model (Wei et al., 2007). The place-based entrepreneur network faces serious challenges in monetary and social capital under the new circumstances, which damages the survival of small- and medium-sized enterprises as one of the pillars of the Wenzhou model (Selmier, 2018). Large-sized private enterprises seek for outward relocation in metropolitan areas like Shanghai and Hangzhou to gain benefits such as the preferential policies of the central and provincial governments and proximity to more advanced agglomeration, infrastructure, management, technology, and information (Wei et al., 2007). Locally-embedded "thick" institutions have weak and delayed adaptability after the global financial crisis and failed their role as a local developmental state by inappropriate

and ineffective economic interventions and discrimination to small- and medium-sized enterprises over large-sized ones (Shen and Tsai, 2016).

4.6 Local analysis of spatially varying mechanisms

Geographically weighted regression (GWR) is used in comparison with the ordinary least squares (OLS) method to understand the mechanisms and their spatial heterogeneity. Built on Cassetti (1972), GWR tackles spatial non-stationarity by allowing a spatially varying coefficient for each data point based on spatially weighted neighboring observations (Brunsdon et al., 1996; Fotheringham et al., 2002):

$$y_i = \beta_0(u_i, v_i) + \sum_k \beta_k(u_i, v_i) x_{ik} + \epsilon_i$$

where y_i is the dependent variable for the ith observation, x_{ik} is the kth explanatory variable for observations, (u_i, v_i) is the coordinates of the ith point in space and $\beta_k(u_i, v_i)$ is a realization of the continuous function $\beta_k(u, v)$ at point i, and ϵ_i is a normally distribute disturbance term.

Drawing upon the multi-mechanism framework, the dependent variable is proxied by the GDP per capita in constant price and five independent variables are selected based on the review of transitional processes in Zhejiang and empirics in provincial China:

1) Fixed assets investment per capita (FIX) is selected to represent the overall extent of investment during China's shifting to a market economy. The regional allocation of fixed

investment is viewed as an important instrument for the Chinese government to coordinate regional development and regional policy. It is hypothesized that this variable is positively related to regional development.

2) Ratio of a county's secondary sector output value in the provincial total (AGM) to proxy the agglomeration level. The study by Cheong and Wu (2014) suggests that the secondary industry sector contributes half of the regional inequality in China. Ke (2010) also finds that industrial agglomeration is an important factor for productivity in China. It is hypothesized that this variable is positively related to regional development.

3) The decentralization process is represented by the local fiscal expenditure per capita (LEX). Since fiscal decentralization in the 1980s and 1990s, local governments have been granted greater power and stimulus to support local development. It is hypothesized that this variable is positively related to regional development.

4) The marketization process is proxied by the ratio of SOEs in gross output value of industrial enterprises above designated size (SOE). There is a consensus that the SOEs represent economic entities with a relatively rigid institutional structure, lagging technological innovation, and aging equipment. It is hypothesized that this variable is negatively related to regional development.

5) The globalization process is represented by the per capita foreign capital actually used (FDI, i.e., foreign direct investment). Previous empirics find that FDI contributes significantly to the economic growth of coastal provinces characterized by the export-oriented economy. It is hypothesized that this variable is positively related to regional development.

The regression result suggests that GWR is a better option than OLS, as suggested by the comparison in adjusted R^2, AICc, and F-test in ANOVA (Table 4.6). The spatial heterogeneity is significant for several variables in most years, like the investment, marketization, and globalization variables. But there are also several variables that are spatially stationary, suggesting the use of mixed GWR.

Table 4.6 Regression results of OLS and GWR, 1990-2015

	1990	1995	2000	2005	2010	2015
FIX	**1.04E+00**	**4.77E-01**	**5.22E-01**	**5.02E-01**	**6.27E-01**	**4.52E-01**
AGM	**1.89E+04**	**4.86E+04**	**6.77E+04**	**9.98E+04**	**2.20E+05**	**1.06E+05**
LEX	8.10E-01	9.20E-01	1.08E+00	9.43E-01	-2.47E-01	-6.09E-01
SOE	-1.59E+02	**-8.93E+02**	-3.90E+03	-1.25E+04	-4.27E+03	-1.52E+04
FDI	-9.34E+00	1.73E+00	5.46E+00	2.34E+00	-1.80E+00	**6.32E+00**
$\overline{R}^2$	0.84/0.87	0.85/0.90	0.82/0.89	0.82/0.90	0.79/0.87	0.70/0.84
AICc	966/ 955	1093/ 1072	1171/ 1148	1234/ 1205	1298/1280	1362/1329
F of ANOVA (GWR vs. OLS)	**2.92**	**3.73**	**3.82**	**4.35**	**3.30**	**4.77**
Num of Units	71	71	71	71	71	71

Note: The bold numbers are significant at 5% level. Spatial variability is significant at 5% level in the underlined coefficients. Adjusted R^2 and AICc are listed in OLS/GWR order.

The comparison between mixed GWR and OLS are listed in Table 4.7. Based on the adjusted R^2 and AICc value, the mixed GWR not only outperforms OLS, but also slightly improves the GWR model. The result suggests that the decentralization mechanism, proxied by local fiscal expenditure per capita, is not significant in both years, which echoes the findings in previous study (Wei and Ye, 2009).

The impacts of marketization are validated by the significantly negative impact of SOE in 1995. As government's agent in economy, SOEs have a negative influence on regional development due to their bureaucratic institutional structure, backward technology and equipment, and uncompetitive productivity and commodities (Yu and Wei, 2003). The SOE variable becomes insignificant in 2015 because the economy in Zhejiang is already dominated by the non-state sector like other coastal provinces (Wei et al., 2011; Yu and Wei, 2008).

The globalization variable is significant and positively related to regional development in 2015 but is only insignificantly positive in 1995. The reason might be that FDI per capita level is low and highly uneven among counties during the 1990s, so it does not necessarily mean that the effect of globalization is not evident in regional development of Zhejiang.

Table 4.7 Comparison of the results from OLS and mixed GWR

	1995			
	OLS	mixed GWR		
		mean coe.	min coe.	max. coe.
FIX	4.77E-01	4.13E-01	-2.31E-01	1.53E+00
AGM	4.86E+04	4.46E+04	1.98E+04	6.18E+04
LEX	9.20E-01	2.13E+00	-	-
SOE	-8.93E+02	-1.14E+03	-2.95E+03	2.36E+02
FDI	1.73E+00	3.32E+00	-7.86E+00	1.51E+01
$\bar{R}^2$	0.85	0.91		
AICc	1093	1070		
Number of Units	71	71		
	2015			
	OLS	mixed GWR		
		mean coe.	min coe.	max. coe.
FIX	4.52E-01	4.89E-01	-8.12E-02	9.53E-01
AGM	1.06E+05	1.50E+05	6.25E+04	3.15E+05
LEX	-6.09E-01	-1.72E-02	-1.04E+00	1.88E+00
SOE	-1.52E+04	-1.26E+04	-4.18E+04	6.47E+04
FDI	6.32E+00	2.26E+00	-	-
$\bar{R}^2$	0.70	0.85		
AICc	1362	1325		
Number of Units	71	71		

Note: The bold variables are significant at 5% level in OLS.

The fixed asset investment and industrial agglomeration are also important factors, which indicates that regional development in Zhejiang is investment-driven and industrial agglomeration plays an important role by stimulating economies. Maps of local coefficient estimates further reveal several interesting findings (Figure 4.10 and Figure 4.11). First, though there is little difference in the investment coefficients in 1995 and 2015 by OLS, the mixed GWR result shows evident spatial heterogeneity with regard to local impacts (Figure 4.10). In 1995, the investment factor mainly takes effect in southern Zhejiang, especially the coastal Wenzhou-Taizhou region, by providing reliable infrastructure for booming private

enterprises. But in 2015, a coastal-interior gradient is observed. The investment instrumental could maximize its impacts in interior Zhejiang because of historical debt in construction and the government's push for inequality alleviation, while for coastal Zhejiang it only has marginal effects.

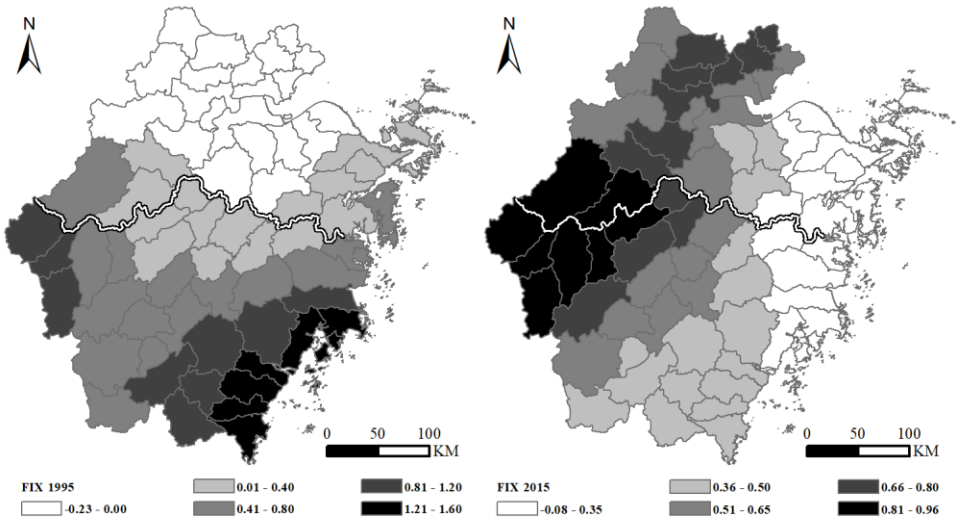

Figure 4.10 GWR results for fixed asset investment per capita in 1995 and 2015

Second, the influence of industrial agglomeration has been strengthened in recent years and its spatial pattern has been reversed (Figure 4.11). The impact of industrial agglomeration is profound in northern coastal Zhejiang in 1995. But in 2015, interior southern Zhejiang could benefit the most from developing agglomeration economies, highlighting the importance of economic restructuring in promoting poor regions. Last, the spatial pattern of variable estimates also helps to understand the mechanisms under the changing regional division in Zhejiang. In the mid-1990s, the emerging coastal-inland divide was mainly driven by the concentration of fixed asset investment in the coastal Wenzhou-Taizhou region and high industrial output in the coastal Hangzhou-Ningbo region. As the common governmental instrumental, fixed asset investment was used by the locally embedded institutions in

Wenzhou to improve the business environment and paved the way for flourishing private enterprises. Together with the traditional industrial agglomerations in Hangzhou and Ningbo, coastal Zhejiang has become more developed than interior Zhejiang, which leads to the transition from the north-south divide to the coastal-interior divide.

Since the 2000s, the focus of the provincial government has been shifting to a more balanced economy and alleviation of regional inequality (Ye et al., 2014). The fixed asset investment is used to solve the uneven regional development and the transfer of industries and fiscal resources to interior Zhejiang is encouraged. Together with the shock of the global financial crisis and the persistent slow-down of economic engine, the Wenzhou-Taizhou region has lagged behind again and a new north-south divide has emerged.

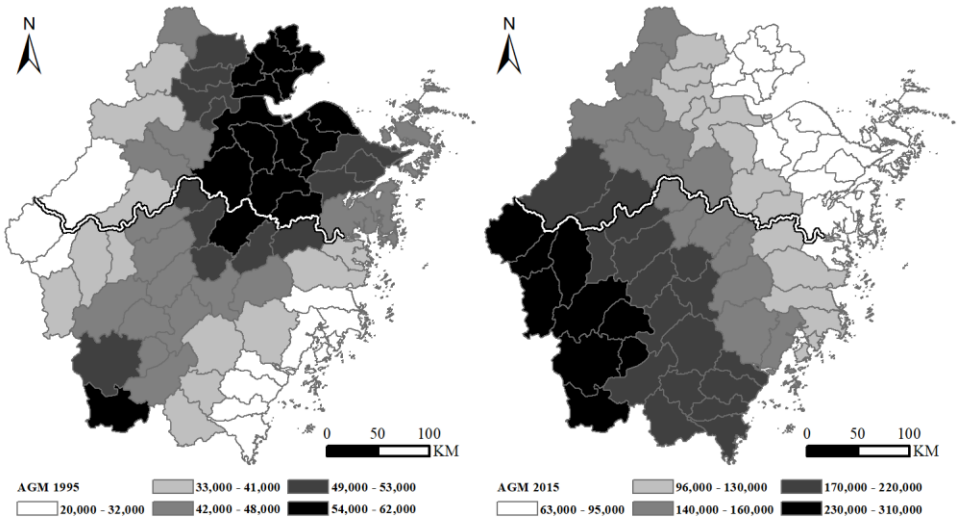

Figure 4.11 GWR results for industrial agglomeration in 1995 and 2015

4.7 Bottom-up forces in Wenzhou model of development

Following the bottom-up strategy (Wei and Ye, 2009), in conjunction with the space-time path method used in the second chapter, this section carries out a more detailed investigation of regional development in Wenzhou-Taizhou region, with a comparison to Hangzhou and Ningbo.

The location quotient (LQ) method is used to evaluate the trend of regional status in terms of economic development and socioeconomic factors[6]. As shown in Figure 4.12, the gap between two clusters, the traditional one of Hangzhou and Ningbo and the emerging one of Wenzhou and Taizhou, has been narrowing from 1990 to the early 2000s. It is in line with literature and previous discussion that the north-south divide of economic landscape has become fragmented and more complex with a sign of coastal-inland divide (Wei and Ye, 2004). However, the status of Wenzhou has remained the same since the early 2000s, so did Taizhou municipality. Meanwhile, Hangzhou and Ningbo were converging to the average, which indicates the gap among prefectures within the coastal region would have narrowed due to the catching up of other prefectures. As shown in Figure 4.13, the success of the Wenzhou model in the 1990s is closely related to the exponentially increasing exports. With the place-based relationship (*guanxi*) network, Wenzhou has benefited from the globalization

[6] The LQ measure could be expressed as $\frac{X_i/\sum X_i}{Y_i/\sum Y_i}$, Where X_i and $\sum X_i$ are the regional and total value of the indicator, like GDP, export, fixed asset investment, local fiscal expenditure, and industrial output, and Y_i and $\sum Y_i$ are the regional and total population base. Therefore, LQ over unity means that a region's status is above the average level in Zhejiang, while LQ less that unity indicates the opposite.

process by channeling foreign investment, market information, new equipment, and global culture back to Wenzhou (Wei, 2009; Wei and Ye, 2004).

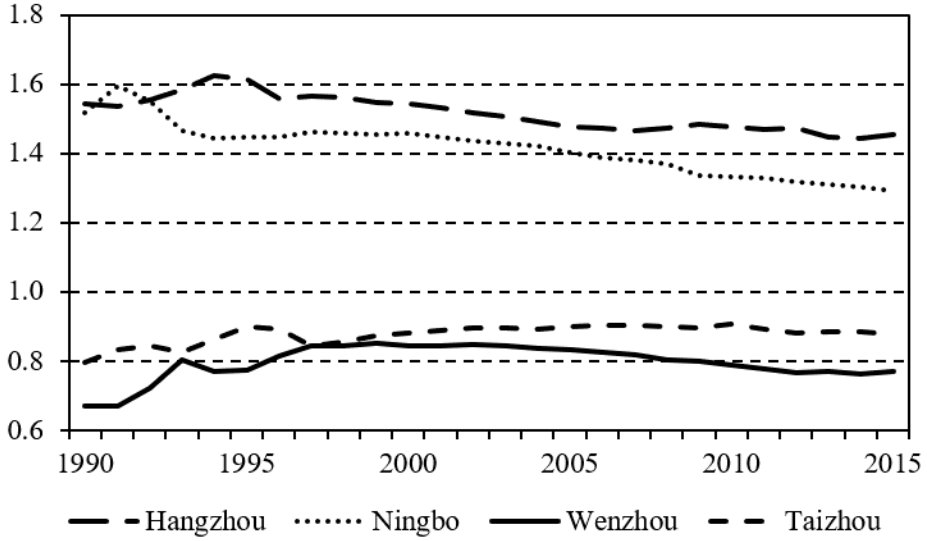

Figure 4.12 Location quotients of GDP per capita in selected prefectures

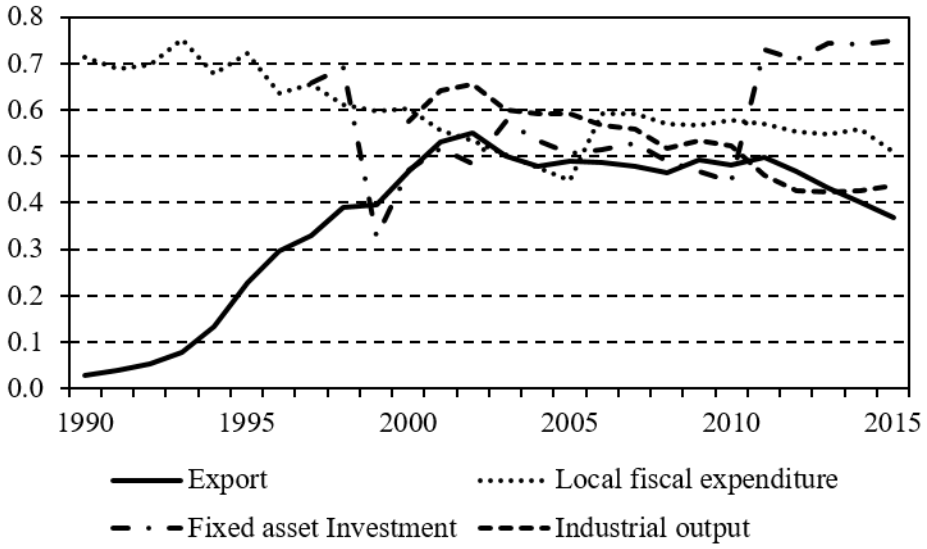

Figure 4.13 Location quotients of various mechanism in Wenzhou

However, the advantageous status of Wenzhou's exports has faded since the early 2000s. Ningbo and Taizhou, with favored locations and a high quality of infrastructure like deep-

water ports, have become the major harbors in Zhejiang. Wenzhou is also known for spearheading marketization in China. The “thick”, locally embedded, pro-business government in Wenzhou has taken one step ahead towards privatization and implemented several policies to improve business environment for the non-state sector. The share of SOEs in industrial output has declined to 21.3% in Wenzhou while the provincial level is 42.7% in 1990 (ZSB, 1991). But with deepening privatization in Zhejiang, Wenzhou has gradually lost its advantages in ownership structure. The share of SOEs in Wenzhou and Zhejiang are at the same level of 8.2% and 4.8% in 2000 and 2015 (ZSB, 2001, 2016). The weakening capacity of the local government is also reflected by Wenzhou’s declining status in terms of local fiscal expenditure and fixed asset investment (Figure 4.13).

The space-time path result further reveals detailed spatiotemporal dynamics of individual counties. In Figure. 4.14, the economic development trajectory of nine counties in the Wenzhou-Taizhou region is illustrated. The points are labeled from dark blue in early years to light blue in more recent years. Most of the trajectories could be classified as Type I pattern (see Chapter 2 for detailed discussion of the space-time path techniques and application in interprovincial inequality), meaning that both the local and the adjacent county’s economy are developing at the same time. The spatial effects of the city districts of Wenzhou and Taizhou are evident, as the nearby counties have experienced rapid economic growth in the 1980s and 1990s. Several counties, like Wenling and Yuhuan in Taizhou, and Ruian and Yueqing in Wenzhou, have once moved beyond the provincial average in the period. As the prototype of the Wenzhou model, Ruian and Yueqing are also known for their specialized light industries and extensive and external network linkages with global markets

(Wei and Ye, 2009). At its peak, local economic development level of Ruian and Yueqing is as high as 1.2 and 1.3 times of the provincial average in 1997. However, the counties influenced by the Wenzhou model of development and the spillovers of Wenzhou city district have encountered persistent recession in the 2000s and 2010s. All the selected counties in Wenzhou and Yuhuan in Taizhou have entered the Type II pattern of trajectory, with both the local and adjacent counties declining in their relatively advanced position among counties in Zhejiang.

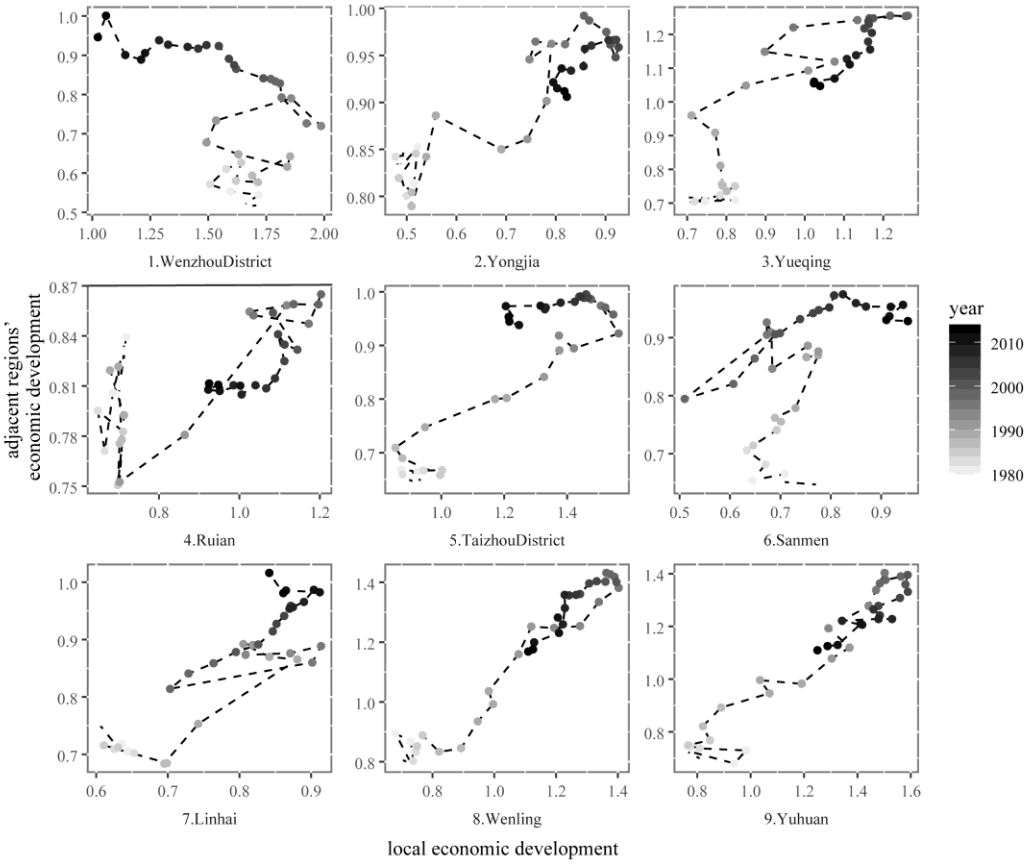

Figure 4.14 Space-time paths of nine interested counties in Zhejiang

To get a more accurate measure of the development trajectory, the Euclidean distance, ΔRS_i^t, in the space-time path space is calculated (Table 4.8). Comparing with the beginning of

reform in 1978, most counties achieved Type I pattern of development in 2015 except the city district of Wenzhou. Among the counties, Yueqing has experienced profound improvement in terms of the position in economic space among counties in Wenzhou, followed by Yongjia and Ruian. Yuhuan and Wenling are the two highest ones in Taizhou, followed by the city district. For the first sub-period, seven out of nine counties are in a Type I pattern and show spontaneous development of the local and adjacent counties, which underlies the rise of the coastal Wenzhou-Taizhou region. But in the second sub-period, the trend has been slowed as the distance change in economic space becomes smaller than the previous sub-period. Type II and Type IV patterns of development appear, indicating the diminishing sustainability of economic development for the Wenzhou-Taizhou cluster. The backward-spinning trend is observed for most trajectories in Figure 4.14 after the late-1990s, which implies that the southern cluster in Zhejiang has been lagging behind the northern region.

Table 4.8 The Euclidean distance change ΔRS_i^t in the economic space

County	1978-2015		1978-1991		1992-2015	
	ΔRS_i^t	Pattern	ΔRS_i^t	Pattern	ΔRS_i^t	Pattern
Wenzhou						
city district	0.82	III	0.28	III	0.55	III
Ruian	0.21	I	0.08	I	0.07	I
Yueqing	0.48	I	0.38	I	0.05	IV
Yongjia	0.33	I	0.25	II	0.04	I
Taizhou						
city district	0.45	I	0.48	I	0.17	III
Wenling	0.55	I	0.52	III	0.08	I
Linhai	0.35	I	0.24	I	0.13	I
Yuhuan	0.60	I	0.62	I	0.12	II
Sanmen	0.33	I	0.23	I	0.20	II

In contrast to the neighboring counties, the city district of Wenzhou shows a Type III pattern mode for the whole period. The relative income level has dropped from two times in the early 1990s to merely the same of the provincial average in the 2010s. There are two reasons for the declining local status of Wenzhou city district. First, the spatial scaling-up of enterprises outward from Wenzhou has hampered its regional competitiveness. As Wei et al. (2007) pointed out, the relocation of Wenzhou enterprises has intensified since the late 1990s as a maneuver to avoid regional lock-ins. The relocation of mature and large-sized enterprises leads to poorer productivity and declining regional development. Wenzhou firms have also diversified their investment in services, especially real estate, while the manufacturing sector lacks the capital and talents to upgrade. Second, the rapid growth of in-migration has a "diluting" effect. In 2010, the *de facto* to *hukou* population ratio in Wenzhou city district is as high as 2.09, ranking first among counties in Zhejiang. The majority of the migrants in Wenzhou are manufacturing workers with low education levels, long working hours, and low wages, which supports local development but contributes less in improving the average income level. From 2000 to 2015, GDP growth rate in the Wenzhou city district was 10.8%, which is almost the same as the provincial average of 11% (Lin and Gaubatz, 2015).

The Wenzhou model is featured as spatial agglomerations of small-scale private enterprises in labor intensive and low-tech light industries. Industrialization centered on manufacturing and the massive migration of cheap labor from the rural areas have underlain the rapid economic growth and altered the spatial configuration of regional development in Wenzhou (Lin and Gaubatz, 2015). Meanwhile, with the overcapacity of the manufacturing sector and

the slow process of industrial upgrading, the marginal benefits from the Wenzhou model has declined constantly. Measured by industrial output per capita, the competitiveness of the Wenzhou model has been diminishing in recent years (Figure 4.13). The productivity of workers is not improved, which urgently calls for upgrades in economic structure and technology profile (Wei et al., 2007)

4.8 Conclusion

This chapter investigates local and regional development in China through a case study of regional inequality and spatial-temporal dynamics in Zhejiang province. Declining inequality is observed at multiple spatial scales in Zhejiang after the mid-2000s. In contrast to the convergence trend, spatial agglomeration has intensified since the reform and opening-up, suggesting economic polarization in the coastal Zhejiang. The analysis of shocks and spatial regimes confirms the core-periphery structure in Zhejiang. The spatial regression of multi-mechanism in regional inequality reveals the spatially heterogeneous effects of transitional processes. After adopting a bottom-up view, the spatial-temporal dynamics in Zhejiang are explained in detail through the Wenzhou model of development and how locality, local context, and local institutions have promoted the rising of Wenzhou-Taizhou region since the reform and opening-up, but failed to adapt during the aftermath of the financial crisis and the "new normal" economy in China.

Following increasing inequality since the reform and opening-up and after the radical marketization reform, inequality among regions, prefectures, and counties in Zhejiang has declined since the early 2000s. The long-run property detected by Markov chain method

further confirms the convergence of regional development in Zhejiang. In contrast to the narrowing gap among counties, spatial analysis indicates an intensifying spatial concentration of economies and highlights the spatial effects in regional development. The level of spatial agglomeration has increased rapidly even with the declining inequality since the 2000s. Clusters of rich counties have gradually expanded northern Zhejiang's Hangzhou-Ningbo region, while southern interior Zhejiang has lagged behind as has its clusters of poor counties. The distributional dynamics detected by the spatial Markov chain method reveals that spillover effects from the developed region is evident in promoting the neighboring counties.

By utilizing spatiotemporal analysis methods, especially spMorph, this chapter helps to reach a more nuanced understanding of the spatial dynamics of regional development in provincial China. With the rise of the Wenzhou model of development centered on small-scale, private enterprises, the traditional north-south divide in regional development of Zhejiang is replaced with an emerging coastal-interior divide (Wei and Ye, 2004, 2009). But since the global financial crisis and slowdown of China's economic growth after 2008, the southern part of coastal Zhejiang, mainly in Wenzhou and Taizhou prefectures, has fallen behind in economic growth and a new north-south divide has emerged, which is rooted in the context of diminishing foreign demand and investment, industrial restructuring and upgrading in China, and regional lock-ins in the relational, interregional, and structural terms of the Wenzhou model (Wei et al., 2007).

The application of mixed GWR enables us to incorporate spatial heterogeneity into the driving forces of regional development. Investment, agglomeration economies, decentralization, and globalization are found to be the important variables in understanding regional inequality. The spatial non-stationarity of fixed asset investment and industrial agglomeration implies that the emerging coastal-interior divide in the 1990s is closely related to heavy investment in the Wenzhou-Taizhou region to pave the way for better business environment and more externality for booming private enterprises, of which the impacts are limited and diminishing in the 2010s.

The analysis of bottom-up forces in Wenzhou and its comparison to Hangzhou, Ningbo, and Taizhou reveals more details about the evolution of regional inequality and the mechanisms. The spatiotemporal trajectory in economic space implies that Wenzhou and its counties have experienced rapid and profound economic growth in the 1990s but most of them have recessed since the early 2000's. The factors that support the Wenzhou model of development, e.g., foreign trade and investment, pro-business and developmental capability of local institutions, ownership and economic structure advantages, and labor intensive and low-tech light industries, have faded away or faced challenges under the new context, which questions the sustainability of the Wenzhou model.

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Chapter 5 Conclusion

Built upon a multi-scale and multi-mechanism framework and a geographical perspective, this dissertation investigates the spatiality of regional inequality in China by focusing on the role of space, scale, and locality. Spatial redistribution processes because of policy shocks are found to cause spatial regime fades in China at the national and provincial level. The geographically biased reform policies have led to the widening gap and the formation of regional clubs in the coastal and interior China. In the case of Zhejiang province, the north-south divide before the reform and opening-up has been replaced with an emerging coastal-interior divide. Regional inequality in China is sensitive to spatial scales. The nested decomposition of overall inequality suggests that the prefectural level contributes most to the overall inequality. The modeling of mechanisms in multi-scalar inequality finds that globalization and high ratio of SOEs in economy is associated with increasing intra-provincial inequality while their effects are opposite for the intra-prefectural inequality. The analysis of bottom-up forces in Zhejiang province elaborates the role of Wenzhou model of development, which is deeply embedded into the "thick" local institutions, in local and regional development. Under the context of global financial crisis and economic slow-down in China, the rise of the Wenzhou-Taizhou region has been interrupted with a widening gap to the core Hangzhou-Ningbo region because of the slow adaptability of local institutions to the new environment.

By employing the most recently-developed GIS methods mostly categorized as ESTDA techniques, this dissertation enrich the empirics of regional inequality in China by providing details about the spatiotemporal dynamics and examining the patterns and mechanisms of

regional development and inequality in China with an emphasis on the effects of economic transition. The empirical work also draws upon both long-run dataset covering sixty years of provincial level economic dataset, and the most disaggregated-level dataset, namely data from more than 2,000 county level units, during the reform era. In doing so, this dissertation has reached several major findings in the chapters.

First, when researching the spatial redistribution of economic activities, the comparison between the normative regions and the analytical regions suggests that spatial regimes are more applicable in representing the dynamics in the core-periphery divide and capturing the policy shocks that change the structure. Normative regions, either at the national level in China or the intra-provincial one in Zhejiang province, can only capture the core-periphery structure in certain periods. The redistribution processes, detected by spatial regime fades that occur when one regime is replaced by another based upon the magnitude of coherence in analytical regions, reveals that open-door policies and the reform have significant impacts on determining the economic development status of individual provinces. Recent spatial regime fades can be attributed to the rise of coastal regions and the declining status of those provincial economies dominated by state owned enterprises. Results in provincial China suggest that the deepening market reforms of the 1990s and the shocks from the global and domestic market in the 2010s have fundamentally changed the core-periphery structure in Zhejiang province.

Second, by investigating the space-time paths of individual provincial and county economies and their spatial dependence, the results reveal that spillover effects vary among different

regions. For example, in the Yangtze River Delta, the spillover from Shanghai on its neighboring provinces of Jiangsu and Zhejiang is more evident as compared to the effects of Beijing and Tianjin on Hebei, which is characterized by weak spillover, or even backwash effects. Another example is the counties influenced by the Wenzhou model of development in Zhejiang province, which have risen and declined with the core of the southern coastal region. Results of spatial Markov chain analysis also suggest there has been a "poverty trap" in remote areas such as southwestern Zhejiang. The persistence of the core-periphery divide is greatly reinforced by spatial agglomeration of economic development and is greatly attributed to the emergence of new clusters.

Third, this dissertation pays particular attention to the multi-scalar pattern of regional inequality and attempts to demystify the scale sensitivity by utilizing a novel three-stage Theil-based nested decomposition technique. After systematical decomposition and filtering of the scale effects, the disparity among prefectures within each province is found to be the largest contributor to overall inequality, followed by the between-region, intra-prefecture, and between-province components. During the reform period from 2000s to 2010s, between-region and intra-prefecture inequality drops more quickly as compared to the contributions made by between-prefecture and between-province inequality. Hence, the indications of a "new" convergence, as well as the effects of urbanization on spatial inequality among urban-rural counties within prefectures, should warrant attention. Locations of individual provinces and geographical contexts also matter. Prefectures and provinces within northeastern and eastern regions demonstrate economic convergence trajectories while prefectures and provinces within western and central China have experienced divergence.

Fourth, regarding the mechanisms of regional development and inequality, the changing level of regional inequality in China corresponds to the "triple process" of transition and globalization, decentralization and marketization, and urbanization. The transformation of the economic system during the reform period has triggered the articulation of states, foreign investors, and local institutions and geographies in China's regional development. The case studies or bottom-up analyses have also confirmed that the core-periphery disparity or the coastal-inland divide in Zhejiang is highly related to the economic transitions. For example, results of GWR modeling in Zhejiang indicates that fixed-asset investments and industrialization are factors that have been more influential in shaping uneven regional economic development in the process of economic transition. On par with the recent scaling-up of the Wenzhou model, the new coastal-inland divide has replaced the traditional north-south divide in Zhejiang.

Based on the abovementioned findings, this research has several implications from both theoretical and policy perspectives. From a theoretical perspective, it has affirmed the weakness of the new convergence theory which is argued to be devoid of time and space (Wei and Ye 2009). Indeed, convergence or divergence trends are greatly confined to the initial levels and cycles of economic development (Petrakos et al., 2005). In China, the evolution of regional inequality in different sub-periods does not follow either the convergence or the divergence schools of thought. The analyses demonstrate more complicated patterns of regional inequality, corroborating a more meso-scale perspective and grounded approach towards uneven regional development.

Moreover, this research carefully analyzes the effects of self-reinforcing spatial agglomeration and the space-time dynamics of the core-periphery model, using advanced GIS spatial analysis techniques (e.g., regionalization or spMorph, space-time paths, and spatial Markov chains). Although the results substantiate the debate over the new economic geography (NEG) model (Gardiner et al., 2013; Krugman, 2011), the geographies of regional polarization have challenged the equilibrium or static viewpoint towards regional convergence or divergence. Specifically, the role played by spatial agglomeration is conditioned upon geographical contexts and local scales (Storper 2018). With the aid of more recently developed ESTDA techniques, the findings confirm that when explaining the geographical concentration of economic activities or regional inequality, the major theoretical thoughts such as neoclassical and new economic geography, could be powerful but may not provide the most comprehensive account.

It is also argued that the integration of western theories and the ground-specific contexts in China is a better approach to analyzing China's regional development and disparities. The results suggest that the spatial inequality of China's economic development is mediated by varying geographical contexts, and the transitional processes. For example, in the case of Zhejiang, the state's investment might have strengthened the coastal(north)-inland(south) divide, although in some developed countries, globalization and investments from outside have reduced regional inequality (Ezcurra and Rodríguez-Pose 2013).

The findings also have policy implications for regional development and planning in China. First, programs at the national level or the top-down approach alone might not be effective in

reducing regional inequality. It is found that national strategies or inequality-reduction policies that target the central and western provinces might contribute to increased inter-city or inter-county inequality in these regions. Policies from below or bottom-up strategies are also needed to more effectively reduce emerging "poverty traps" in the western and central regions as well as in specific poor regions within provinces.

Secondly, as China's economic transition continues and reform deepens, the "triple process" of globalization, decentralization and marketization will certainly leave its footprint. For instance, it is identified that in the case of Zhejiang, the development of "new" and "globalized" economies in the northern part of Zhejiang centred on Hangzhou may reinforce the coastal-inland divide. How lagging regions could attract new investments with local resources is a challenging issue for policymakers. In this regard, a more integrated development model, which relies on both the international market and booming domestic market, may better sustain economic growth and alleviate the uneven regional distribution of income.

Thirdly, as China's economy becomes more reliant on new growth strategies such as high-end services and the high-tech sector, new forms of regional inequality have been generated as indicated in the empirical analysis. In particular, despite the positive impact of rural industrialization or grassroots-level enterprises on regional development, new economic spaces have emerged in provincial China, as evidenced in Zhejiang province. Places with advantages in technology and innovation, such as Hangzhou where Alibaba's HQ is located, are moving further ahead in development, which is even more difficult to overcome.

Policymakers must think more proactively about the distributional impacts of new economic development strategies in favor of less developed regions (Chen and Groenewold, 2018, 2011). For instance, technological change does provide some opportunities for less developed regions, which the government should certainly pay special attention to.

Finally, the study could be improved in several aspects: (1) The study mainly emphasizes the influence of economic transitions on inequality. Recent literature has been more interested in the relationship between sectoral transitions (Ye et al., 2017). The research on the spatial impact of sectoral transformation in China is promising. (2) The study mainly focuses on the economic inequality and relies on the available economic indicator to measure development level. Multi-dimensional inequality like innovation capability, health, education, environment, and human development, has drawn increasing attention from scholars (Wei, 2015). The economic inequality could be extended into different forms (e.g., urban-rural inequality and inequality in functional oriented zones and metropolitan areas) (Li et al., 2020). The sole indicator of GDP per capita could be improved by different indicators (e.g. labor productivity, wage, or consumption level) or different data sources (e.g., remotely sensed data and big open data) (Peng et al., 2018). (3) In addition to the Wenzhou model of development, future work on Zhejiang province that focuses on in-depth cases in the most influential municipalities like Hangzhou and Ningbo in the context of the uneven development would be of great research significance. Scaling up the findings in Zhejiang province and comparing regional inequality in different provinces is also a promising avenue for future study. For example, regional development in the Greater Beijing Area is more policy-driven given the subsidies from the central government. Future comparative case

studies could shed more light on the applicability of a multi-scale and multi-mechanism frameworks in different geographical contexts and institutional settings. (4) Finally, applications of more rigorous GIS and spatial modelling approaches, such as spatial-filtering and geographically and temporally weighted regression, are also likely to deepen our understanding of spatially varying drivers of economic growth in China. The results of modelling could be more informative if it used some techniques that can trace the non-linear effects of economic transition in regional inequality (Dai et al., 2017).

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