# Spatiotemporal Evolution of Specialized Villages and Rural Development: A Case Study of Henan Province, China

Jiajun Qiao,* Jay Lee,[†,‡] and Xinyue Ye[‡]

*Key Research Institute of Yellow River Civilization and Sustainable Development and College of Environment and Planning, Henan University
[†]Department of Geography, Kent State University
[‡]College of Environment and Planning, Henan University

Regional economic development is inherently uneven as determined by the local conditions and available resources. Specialized villages (SVs) in China played a very important role in the development and economic transformation in rural areas. By integrating regional spatial structure theory, multilevel network theory, and spatial interface theory, this article examines the spatial and temporal evolution of SVs in Henan Province, China. Results from the analyses show that the development of SVs over time progressed in four stages, each corresponding to important adjustments in national agricultural policy. SVs were distributed unevenly in space and the distribution seemed to be scale-dependent. At a macrolevel, SVs displayed a dispersed pattern over a large area. SVs showed localized clusters at a microlevel, however, also exhibiting a core–periphery structure. Rural economic development in China showed that SVs formed a multilevel network hierarchy. We also observed that SVs were often in transitional areas including urban–rural and plain–mountain interfaces and administrative marginal zones. Finally, spatiotemporal clusters of SVs helped to identify the locations and time periods when SVs grew significantly for analysis of impacts by national policies on rural development.
*Key Words: China, rural development, spatiotemporal evolution, specialized villages (SVs).*

*Annals of the Association of American Geographers*, 0(0) 2016, pp. 1–19 
Initial submission, March 2015; revised submission, May 2015; final acceptance, July 2015
Published by Taylor & Francis, LLC.

With the remarkable economic development in China since the 1980s, most research in regional economic development has focused on examining the growth of manufacturing and industrial activities from the industrial perspective (Tisdell 2009). The role of the agricultural sector in rural areas in China's economy has received only limited attention. Using geographic information systems (GIS) and geospatial analytics, this article presents a close examination of how economic activities in rural China developed and how that contributed to the fast-paced economic development in the country. This article contributes to the literature on regional economic development by suggesting a new approach that integrates three theories under the broad concept of spatial imbalance theory. In addition, we provide a new approach of assembling a series of geospatial analytics to reveal and understand the spatiotemporal trends of such uneven growth. The analysis of these trends revealed that growth poles existed, serving as the leading force that brought economic growth to their peripheral regions.

Since 2004, a series of agriculture policies have been implemented in China to speed up economic development in rural areas. An obvious example was the New Rural China Construction, as established by Central Document No. 1 in 2004. Under this policy, all agricultural taxes were to be abolished on 1 January 2006. This policy aimed to significantly reduce the tax burden on farmers and to increase farmers' disposable income for investment or for stimulating local economies in rural areas (Long et al. 2011). Beginning in 2007, the Chinese government started to provide financial subsidies to farmers based on farm sizes. Since then, financial subsidies have been increased and expanded to include financial assistance in seeding, fertilizing, and the purchase of farming equipment. National policies of China's central government were critical in stimulating and guiding the development of the rural economy. For example, the nationwide Household Contract Responsibility System was responsible for raising productivity in rural areas by 46.9 percent (Lin 1992) and was argued to be the main force in the development of specialized villages (SVs) in China. To that end, local economic policies have become secondary in their importance in the development of SVs.

As pointed out by many authors (Weitz 1971; Veeck and Pannell 1989; Lin 1992; Kanbur and Zhang 2009; Tisdell 2009), regional specialization can be an important method of regional economic development. The role of individual entrepreneurships and local regional specialization in rural China was critical in the course of past rural development. This was discussed by Bellandi and Tommaso (2005), Whiting (2006), A. Chen (2002), Christerson and Lever-Tracy (1997), Putterman (1997), and Qiao, Li, and Kong (2006). In these discussions, SVs, as a lower level spatial entity than specialized towns (Bellandi and Tommaso 2005), were often identified as leading the direction of changes in a rural economy. This was especially apparent when SVs conglomerated to achieve scale economies (Coates, Johnston, and Knox 1977; Fuchs and Demko 1979).

To fully understand the role that SVs played in China's rural economy, this article proposes a conceptual framework that integrates three regional economic theories under the spatial imbalance theory (Ottaviano and Thisse 2004; Gardiner et al. 2013) to explain the imbalanced development of rural economies in Henan Province, an important region in China's rural economy for its size, location, and cultural position. The first theory is regional spatial structure theory, which explains the urban core (growth pole), rural areas (periphery), and the interrelation between them. The second is the multilevel network theory that allows the placement of villages of different functions into a hierarchical network. Finally, the spatial interface theory explains how economic factors aggregated different systems and how the growth pole and its peripheral areas were interrelated.

We begin our discussion with a brief description of the study area and the reason why it was chosen for this research. We then describe and discuss the geospatial analytics used in this work. Finally, we conclude our discussion by highlighting the polarization effect and spillover effect that were apparent in the studied area and time periods.

## Relevant Literature

In the wave of an expanding global economy, traditional rural development has been increasingly influenced by agricultural technology, industrialization, globalization, and other exogenous factors (Kaya 2007; Long, Zou, and Liu 2009; Li et al. 2010). To transform from a traditional agricultural society into a modern society, area specialization and cooperation were often encouraged as a way to stimulate economic growth in a rural areas (Habermas 1991; W. Zhang, Deng, and Zhang 2014). These methods can help to attain an economy of scale so that agricultural practices are more efficient, farmers are able to bargain for better prices, and

farming becomes friendlier to ecosystems and environments (Dobson and Matthes 1971; Fernández 2014).

Villages are important bases for implementing sustainable development and state policies (Taylor, Yunez-Naude, and Hampton 1999). This was especially the case in China, where the village-level economy was the key to developing rural economies (Qiao, Kong, and Li 2008). This is in line with the suggestion of Mills and McDonald (1992), who suggested that area specialization assisted the attainment of economies of scale with favorable external economies. SVs began to take off when they had developed to a stage that achieved a sizable spatial agglomeration, a significant milestone in the expansion of SVs. Achieving spatial agglomeration was an essential condition of realizing the optimization of rural development. It was a plausible solution for reducing the difference between urban and rural regions and for promoting agricultural economic development (Douglass 1998; Owusu 2005).

## The Concept of Specialized Villages

An SV is a rural settlement in which households engage in production or some interrelated commodities or service activities. Such activities constitute the main body of the social and economic values of this village (Li et al. 2010). We classified villages in China to be SVs if they meet the following requirements:

- SVs had to be, first of all, villages, from an administrative point of view (the equivalent of communities).
- For each SV, at least 50 percent of the entire village's output was produced by one or just a few particular leading industries, offering unique, marketable products by using certain scientific and technological processes.
- For each SV, revenue from the leading industries or products dominated the village's total income and was the main source of household incomes.
- For each SV, a majority of farmers were employed by the leading industries or participated in the production of the specialized products and corresponding business activities.

## The Role of Specialized Villages

The benefits of an SV included having an active economy, a diverse society, a larger population, and better use of environment and resources (Galloway, Sanders, and Deakins 2011). SVs could also have potential negative impacts, though, such as paternalism, a lack of ethnic diversity, and overextraction of local resources, among others (Clark 2006). In China, the contribution of SVs to rural development has been very significant in recent years. The total number of SVs in China was 45,650 in 2008, which was only 7.10 percent of all administrative villages. In that year, economic income from SVs was around US$219 billion, which was approximately 3.92 percent of China's gross domestic product (GDP) then. In time, the number of SVs increased to 54,217 in 2013, or 8.58 percent of all villages. In 2013, the economic income generated by SVs was US$431 billion, or 4.64 percent of China's GDP. In 2013, the average annual income per person in SVs was US$1,672, about 15 percent higher than the national average. In 2008, there were 1,569 SVs, each with a collective income exceeding US$16 million. There was a growth rate of 10.26 percent for the period from 2008 to 2013.

The average per capita income of all 487 SVs in Henan Province was US$933 in 2008, which was 45.46 percent higher than the average of the entire province. The minimum per capita income of all SVs was about US$693 and the maximum was US$7,071. Among all SVs, the highest total village income was US$961 million and the lowest was US$229,000 in 2008. Although SVs in Henan saw rapid growth in the villages' total income, their income levels were still low compared to those of SVs in coastal provinces.

## Existing Questions in Current Research

There remain some research questions to be addressed with regard to SVs. First, at the regional scale, existing literature mainly focused on SVs in developed countries, paying less attention to those in developing countries. This is especially true in the case of SVs in China. It is a gap in the research on SVs that desperately needs to be closed because SVs in China are unique in the way that they developed with an agricultural practice that had been developed over several thousands of years. Second, existing research mostly examined SVs from the perspectives of social injustice and less from the perspective of regional economic development. Third, most studies in the current literature tended to examine SVs from the viewpoint of political interests but not a search for solutions to problems of individual households and problems in agro-development in rural areas. Finally, existing literature provided only limited studies on the types of industries that SVs engaged, such as mining, lumber,

light manufacturing, or coal extraction. New or recently developed industries, such as special plants, aquaculture industry, and service industries in tourism that had been adopted by SVs, require more research to find out how they could be further promoted and made more efficient.

## Rural Development Theories

There are many theories that have tried to explain rural economic development, but these theories usually assign rural areas a lower status than urban areas and consider them as having a less important role than cities. To address this gap, we suggest that an integrated approach based on three theories could better explain and model the economic development in rural areas. Under spatial imbalance theory as the overall conceptual framework, these theories are regional spatial structure theory (RSST), multilevel network theory (MLNT), and spatial interface theory (SIT). Each is briefly discussed next.

### Regional Spatial Structure Theory

RSST is based on observations that the spatial structure of resource distribution in a region is closely related to the spatial patterns of economic activity (Ottaviano and Puga 1998; Granovetter 2005). In a region, there often existed a developmental imbalance between the growth core and peripheral areas. This might be due to either the uneven spatial distribution of resources or the different value-added ability between economic productions being engaged in peripheral areas and those in urbanized areas. RSST usually regarded rural areas as peripheral areas, hinterlands, outback areas, or areas that depend on urbanized areas as economic cores, following classical economic geography theories (Christaller 1966; Getis and Getis 1966; Berry 1968; Mulligan 1984; Sunley et al. 2005). Instead of simply distinguishing rural areas and urban areas, RSST in this article suggests that rural areas or urban areas were not homogeneous as indicated by the existence of interface areas between rural and urban.

If we considered rural areas as entities independent from urban areas, the issue of economic development in rural areas would in fact be a problem of how viable their locations are in accessing transportation routes and markets for their products and how capable their local resources (raw materials and labor force) are of supporting their economic activity. SVs in China had been successful in that they brought prosperity to rural areas and effectively increased the income of rural households. Their development seemed to suggest that rural areas were closing the income gap with that of urbanized areas, albeit slowly. Nevertheless, SVs had made significant imprints on the spatial structure of regional economies in China. In short, RSST provided the theoretical foundation for not regarding all rural areas to be at the same level of development and for regarding rural areas and urban areas to be at multiple levels of development.

### Multilevel Network Theory

It should not be a surprise that economic development in rural areas in China was not spatially even (Rozelle 1994; Yang 1999; Walder 2002; Marsden and Sonnino 2008). Areas with more advanced development could be regarded as developed points at a macro scale. They functioned as growth poles for the entire region (Takashi 2003). In rural China, SVs have been a very important element in the course of regional development, especially in less developed rural regions (Li et al. 2010). These SVs became growth poles from which spillover (trickling down) effects could take place to spread economic development to nearby villages.

In our study, we identified five levels of development clusters among SVs in Henan Province. The SVs were classified into five levels according to the practical criteria of SVs presented earlier. First, the highest level was the *specialized towns*, whose economic development was the most specialized and advanced in the region. They were SVs with other villages supporting them. There were only several of these in the entire Henan Province. These SVs were the growth poles in the region.

The second level was the clusters of *agglomerated SVs*. These SVs often had high levels of specialization in the economic activity in which they engaged. SVs in this level were the backbone of the region's economic development. They were the first group of SVs receiving the trickle-down growth from the specialized towns (growth poles).

Villages in the third level were SVs that had slightly lower levels of specialization than those in the second level. Still, SVs of this level made up the majority of all SVs and they were distributed throughout the entire province. Villages in the fourth level were *supporting SVs* that supported or serviced SVs of higher levels. They did so by providing land, labor, and other resources. Villages of the lowest (fifth) level were

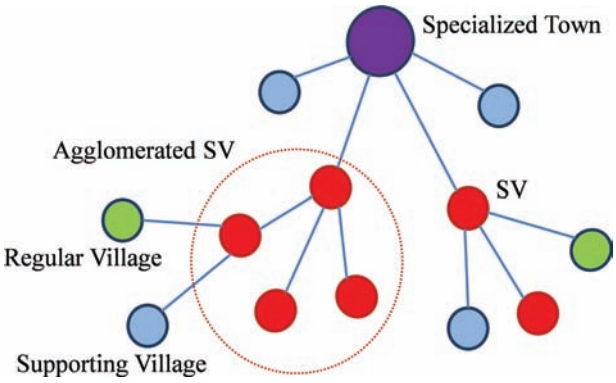


**Figure 1.** Multilevel network hierarchy of specialized villages (SVs). (Color figure available online.)

*regular or nonspecialized villages* that had existed for centuries. Given the right stimulus, and perhaps the right supports, from government, the supporting villages (level four) and regular villages (level five) could be developed into SVs or even become parts of SV agglomerations. If most villages in a town were transformed into SVs, this town is a specialized town.

The five levels of villages in the multilevel network hierarchy are described in Figure 1. In Figure 1, a specialized town can consist of many villages, including ordinary villages, SVs, and supporting SVs. The lines in Figure 1 describe the relationships among these different types of villages. Some specialized villages might be clustered to achieve an agglomeration economy. MLNT helps explain why SVs had different levels of specialization and why villages remained regular villages or support or serviced SVs.

## Spatial Interface Theory

Because urban and rural areas coexisted in a region, the transitional zone between these two areas likely possessed features from both but with lower intensity. Housing, for example, would be less dense than that in urban areas but denser than in rural areas. Similarly, farming activities in the transitional zone would be greater than in urban areas but less than in rural areas. This transitional zone is also known as the *spatial interface*. A transitional zone can also be identified between mountainous areas and plain areas.

SIT suggests that this transitional zone, however, often provides opportunities for new development because this zone provides cheaper land and lower rents than urban areas. At the same time, this zone possesses larger labor pools and has better access to transportation routes than rural areas. The concept of an interface between urban and rural areas has been applied elsewhere to examine how the transitional zone helps improve the flow of raw materials, energy, information, and people (Sutherland et al. 1984; Gránásy 1996; Pismen 2001; Hoffman 2009).

This transitional zone usually had less control by a city government and was more likely to have a diverse social and cultural environment. The concept of distance decay in geography fully explained the gradual decrease of the intensity of urban functions as places are farther from urbanized areas. This was also the case in Henan Province.

## Integrating Three Theories

RSST helped to explain the spatial structure of rural economic development. MLNT connected SVs into a hierarchy of different SVs to help understand the way agglomerations or clusters of SV were formed. Finally, SIT provided a way to explain how urbanized areas interacted with rural areas.

Using geometric forms to represent these theories, RSST saw SVs as polygons when considering the economic development of each rural area. MLNT saw SVs as points that were organized into different levels in a hierarchy and at different scales. Finally, SIT treated the interactions between urbanized areas (economic cores) and rural areas (peripheral areas) as lines. These lines might be physical linear features such as a river, a transit line, or a highway that connected urbanized areas to rural areas. They could also be symbolic or invisible lines, such as social relationships or cultural traits between people living in urbanized areas and those in rural areas. The analogues of these three theories to the three geometric forms were originated from considering them as matrices, corridors, and ecological nodes as discussed in Cantwell and Forman (1993) and Harris, Dickinson, and Whigham (2014). These three theories can be described by the configuration shown in Figure 2.

In summary, the fact that there were five types of SVs was the exact reason MLNT, SIT, and RSST were integrated. This is because MLNT explained the relationships among supporting villages, SVs, clusters of SVs, agglomerated SVs, and the growth poles. MLNT also explained the hierarchy of SVs. SIT explains why SVs by the growth pole were the first group to receive trickle-down economic growth. RSST, in turn, explained the imbalanced growth.

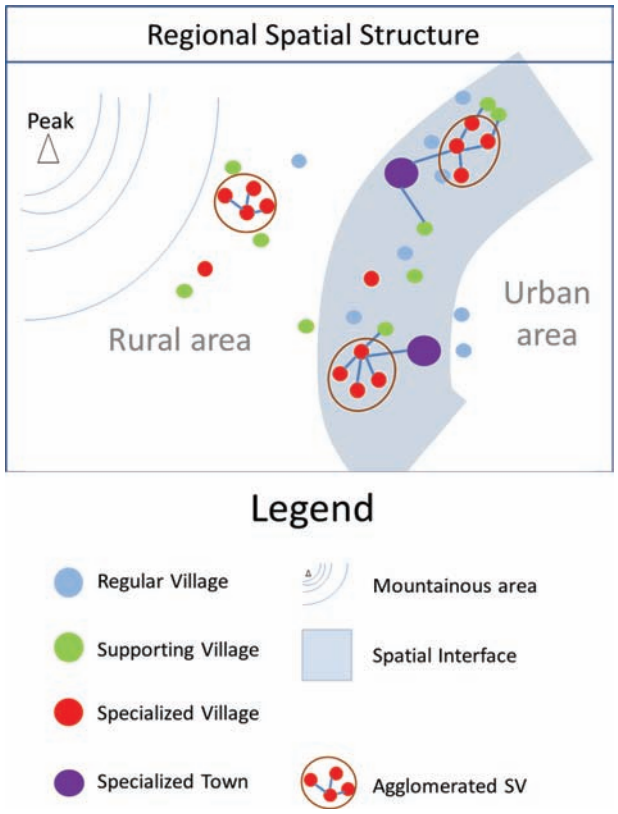


**Figure 2.** Integration of regional spatial structure theory, multilevel network theory, and spatial interface theory. *Note:* SV = specialized village. (Color figure available online.)

## Concept, Survey Region, and Data Processing

The definitions of SVs are different for different countries at different developmental stages or historical periods. Definitions of SVs have not been static, either. They have been dynamic and have been changed or adjusted gradually over time. For this study and based on the definition outlined earlier, an SV needed to have a leading industry that was responsible for at least 50 percent of the revenue in the SV. Alternatively, the revenue of households engaged in the leading industry or product management activity should take up at least half of the family's total income. For this study, we defined villages in Henan Province to be SVs if they met these criteria.

### Survey Region

Henan Province is located in the northern central part of China (Figure 3). Due to its large population, it is also a very important region in China's economic development. Henan is mountainous, coming off the Loess Plateau in the west. In addition, the northwestern and southern parts of the province are also mountainous regions. Most villages in the mountainous regions are small and lack economies of scale. As such, very few villages in mountainous regions ever developed into SVs.

Henan had a total population of about 106 million people as of 2013, accounting for 7 percent of China's population, giving it one of the largest populations among all provinces. Compared with other provinces, Henan is a unique province. It is the cradle of Chinese civilization, as it hosted many earlier dynasties in Chinese history. It has an important strategic position in national economic and social development (Qiao, Li, and Kong 2006). The annual per capita income of rural residents in Henan Province was US$1,356 in 2013, which was below the national average of US$1,423 (National Bureau of Statistics of China 2014) but was typical for rural areas in central China.

After the Central Plains Economic Zone (CPEZ) was set up by the Chinese State Department in 2012, Henan Province had become a model province for industrialization, urbanization, and agricultural modernization. From these rural areas, manual laborers had continued their exodus to cities in search of better employment opportunities and higher pay. Such migrating laborers did provide cheap labor to enterprises in cities (Murphy 2002; Jackson et al. 2005). With whatever labor force was left in rural areas, SVs could only engage in labor-intensive industries because there were no better alternatives for the peasants when they were not farming their fields. Given this, there were available labor reserves, lower opportunity costs, and lower operating costs in Henan. With the large population and a low level of urbanization, Henan was ripe for development of SVs.

### Data Processing

Based on our definitions for SVs, we selected 487 SVs from approximately 300,000 villages in Henan. The data for the 487 SVs came from the Provincial Rural Work Office (PRWO) and eighteen Municipal Rural Work Offices (MRWOs). A database of attribute information of the 487 SVs was built by assembling statistical data from the *Henan Province Statistics Yearbook* (China Statistics Press 2009b) and *China's Rural Statistical Yearbook* (China Statistics Press 2009a).

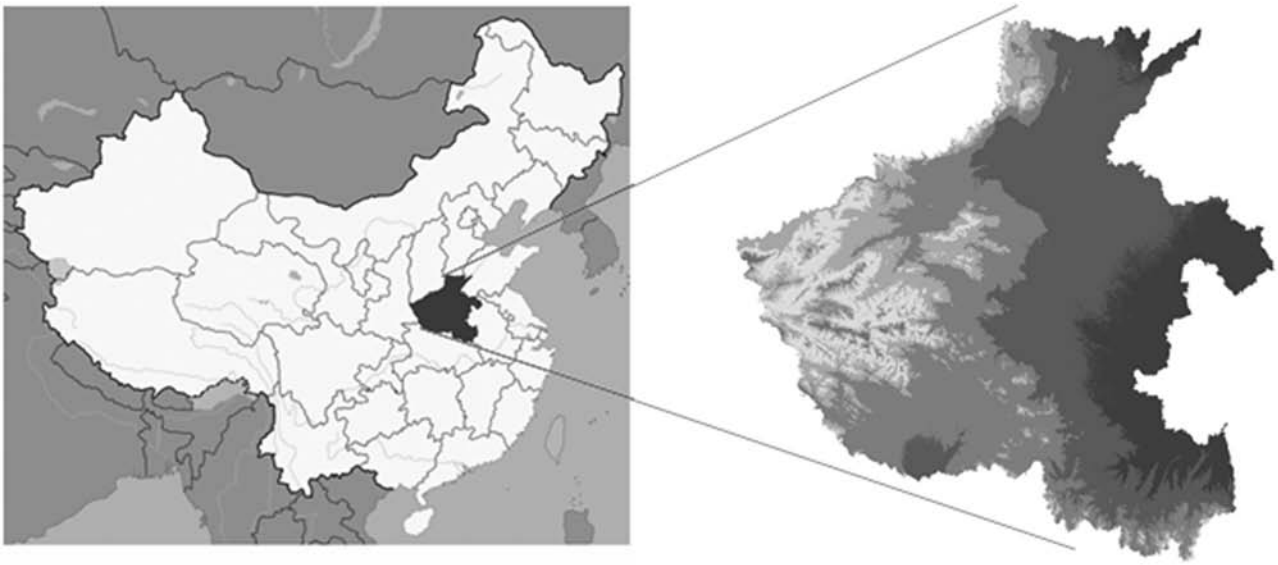

**Figure 3.** Location and topography of Henan, China. *Source:* Left graphic from http://mapsof.net/map/china-henan-location-map; right graphic from authors. Left image reproduced under the Creative Commons Attribution-Share Alike 1.0 License.

The attribute database consisted of seventy-one variables for each specialized village. These variables included population, labor size, area size, size of cultivated farmland, housing number and structure, an assortment of economic indexes, wage level and its structure, location information, the output value and products of leading industries, the sources of production cost and technology, markets, and sizes. Consequently, the attribute table was a matrix of 487 rows and seventy-one columns.

## Temporal and Spatial Evolution of SVs in Henan, China

The economic development in Henan had not been an even process spatially (Qiao, Kong, and Li 2008). There existed regional economic imbalances that would need further investigation and research to find ways to correct them. The evolution of SVs had been uneven over time as well, which also requires studies to understand its processes.

The database assembled from field surveys and from government statistics was valuable because it was the only such database that allowed us to look into the way SVs were formed, how SVs are related to each other, and the different pathways the different SVs took. Specifically, the mechanism of analysis proceeded as (1) using quantitative indexes (i.e., localized Moran's *I*) to assess the level of spatial agglomeration to verify whether indeed economies of scale contributed to and influenced the spatial imbalance of regional economic development; (2) analyzing the temporal trends of the numbers of SVs to detect the periods of time when the numbers of SVs saw significant changes; and (3) applying spatiotemporal scans with SatScan to identify the clusters that showed the characteristics of spatial and temporal clustering. The three steps of this analysis provided an integrated approach to examine the changing spatial structure of SVs. This is also an assembly of analytics that can be applied to other studies of spatiotemporal analysis.

### Temporal Evolution of SVs

The pace of development of SVs had been accelerating since the economic reforms started in 1978. As can be seen in Figure 4, the growth of SVs had

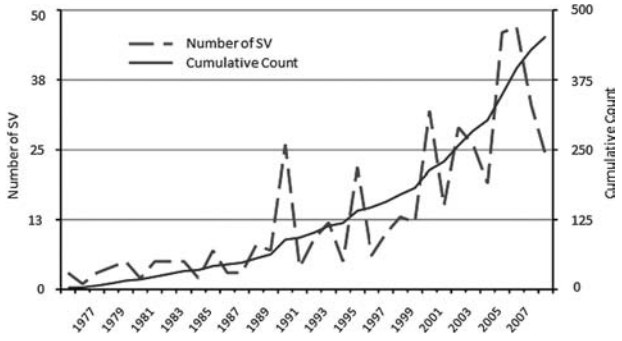


**Figure 4.** Temporal trend of specialized village (SV) growth in Henan Province, China, 1960–2008.

fluctuated between 1960 and 2008. Also, as described in Figure 4, there were four peaks in the number of SVs between 1960 and 2008: 1990, 1995, 2001, and 2005–2006. Two possible factors might have contributed to these phenomenal increases. First, external factors such as national policies on industrial development in those periods favored the establishments of SVs (Lin 1992; Rozelle, Pray, and Huang 1997; Lichtenberg and Ding 2008). As a result, the growing number of SVs was due to the inauguration of the Rural Household Contract Responsibility System proposed by Deng Xiaoping in 1978, the decentralized controls over state-owned enterprises since 1978, the implementation of China's opening-up policy and market-oriented reforms in 1992 (Meisner 1999), additional opportunities created by the Asian financial crisis in 1997, and the eleven-year effort for developing rural areas as the nation's top priority since 2004.

Second, this fluctuating developmental trend could also be the result of influences by internal factors of SVs. In general, agricultural SVs were easily formed because of the familiar production environment and the familiar product technology used. Those SVs engaging in secondary and tertiary industrial activities, however, needed more time to incorporate new technology and develop new markets. From the changing numbers of SVs in Figure 4, the cumulative number of SVs went from 20 in 1978 to 100 in 1992, 160 in 1997, and eventually 300 in 2004. These changes showed that there was an accelerating increasing trend. This has been especially significant since start of the twenty-first century when the newly emerged SVs accounted for 55.65 percent of the total. It suggested that SVs could be replicable prototypes for successful economic developments in rural China (Parish and Whyte 1980; X. Zhang and Hu 2013).

In China, most of the rural households tended to be small operations, and some scholars named them smallholders (Sharma et al. 2013). With limited available funding, these smallholders often had long waiting times before adopting new seeds and seeding methods, new technology, less polluting fertilizers, or any other new agricultural practices. Only after these smallholders witnessed the benefits of adopting new agricultural practices would they follow suit. Once that occurred, new practices quickly prevailed and continued to be used in adjacent communities. This temporal process would normally take one or more decades from initiation to formation. Now, however, the developmental cycle of SVs had been greatly shortened because of the gradual improvement in the level of educational attainment in rural households, the changing attitudes toward new technologies by farmers, and the encouraging external environments created by local and central governments (Spence 1990; Li et al. 2010; Geng 2014).

As shown in Figure 4, there were only twenty SVs by 1978 (i.e., nine SVs before 1978 and eleven in 1978), accounting for 2.26 percent of the total number of SVs in the entire historical period in Henan Province. Because 1978 was when China's economic reform started, the temporal evolution of the SVs can be examined starting with 1978. Since the reform, village-level economies had become increasingly prominent in China's economic development in rural areas (Qiao, Kong, and Li 2008). A nonlinear regression model was built to describe the temporal increases of SVs using SPSS 17.0 (IBM Corporation, Armonk, NY). The resulting curve is shown in Figure 5. The equation for this regression model is

$$y = 9.625E-67e^{0.079x} (R^2 = 0.995; F = 5437.008; Sig. = 0.000),$$

where $y$ is the cumulative number of SVs and $x$ represents years.

This model explains the temporal trend very well, with an $R^2$ value of 0.995 and a statistically significant $F$ value of 5,437. It should be noted that the fitted curve shows a reflection point soon after the year of 1978, suggesting that the time when SVs took off in numbers coincide

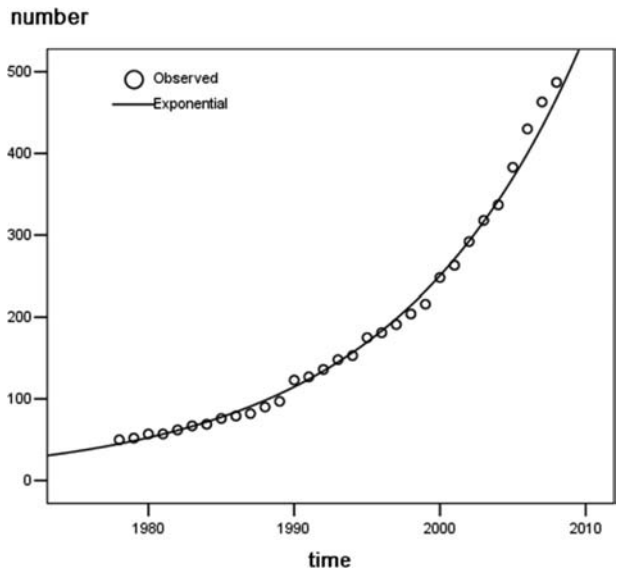


**Figure 5.** Regression model for the temporal evolution of specialized villages in Henan, China.

with the beginning of economic reform in China. This helped to reinforce the understanding of how governmental policy changes might affect the growth of rural economies. In addition, the identified temporal trend showed a nonlinear form, indicating that the increase in the number of SVs over time was not following a linear trend but proceeding in an accelerated manner.

## Spatial Distribution of SVs

In the context of regional spatial structure theory, the spatial distribution of SVs in Henan is indeed unique. First, the spatial distribution of SVs formed a multilevel core–periphery spatial structure. The two lines in Figure 6 connect three cities: Luoyang, Puyang, and Zhumadian. These lines delineate a triangular area of dense SVs in Henan. Inside this triangular area is the vicinity of Zhengzhou City, where the most SVs were located. Given the gradual reduction of the density of SVs as we moved away from Zhengzhou (the provincial capital), it seemed that Zhengzhou City was the core of economic activities, with its surrounding areas as the periphery. Similar to what was suggested by Veeck and Pannell (1989), this was mainly due to the higher level of urbanization inside the delineated region. This pattern is unique among other provinces in China when compared to what was described by Spencer and Horvath (1963). Notice that some areas immediately adjacent to Zhengzhou City show very low densities of SVs. This appears to be the polarization effect of Zhengzhou City being the growth pole, taking away the economic opportunities of these outskirt areas because any potential economic developments would have been drawn to nearby Zhengzhou City instead.

Second, as shown in Figure 6, most of the SVs in Henan were concentrated in the northern central parts of the province because counties with ten or more SVs were mostly in northern and central Henan. At the same time, counties in western, southern, and southwestern Henan have only a few SVs. The third trend that can be observed from Figure 6 is that there existed some "hollow areas" in southern and southwestern Henan where hardly any SVs. There were sixteen counties in this region forming a contiguous belt without any SVs. These counties were mostly located in the marginal regions with high elevations or in mountainous areas.

Overall, the spatial distribution of SVs in Henan did show evidence of a multilevel network in which specialized towns led regional economic growth, agglomerated SVs were formed by SVs engaging in similar productions, and individual SVs were integrated vertically or horizontally into the regional economic structure with supporting SVs. The connections between SVs of different levels are outlined in Figure 1.

Fourth, there were areas in Henan that were blocked out by governments from economic development. No SVs could be developed in these areas. For example, Zhongmou County was adjacent to Zhengzhou City, but industrial activity was prohibited here

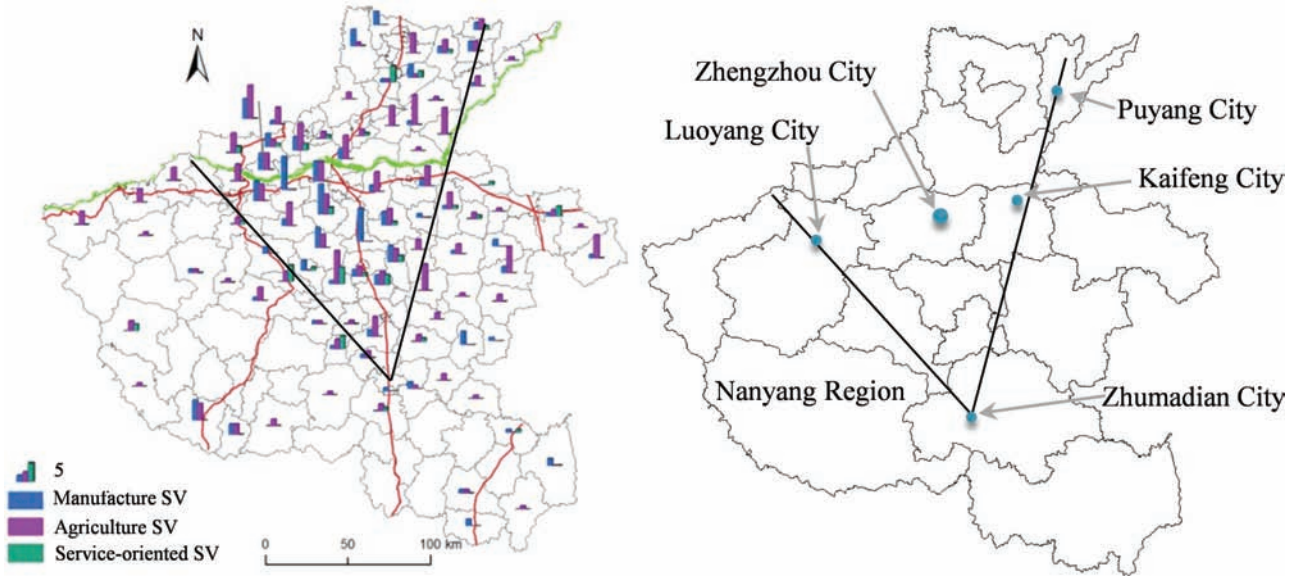


**Figure 6.** Spatial distribution of specialized villages (SVs) in Henan, China. (Color figure available online.)

for the purpose of protecting natural resources. Consequently, few SVs were established in that county.

### Spatial and Industrial Evolution of SVs

SVs did offer a welcome alternative to traditional farming and became an economic force in Henan's rural areas. According to regional spatial imbalance theory, the development of a region's economy often progressed in stages. Adopting this approach, the development of SVs in Henan Province was divided into four periods:

1. Before 1978, which was a period with a relatively balanced economic structure with an overall low level of industrial output.
2. Between 1978 and 1989, which was a period with a slightly more balanced economy among SVs and a period of upgrades to secondary and tertiary industrial activities.
3. In the 1990s, which was a period that began to see differential developments among SVs that resulted in economic inequality.
4. After 2000, which was a period of significant inequality but with an overall increase of industrial output from SVs.

In short, the spatial pattern of SV development in Henan Province had evolved from having a low-level homogeneity to having the spatial clustering pattern of inequality shown in Figure 7.

Before 1980, SVs existed only sparsely. By the 1980s, many SVs were established with secondary economic activity as the primary business. In addition, we witnessed the initial appearance of SVs engaging in tertiary economic activities, albeit only a few of them. We can also see that many new SVs were established for primary and secondary economic activities during the period between 1990 and 1999. Finally, the

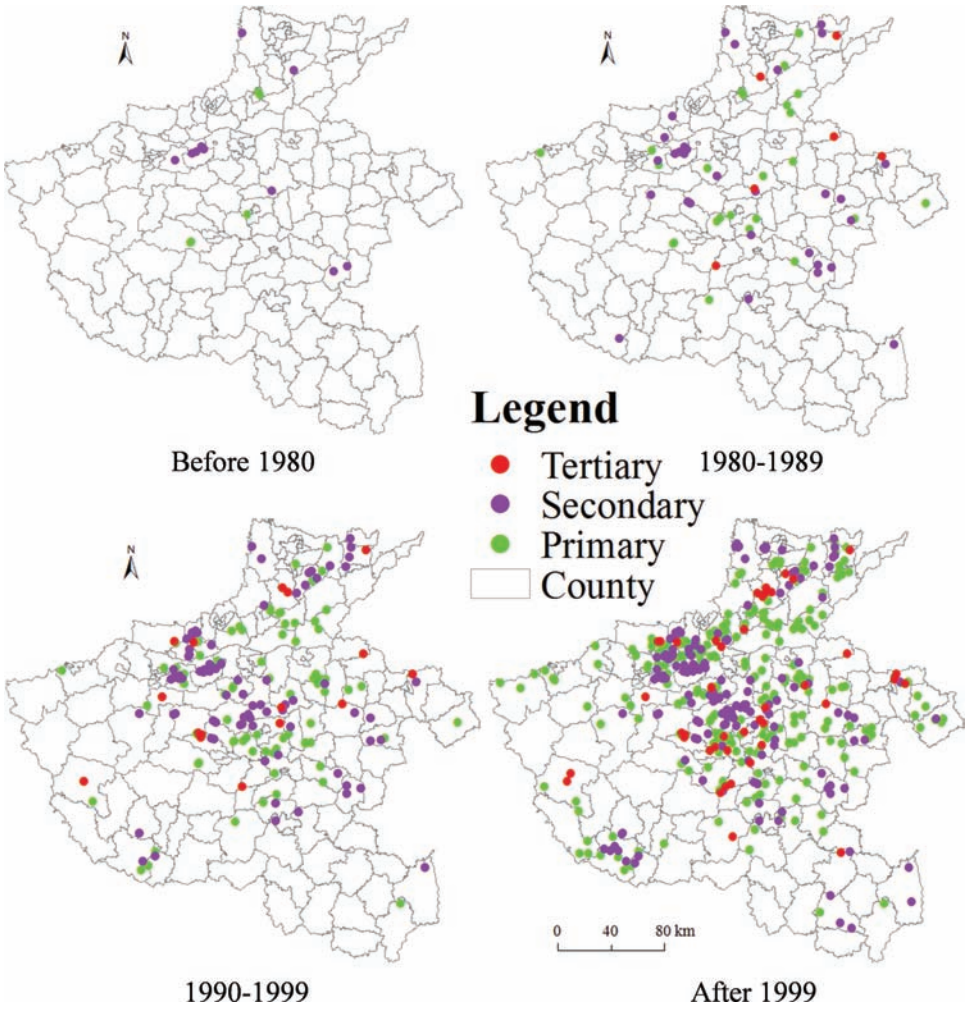


**Figure 7.** The spatial and industrial evolution of specialized villages in Henan, China. (Color figure available online.)

distribution of SVs after 1999 showed both a trend of continuing increases of SVs and engaging in tertiary economic activities.

*Relative Equality and Lower Industrial Level Period of SVs*

There were only a few SVs in Henan before 1978 when the economic reforms started, and they were scattered spatially. They were involved in traditional food processing industries, including tofu, tea, and vegetables. There were seven SVs added between 1978 and 1980. Some of these SVs exported fruits, vermicelli, or incense, whereas others shipped out supplies such as pipe fittings and screen equipment. The latter accounted for 85.7 percent of all economic output at the time. It was such a success that the outcome persuaded local government officials to further promote the economic structure of SVs (Perkins and Yusuf 1984; Ho 1994; Long 2014).

By the 1980s, the number of SVs had increased to forty-four. Geographically, SVs covered all of the seventeen regions listed in Table 1. During this period, SVs took on new industries, such as those in the primary sector: forestry nursery, wine making, and special planting and breeding of livestock. Among those SVs, some engaged in secondary sector economic activities, including beer production, stone and grass processing, jade carving, and production of steel measuring tapes and other metal products. At the same time, there were SVs engaging tertiary economic activities, such as wholesale and retail of grains, crafts made by wheat straw, and Chinese paintings. The period before 1990 was a golden era of industrial development in rural China (Long et al. 2011).

Before 1990, SVs were scattered only sparsely in Henan Province. As can be seen in Table 1, outputs from SVs in the period from 1978 to 1989 were more balanced among SVs than in the previous period (before 1978). Between these two periods, regions that had SVs increased from five to seventeen. Before 1978, the top five regions accounted for output from all of the SVs. Between 1978 and 1989, however, the top five regions accounted for only about 50 percent of total output.

*Imbalanced Industrial Development Period of SVs*

The number of SVs increased significantly during the 1990s. There were twice as many SVs as there were

**Table 1.** Spatial and industrial evolution of specialized village formation

| | Number of SVs | | | |
|---|---|---|---|---|
| Region | Before 1978 | 1978–1989 | 1990–1999 | After 2000 |
| Total | 9 ($I^5 + II^4$) | 52 ($I^{20} + II^{26} + III^6$) | 119 ($I^{57} + II^{51} + III^{11}$) | 271 ($I^{173} + II^{71} + III^{27}$) |
| Zhengzhou | 3 ($II^3$) | 4 ($I + II^3$) | 14 ($I^6 + II^8$) | 29 ($I^{14} + II^{13} + III^2$) |
| Kaifeng | | 4 ($I^2 + II + III$) | 8 ($I^5 + II^3$) | 12 ($I^8 + II^3 + III$) |
| Luoyang | | 3 ($I^2 + II$) | 11 ($I^4 + II^6 + III$) | 8 ($I^8$) |
| Pingdingshan | 3 ($I^3$) | 2 ($II + III$) | 10 ($I^3 + II^3 + III^4$) | 11 ($I^5 + II^4 + III^2$) |
| Anyang | 1 (II) | 3 ($I^2 + II$) | 4 ($I^2 + II^2$) | 16 ($I^9 + II^7$) |
| Hebi | | 3 ($I + II + III$) | 4 ($II^3 + III$) | 7 ($I + II + III^5$) |
| Xinxiang | 1 (I) | 3 ($I^3$) | 10 ($I^9 + II$) | 25 ($I^{21} + II^3 + III$) |
| Jiaozuo | | 2 ($II^2$) | 14 ($I^5 + II^7 + III^2$) | 46 ($I^{33} + II^{10} + III^3$) |
| Puyang | | 3 ($II^2 + III$) | 2 ($II^2$) | 12 ($I^{10} + II^2$) |
| Xuchang | 1 (I) | 5 ($I^3 + II^2$) | 17 ($I^6 + II^{10} + III$) | 28 ($I^{11} + II^{11} + III^6$) |
| Luohe | | 2 ($I + II$) | 3 ($I^2 + II$) | 4 ($I^2 + III^2$) |
| Sanmenxia | | 1 (I) | | 7 ($I^7$) |
| Nanyang | | 1 (II) | 7 ($I^4 + II^2 + III$) | 16 ($I^9 + II^6 + III$) |
| Shangqiu | | 5 ($I + II^2 + III^2$) | 3 ($I^2 + III$) | 13 ($I^9 + II^2 + III^2$) |
| Xinyang | | 1 (II) | 1 (I) | 7 ($I + II^5 + III$) |
| Zhoukou | | 8 ($I^2 + II^6$) | 6 ($I^5 + II$) | 15 ($I^{14} + II$) |
| Zhumadian | | 2 ($I + II$) | 5 ($I^3 + II^2$) | 15 ($I^{11} + II^3 + III$) |
| Average | 1.80 (1.67, 2.00, —) | 3.06 (1.64, 1.47, 2.00) | 7.00 (4.07, 3.64, 1.57) | 15.94 (10.18, 4.87, 2.27) |
| Standard deviation | 1.10 (1.15, 1.41, —) | 1.78 (0.81, 0.64, 2.00) | 4.99 (2.13, 2.90, 1.13) | 10.64 (7.72, 3.80, 1.74) |
| Coefficient of variation | 0.61 (0.69, 0.71, —) | 0.58 (0.49, 0.44, 1.00) | 0.71 (0.52, 0.80, 0.72) | 0.67 (0.76, 0.78, 0.76) |

*Note:* The number in the table is the number of SVs. I, II, and III indicate primary, secondary, and tertiary industries in which SVs engaged. Superscripts represent the number of SVs engaging in the corresponding industry. For average, standard deviation, and coefficient of variation, the overall value is reported for each time period along with corresponding values for the primary, secondary, and tertiary sectors listed in parentheses. SV = specialized village.

in the preceding period. Some of the regions listed in Table 1 had an increase of more than 300 percent in the number of SVs. Most SVs added during this period were in northern and central Henan. The total number of SVs in northern and central Henan increased to seventy-six, accounting for approximately two thirds of the SVs in Henan Province for this period.

In terms of industrial structure of SVs, the primary and secondary industries were still the dominant economic sectors during the 1990s. Combining the primary and secondary sectors, they accounted for 91 percent of all SV output in the 1990s (Table 2). Also, as shown in Table 1, the average output from these two industrial sectors showed significant increases.

If the period before 1980s could be considered the start of the era of sprouting SVs in Henan's rural areas, then the 1990s were a period of fast growth in SVs. This trend can be seen in the 1990–1999 column in Table 2, where the ratio of output value from the secondary industrial sector accounted for 94 percent of output values from all sectors (i.e., US$3.56 billion of a total of US$3.80 billion).

*Diversification and Spatially Clustering Period of SVs*

Since the turn of the century, all seventeen regions listed in Table 1 showed increased numbers of SVs. Comparing the values of averages, standard deviations, and coefficients of variation between those of the periods of the 1990s and those of the period since 2000 in Table 1, we can see that all regions gained in the numbers of SVs (averages increased from 7.00 to 15.94 SVs). The distribution had become widened with increased standard deviations (from 4.99 to 10.64). There was also a slight decline in the coefficients of variation, however (from 0.71 to 0.67). The top five regions that had the most SVs were also mainly located in northern and central Henan. The 147 SVs in these five regions represented 54 percent of all SVs in Henan.

Since 2000, there has been a clear trend that more SVs have started to engage in the tertiary economic sector. In this period, 10 percent of SVs with 12 percent of rural households produced nonagricultural industrial output that accounted for 4 percent of all economic output in Table 2, which was the highest level since SVs started to operate.

The key factors that affected the spatial distribution of SVs might include terrain, climate, and water resources. These were especially important for SVs that engaged in their early stages of development when they mainly focused on agriculture-related production. As pointed out by Ginsburg (1957), the possession of a sizable and diversified natural resource endowment would be a huge advantage in initializing a region's economy, so available natural resources could definitely help SVs to achieve rapid economic growth early on. Once SVs were established, their success would depend on transportation infrastructure, access to developed markets, and their political role, especially for nonagricultural SVs (Carlsson et al. 2012; Zhou and Qin 2012; Y. Chen, Hu, and Sweeney 2013).

**Table 2.** Evolution of specialized village structure in Henan, China

| Number of SVs | Before 1978 | 1978–1989 | 1990–1999 | After 2000 |
|---|---|---|---|---|
| SVs in I | 5 | 20 | 57 | 173 |
| SVs in II | 4 | 26 | 51 | 71 |
| SVs in III | 0 | 6 | 11 | 27 |
| Total of SVs | 9 | 52 | 119 | 271 |
| Ratio of I:II:III | 56:44:0 | 38:50:12 | 48:43:9 | 64:26:10 |
| Output value of I (US$ millions) | 3.94 | 27.98 | 188.06 | 732.06 |
| Output value of II (US$ millions) | 60.76 | 213.49 | 3,562.44 | 2,008.14 |
| Output value of III (US$ millions) | 0 | 5.61 | 47.57 | 101.81 |
| Total of output value (US$ millions) | 64.70 | 247.08 | 3,798.07 | 2,842.01 |
| Ratio of I:II:III | 6:94:0 | 11:86:2 | 5:94:1 | 26:71:4 |
| Households of I | 1,574 | 6,157 | 20,986 | 31,645 |
| Households of II | 2,043 | 6,920 | 15,263 | 16,926 |
| Households of III | 0 | 1,507 | 3,020 | 6,922 |
| Total of households | 3,617 | 14,584 | 39,269 | 55,493 |
| Ratio of I:II:III | 44:56:0 | 42:48:10 | 53:39:8 | 57:31:12 |

*Note:* I, II, and III represent primary, secondary, and tertiary industries. Conversion between Chinese yuan and U.S. dollar was calculated with a ratio of 6.945 to 1 (2008). SV = specialized village.

### Spatial Interface Areas

Nanyang City is the largest city in the Nanyang Basin in southwest Henan, which provided an ideal setting for understanding how SVs evolved in detail. As a representative example for SVs in Henan, we selected all SVs in Nanyang City and their corresponding supporting villages for in-depth study.

There are twenty-four SVs, ninety-six supporting villages, and 4,386 regular villages, according to the official data from the Nanyang Statistics Bureau. This study selected eighty-three villages that were dominated by agricultural production. They included thirteen agricultural SVs and their corresponding seventy supporting villages. The study performed three investigations: a pilot survey, a questionnaire survey of all selected villages, and a follow-up survey with telephone communication. The data collection was performed between April 2009 and September 2012.

Similar to the spatial differentiation in Henan Province, there existed inequality among SVs in Nanyang City in terms of their levels and economic output. As can be seen in Figure 8, SVs with larger industrial output were located in the transitional areas between mountainous areas and plains. In addition, there were no SVs that were within 60 km of Nanyang City downtown, which includes the urban–rural transitional areas. These two trends suggested that SIT was applicable to explaining the spatial distribution of SVs in the Nanyang Basin.

We found that there was a marginal zone, the interface edge of some administrative regions, located in many SVs and supporting villages if we enlarged the spatial scale and focused on the distribution of these SVs in the west of Nanyang City. An administrative marginal zone (AMZ) is a spatial interface between different administrative regions, and it can create an edge effect or border effect. For example, there was an obvious zone of SVs with a north–south orientation at the junction of four counties (i.e., Xixia, Neixiang, Xichuan, and Deng, as shown in Figure 8). A 5-km buffer zone around these counties, representing an AMZ, included sixteen SVs and their supporting villages that accounted for 54 percent of all villages in the four-county area in the Nanyang Basin. Based on results from the questionnaire survey, villages that were farther away from downtown Nanyang City had fewer technology, finance, transportation, market information, and policy information supports. This weakness led these villages to be mostly agricultural SVs, with relatively less developmental strength.

## Spatial Differentiation and Agglomeration in a Multilevel Network of SVs

### Measurement and Agglomeration of SVs

Regional integration and globalization of the economy resulted in uses of many resources being restructured

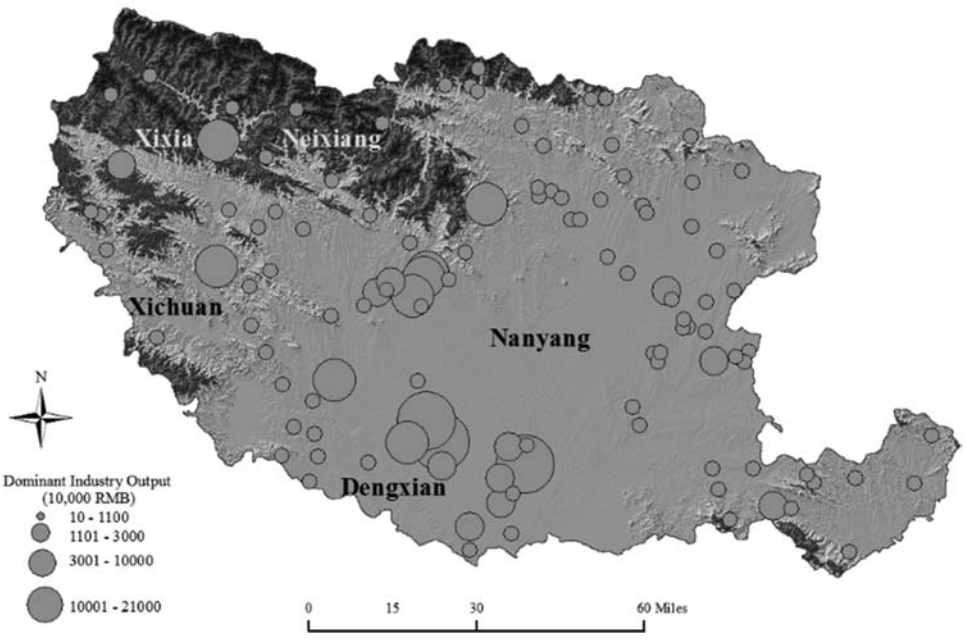


**Figure 8.** Industrial outputs from specialized villages in Nanyang Basin.

**Table 3.** The average nearest neighbor of specialized villages of Henan Province

| Index | Before 1980s | 1980s | 1990s | After 2000 |
|---|---|---|---|---|
| Observed mean distance | 0.195601 | 0.158105 | 0.093592 | 0.063714 |
| Expected mean distance | 0.253738 | 0.230290 | 0.157757 | 0.106431 |
| Nearest neighbor ratio | 0.770877 | 0.686548 | 0.593268 | 0.598641 |
| *Z* score | −3.160827 | −5.905920 | −11.435775 | −16.944469 |
| *p* value | 0.001573 | 0.000000 | 0.000000 | 0.000000 |

in rural areas (Grant and Nijman 2002). Empirical studies found that clustered SVs could reduce production costs but the SVs in developing countries generally lacked effective links to technical innovations. Only in the late stages of development were there joint operations and technology spillovers observed in SV clusters. In Henan Province, 453 of the 487 sampled SVs had records indicating exactly when they were established. Consequently, only those were used in the subsequent analysis.

First, Table 3 lists the values of nearest neighbor ratio. In addition, Table 3 also lists observed mean distances, expected mean distance, *Z* score, and associated *p* value for nearest neighbors. The results suggest that there existed statistically significant spatial clustering in terms of locations of SVs in each stage. Given the decreasing values of nearest neighbor ratio, it seemed that there had been an increasing degree of spatial agglomeration of SVs over time.

## Spatial Variation and Agglomeration of SVs

To observe spatial variation of agglomeration of SVs, SVs were aggregated by counties. The localized indicator of spatial association (LISA) was used to detect forms of spatial clusters. In general, output from applying LISA would show clusters of counties in four types, including high–high (HH), low–high (LH), low–low (LL), and high–low (HL). The HH type shows that the number of SVs in each county was high and neighboring counties also had high numbers of SVs. The LL type shows that the numbers of SVs in a county and its neighboring counties are all low. In Figure 9, counties belonging to these two types were shown in different colors to identify them as hot spots (HH) and cold spots (LL) by the number of SVs in each county.

Counties of HL type were in clusters where a county with many SVs was surrounded by counties of fewer SVs. Alternatively, counties of LH type are those with few SVs being surrounded by counties with many SVs. They typically had a strong negative spatial autocorrelation. Data for 453 villages were used to calculate LISA value by different stages using the GeoDa software (GeoDA Center, Tempe, AZ). Results are shown in Figure 9.

Using LISA, counties in Henan Province show their memberships in different types of spatial clusters. A hot spot (HH) of SVs started in the vicinity of Zhengzhou City before the 1980s. Note that according to LISA calculated for the period before the 1980s, many counties adjacent to Zhengzhou City appeared as cold spots (LL). These existed because economic opportunities were drawn to the growth pole, leaving limited prospects for the cold spots to grow. Before the 1980s, these counties were mainly concentrated in the second quadrant. In time, more counties appeared in the other quadrants, especially in the first quadrant in the 1980s. As indicated by Figure 9, the 1980s was a period when spatial agglomerations of SVs began to form.

## Spatial Cluster and Agglomeration of SVs

To study the evolution of SVs in Henan, all of the 453 SV that had years of establishment were selected. Using a space–time permutation model in SatScan (http://www.satscan.org; Harvard Medical School and Harvard Pilgrim Health Care Center, Boston, MA)), a total of eight spatiotemporal clusters were detected. As shown in Figure 10 and Table 4, only two detected clusters were statistically significant. One of these two clusters contained fourteen SVs (colored in red). They were in a transition zone from mountainous terrains to piedmont plains in northwest Henan. This region has a flat terrain surface with a well-developed transportation infrastructure. In this spatial cluster, there were ten agricultural SVs, two industrial SVs, and two service-oriented SVs. The SVs in this cluster originated from gardening and aquaculture industries in 1993. A

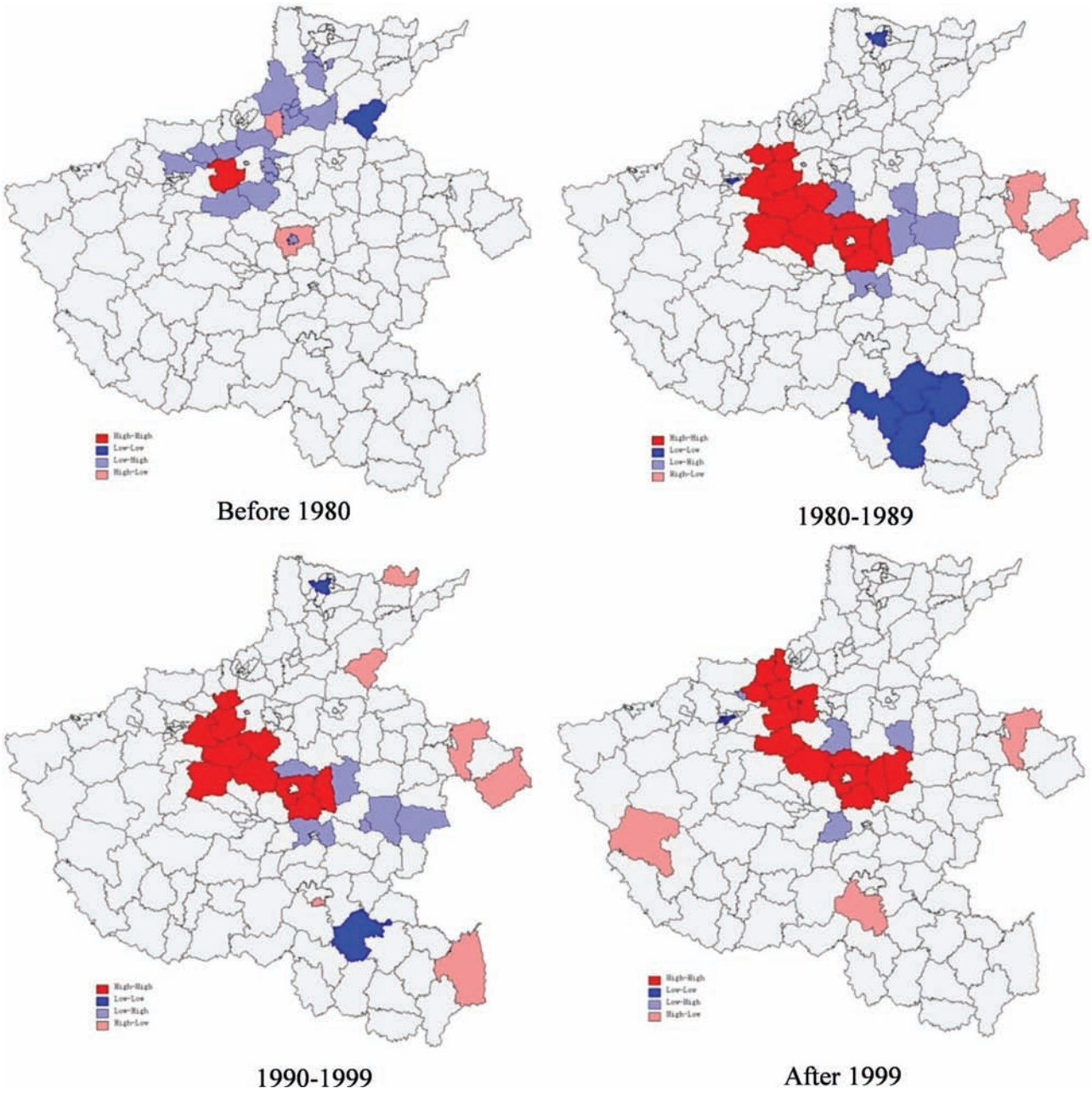


**Figure 9.** Localized indicator of spatial association (LISA) of specialized villages of Henan Province. (Color figure available online.)

significant expansion of SVs in this cluster occurred in 2007. Based on their locations, the SVs in this cluster seemed to have taken advantage of the transportation infrastructure available to them. Using data collected via field surveys, initial capital investments in the SVs in this cluster seemed to be from local sources. Specifically for initial investment, about 45 percent came from personal savings, 23 percent from relatives, and 27 percent from bank loans. Outside investment constituted less than 5 percent.

The second cluster was located in piedmont plains (colored in pink), also in a plains–mountain transitional zone in the central part of Henan Province. There were three agricultural SVs in this spatial cluster, all formed in 1967. Their leading industry was cultivation of vegetables, mostly by small growers using traditional means. Their produce was shipped to nearby markets in urban areas. Given that SVs in each of these two clusters engaged in very similar economic activities, it could be argued that spreading the

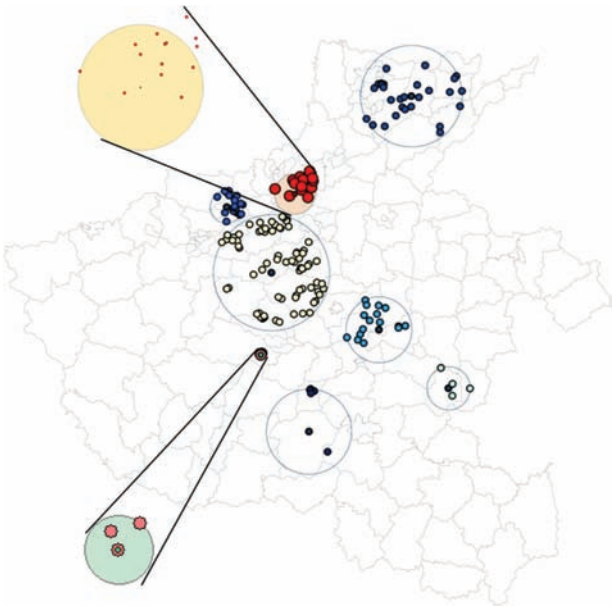

**Figure 10.** Space–time analysis and the identified specialized village clusters. (Color figure available online.)

concept and the ways of operations of SVs to villages in close proximity was how spatial agglomeration of SVs formed (Xu et al. 2006).

In terms of marketing products produced by SVs in the two clusters, local markets consumed about 26 percent (Cluster 1) and 21 percent (Cluster 2). Henan Province, as the market, consumed 41 percent (Cluster 1) and 50 percent (Cluster 2).

## Discussion and Conclusions

SVs normally had strong ties to their surrounding rural areas, especially in less economically developed regions. With prosperous SVs in a region, the surrounding areas could benefit from what that SV brought to the region. The classic polarization and trickle-down (spillover) effects explained this relationship perfectly. Based on what we observed from SVs in Henan, the interplays between polarization and trickle-down effects were significant. For example, the areas immediately adjacent to Zhengzhou City, the provincial capital, did not have any SVs because economic opportunities mostly went to Zhengzhou instead of those rural areas. As the spatial cluster of SVs expanded over time, the trickle-down effect was evident when the spatial distributions changed from what they were before and after 2000.

**Table 4.** Status of eight clusters

| Cluster number | Number of SVs | Time frame | Test statistic | *p* value |
|---|---|---|---|---|
| 1 | 14 | 2007 | 13.899 | 0.0014 |
| 2 | 3 | 1967 | 12.068 | 0.010 |
| 3 | 75 | 1990–1992 | 9.216 | 0.326 |
| 4 | 7 | 2003 | 8.012 | 0.774 |
| 5 | 5 | 1978–1983 | 7.449 | 0.924 |
| 6 | 17 | 1995–1996 | 7.339 | 0.947 |
| 7 | 21 | 1962–1997 | 7.228 | 0.961 |
| 8 | 29 | 2006–2008 | 6.737 | 0.995 |

*Note:* SV = specialized village.

SVs in Henan Province seem to have developed in stages. Each stage showed distinctive characteristics in terms of how even or uneven performance of SVs was, how the number of SVs increased and clustered spatially, and how SVs went from primarily focusing on the primary and secondary economic sectors to embracing the tertiary economic sector. Overall, the development of SVs did benefit rural areas in China by providing ways to actively participate in economic production with the natural resources and labor forces available to them.

The spatial agglomeration of SVs was important for the development of rural areas. SVs were developed in accordance with the division of labor, increasing returns of scale, and external economies. With SVs developed in a region, the region could further promote the development of specialized industrial zones. The trend in Henan that SVs went from a homogeneous spatial distribution to a spatially clustered pattern suggested the play-out of polarization and trickle-down effects.

In developing countries or regions, there were usually five forms and grades of population settlements, such as specialized towns, clusters of agglomerated SVs, SVs and their supporting villages, and regular villages from the perspective of specialization. These different types of settlements usually formed a multilevel networked hierarchy. Rural areas of lower economic levels were usually less specialized and were usually supporting villages for SVs or other villages. Villages with higher levels of specialization in what they produced were often those with better resource endowment or better access to regional markets. Unlike most existing studies in the literature that tended to focus mainly on urban systems and settlement systems, we adopted the approach of classifying villages to different grades of SVs or specialized towns so that it was possible to see where economic progress was most effective and how these SVs benefited their surroundings.

We suggest that SIT is a better theory for interpreting the distribution of SVs and how they changed

spatially and temporally. Many SVs were in areas of spatial interface between urban and rural areas, between plains and mountains, and between cities and AMZs. The study presented here focused more on human elements, including how the urban and rural areas developed and the role of governmental policies.

Historically, SVs did not appear randomly. They were formed in places with natural resources or with better access to markets via some form of transportation. Once SVs were formed in an area, more could appear in nearby locations to take advantage of scale and external economies. There would be forward and backward linkages between industries taken on by SVs. The evolution of space structure of SVs often resulted in a division of labor and specialization of industries among villages. In addition, any success achieved by SVs would require other villages to provide labor and other raw materials. In this manner, supporting villages were recruited to support SVs by providing labor, helping with marketing and sales, providing needed lands, and so on. This was in stark contrast to other existing studies in which most rural areas were regarded merely as fringe areas at best. This study treated SVs as a specialty engine and the core elements of this rural development that likely would also bring economic progress to the other rural areas.

The formation, growth, and agglomeration of SVs played a critical role in rural economic development. Studies that analyze villages tend to reveal more details of the mechanisms of regional economic development in rural areas. Depending on the scale, each SV could be regarded as an area in which specialized production and industrial activities functioned as its economic base. Systematically studying a collection of SVs would allow us to better understand how the different functions work for individual SVs as well as for a cluster of SVs. On the other hand, each SV can be regarded as a point in a larger region. Studying how individual points functioned in the region as a whole would allow us to see the region's economic development in a holistic view, which would allow better and more effective policies to be formulated and implemented.

Finally, we wish to highlight the sequence of analytical procedures in applying spatial statistics to assess the level and patterns of spatial dependency as exhibited by the locations of SVs. With that revealed, the application of hot and cold spot analysis helped to discover the agglomeration of SVs for the purpose of understanding economies of scale. The use of SatScan, in turn, allowed the identification of statistically significant clusters of SVs. Such identification enabled us to carry out in-depth analysis of the types of economic activities and market links of SVs in the clusters. Overall, this assembly of geospatial analytics provided a feasible approach to studying imbalanced economic development in rural China.

## Funding

Funding for this research came from the National Science Foundation of China (NSFC Grants 41171150, 41329001) and the MOE Project of Key Research Institute of Humanities and Social Sciences at Universities (No. 14JJD790011).

## References

Bellandi, M., and M. Tommaso. 2005. The case of specialized towns in Guangdong, China. *European Planning Studies* 13 (5): 707–29.

Berry, B. 1968. Interdependency of spatial structure and spatial behavior: A general field theory formulation. *Papers in Regional Science* 21 (1): 205–27.

Cantwell, M., and R. Forman. 1993. Landscape graphs: Ecological modeling with graph theory to detect configurations common to diverse landscapes. *Landscape Ecology* 8 (4): 239–55.

Carlsson, F., H. He, P. Martinsson, P. Qin, and M. Sutter. 2012. Household decision making in rural China: Using experiments to estimate the influences of spouses. *Journal of Economic Behavior & Organization* 84 (2): 525–36.

Chen, A. 2002. The structure of Chinese industry and the impact from China's WTO entry. *Comparative Economic Studies* 44 (1): 72–98.

Chen, Y., W. Hu, and S. Sweeney. 2013. Resource availability for household biogas production in rural China. *Renewable and Sustainable Energy Reviews* 25:655–59.

China Statistics Press. 2009a. *China rural statistics yearbook, 2009*. Beijing, China: China Statistics Press.

———. 2009b. *Henan Province statistics yearbook, 2009*. Beijing, China: China Statistics Press.

Christaller, W. 1966. *Central places in southern Germany*. Englewood Cliffs, NJ: Prentice-Hall.

Christerson, B., and C. Lever-Tracy. 1997. The third China? Emerging industrial districts in rural China. *International Journal of Urban and Regional Research* 21 (4): 569–88.

Clark, J. 2006. *Company town in America 1880 to 1930*. Arcata, CA: Humboldt State University.

Coates, B., R. Johnston, and P. Knox. 1977. *Geography and inequality*. Oxford, UK: Oxford University Press.

Dobson, W., and R. Matthes. 1971. University–agribusiness cooperation: Current problems and prognosis. *American Journal of Agricultural Economics* 53 (4): 557–64.

Douglass, M. 1998. A regional network strategy for reciprocal rural–urban linkages: An agenda for policy research with reference to Indonesia. *Third World Planning Review* 20 (1): 1–33.

Fernández, E. 2014. Trust, religion, and cooperation in western agriculture, 1880–1930. *The Economic History Review* 67 (3): 678–98.
Fuchs, R., and G. Demko. 1979. Geographic inequality under socialism. *Annals of the Association of American Geographers* 69 (2): 304–18.
Galloway, L., J. Sanders, and D. Deakins. 2011. Rural small firm's use of the Internet: From global to local. *Journal of Rural Studies* 27:254–62.
Gardiner, B., R. Martin, P. Sunley, and P. Tyler. 2013. Spatially unbalanced growth in the British economy. *Journal of Economic Geography* 13 (6): 889–928.
Geng, X. 2014. Chinese aquatic farmers' participation in modern marketing channels. *British Food Journal* 116 (5): 780–91.
Getis, A., and J. Getis. 1966. Christaller's central place theory. *Journal of Geography* 65 (5): 220–26.
Ginsburg, N. 1957. Natural resources and economic development. *Annals of the Association of American Geographers* 47 (3): 197–212.
Gránásy, L. 1996. Diffuse interface theory for homogeneous vapor condensation. *The Journal of Chemical Physics* 104 (13): 5188–98.
Granovetter, M. 2005. The impact of social structure on economic outcomes. *Journal of Economic Perspectives* 19 (1): 33–50.
Grant, R., and J. Nijman. 2002. Globalization and the corporate geography of cities in the less-developed world. *Annals of the Association of American Geographers* 92 (2): 320–40.
Habermas, J. 1991. *The structural transformation of the public sphere: An inquiry into a category of bourgeois society*. Cambridge, MA: MIT Press.
Harris, K., K. Dickinson, and P. Whigham. 2014. Functional connectivity and matrix quality: Network analysis for a critically endangered New Zealand lizard. *Landscape Ecology* 29 (1): 41–53.
Ho, S. 1994. *Rural China in transition: Non-agricultural development in rural Jiangsu, 1978–1990*. Oxford, UK: Clarendon.
Hoffman, D. 2009. The interface theory of perception: Natural selection drives true perception to swift extinction. In *Object categorization: Computer and human vision perspectives*, ed. S. Dickinson, A. Leonardis, B. Schiele, and M. Tarr, 148–65. New York: Cambridge University Press.
Jackson, S., A. Sleigh, L. Peng, and L. Xi-Li. 2005. Health finance in rural Henan: Low premium insurance compared to the out-of-pocket system. *The China Quarterly* 181:137–57.
Kanbur, R., and X. Zhang. 2009. *Governing rapid growth in China: Equity and institutions*. London and New York: Routledge.
Kaya, Y. 2007. Globalization, industrialization and social class in less developed countries, 1980–2005. Unpublished doctoral dissertation, Duke University, Durham, NC.
Li, X., J. Qiao, R. Li, G. Gao, X. Fan, C. Zheng, and L. Lu. 2010. *Rural development research of central China*. Beijing: Science Press (in Chinese).
Lichtenberg, E., and C. Ding. 2008. Assessing farmland protection policy in China. *Land Use Policy* 25 (1): 59–68.
Lin, J. 1992. Rural reforms and agricultural growth in China. *The American Economic Review* 82 (1): 34–51.
Long, H. 2014. Land consolidation: An indispensable way of spatial restructuring in rural China. *Journal of Geographical Science* 24 (2): 211–25.
Long, H., J. Zou, and Y. Liu. 2009. Differentiation of rural development driven by industrialization and urbanization in eastern coastal China. *Habitat International* 33 (4): 454–62.
Long, H., J. Zou, J. Pykett, and Y. Li. 2011. Analysis of rural transformation development in China since the turn of the new millennium. *Applied Geography* 31 (3): 1094–1105.
Marsden, T., and R. Sonnino. 2008. Rural development and the regional state: Denying multifunctional agriculture in the UK. *Journal of Rural Studies* 24 (4): 422–31.
Meisner, M. 1999. *Mao's China and after: A history of the People's Republic*. 3rd ed. New York: Simon and Schuster.
Mills, E., and J. McDonald. 1992. Editors' introduction. In *Sources of metropolitan growth*, ed. E. Mills, and J. McDonald, xiii–xxv. New Brunswick, NJ: Center of Urban Policy Research, Rutgers University.
Mulligan, G. 1984. Agglomeration and central place theory: A review of the literature. *International Regional Science Review* 9 (1): 1–42.
Murphy, R. 2002. *How migrant labor is changing rural China*. Cambridge, UK: Cambridge University Press.
National Bureau of Statistics of China. 2014. *China statistical yearbook 2014*. Beijing: China Statistics Press.
Ottaviano, G., and D. Puga. 1998. Agglomeration in the global economy: A survey of the "new economic geography." *The World Economy* 21 (6): 707–31.
Ottaviano, G., and J. Thisse. 2004. Agglomeration and economic geography. *Handbook of Regional and Urban Economics* 4:2563–2608.
Owusu, G. 2005. The role of district capitals in regional development: Linking small towns, rural–urban linkages and decentralisation in Ghana. *International Development Planning Review* 27 (1): 59–89.
Parish, W., and M. Whyte. 1980. *Village and family in contemporary China*. Chicago: University of Chicago Press.
Perkins, D., and S. Yusuf. 1984. *Rural development in China*. Baltimore, MD: Johns Hopkins University Press.
Pismen, L. 2001. Nonlocal diffuse interface theory of thin films and the moving contact line. *Physical Review E* 64 (2): 021603 (1–9).
Putterman, L. 1997. On the past and future of China's township and village-owned enterprises. *World Development* 25 (10): 1936–55.
Qiao, J., Y. Kong, and X. Li. 2008. Analysis of types and changes of village-level economy in rural Gongyi City, Henan Province since 1990. *Chinese Geographical Science* 18 (2): 1–8.
Qiao, J., X. Li, and Y. Kong. 2006. Status and dynamic change of regional man–land system in view of micro-level quantitative aspect: Case study of Gongyi city of Henan Province. *Chinese Geographical Science* 16 (1): 9–17.
Rozelle, S. 1994. Rural industrialization and increasing inequality: Emerging patterns in China's reforming economy. *Journal of Comparative Economics* 19 (3): 362–91.
Rozelle, S., C. Pray, and J. Huang. 1997. Agricultural research policy in China: Testing the limits of

commercialization-led reform. *Comparative Economic Studies* 39 (2): 37–71.
Sharma, V., B. Vorley, J. Huang, A. Suleri, L. Digal, and T. Reardon. 2013. *Linking smallholder producers to modern agri-food chains: Case studies from South Asia, Southeast Asia and China*. New Delhi: Allied.
Spence, J. 1990. *The search for modern China*. New York: Norton & Company.
Spencer, J., and R. Horvath. 1963. How does an agricultural region originate? *Annals of the Association of American Geographers* 53 (1): 74–92.
Sunley, P., B. Klagge, C. Berndt, and R. Martin. 2005. Venture capital programmes in the UK and Germany: In what sense regional policies? *Regional Studies* 39 (2): 255–73.
Sutherland, R., C. Dähne, J. Place, and A. Ringrose. 1984. Immunoassays at a quartz–liquid interface: Theory, instrumentation and preliminary application to the fluorescent immunoassay of human immunoglobulin G. *Journal of Immunological Methods* 74 (2): 253–65.
Takashi, K. 2003. Specialization and diversification in agricultural transformation: The case of West Punjab, 1903–92. *American Journal of Agricultural Economics* 85 (2): 372–86.
Taylor, J., A. Yunez-Naude, and S. Hampton. 1999. Agricultural policy reforms and village economies: A computable general-equilibrium analysis from Mexico. *Journal of Policy Modeling* 21 (4): 453–80.
Tisdell, C. 2009. Economic reform and openness in China: China's development policies in the last 30 years. *Economic Analysis & Policy* 39 (2): 271–94.
Veeck, G., and C. Pannell. 1989. Rural economic restructuring and farm household income in Jiangsu, People's Republic of China. *Annals of the Association of American Geographers* 79 (2): 275–92.
Walder, A. 2002. Markets and income inequality in rural China: Political advantage in an expanding economy. *American Sociological Review* 67 (2): 231–53.
Weitz, R. 1971. *From peasant to farmer: A revolutionary strategy for development*. New York: Columbia University Press.
Whiting, S. 2006. *Power and wealth in rural China: The political economy of institutional change*. New York: Cambridge University Press.
Xu, B., P. Gong, E. Seto, S. Liang, C. Yang, S. Wen, D. Qiu, X. Gu, and R. Spear. 2006. A spatial–temporal model for assessing the effects of intervillage connectivity in Schistosomiasis transmission. *Annals of the Association of American Geographers* 96 (1): 31–46.
Yang, D. 1999. Urban-biased policies and rising income inequality in China. *American Economic Review* 89 (2): 306–10.
Zhang, W., Y. Deng, and S. Zhang. 2014. On the new mode of production of agricultural modernization: Conception and the policy suggestion of establishing the countryside Datong's society. In *SHS Web of Conferences*. Vol. 6, 212–18. Les Ulis Ceder, France: EDP Sciences.
Zhang, X., and D. Hu. 2013. Overcoming successive bottlenecks: The evolution of a potato cluster in China. *World Development* 63:102–12.
Zhou, Y., and Y. Qin. 2012. *Empirical analysis on income inequality of Chinese residents*. New York: Springer.

JIAJUN QIAO is a Professor in the Key Research Institute of Yellow River Civilization and Sustainable Development and the College of Environment and Planning at Henan University, KaiFeng, Henan 475001, China. E-mail: jjqiao@henu.edu.cn. His research focuses on Economic Geography, especially on rural economic development.

JAY LEE is a Professor in the Department of Geography at Kent State University, Kent, OH 44242 and an Adjunct Professor in the College of Environment and Planning at Henan University. E-mail: jlee@kent.edu. His research stems from a broad interest in the areas of spatio-temporal analysis of geographic events/objects. Lee directs Kent State Applied Geography Lab, organizes the annual Applied Geography Conferences, and edits the journal of *Papers in Applied Geography*.

XINYUE YE is an Assistant Professor in the Department of Geography and Director of Computational Social Science Lab at Kent State University, Kent, OH 44240. E-mail: xye5@kent.edu. His research interests include space-time analytics, social network analysis, and urban/economic geography.