The effects of Taobao villages' spatiotemporal agglomeration on urbanization:
A case study of Quanzhou, Fujian

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Abstract: The agglomeration of the rural e-commerce industry represented by Taobao villages has reshaped the existing urban and rural spatial organization and proposed a new urbanization model. This study identified the spatiotemporal characteristics of Taobao villages in Quanzhou city and built panel regression models to examine the impact of these villages on urbanization level, which is measured via nighttime light (NTL). The results show that (1) while the number of Taobao villages in Quanzhou city has increased rapidly, it has also experienced sporadic growth and monocentric agglomeration, finally forming a polycentric agglomeration pattern; (2) Taobao villages display a significant near-city tendency, and the urbanization level of towns with Taobao villages is higher than that of towns without Taobao villages; (3) the panel regression model highlights that Taobao villages have a significant positive impact on urbanization level. Taobao villages near the city exhibit a greater effect; meanwhile, those that are far away from the city cannot improve their urbanization level unless they reach a considerable degree of agglomeration. Rural e-commerce will become an important direction for the transformation of urban fringe areas, which provides a certain reference for the development of new urbanization in China.

Keywords: rural e-commerce; Taobao village; new urbanization; nighttime light; Quanzhou city

1　Introduction

In the rapidly changing Internet age, information and communication technology (ICT) has become an important means to promote the coordinated development of urban and rural areas (Salemink *et al*., 2015; Hodge *et al*., 2016). Specifically, the wide application of ICT in rural areas has provided new opportunities (Mathur and Ambani, 2005; Mukherjee, 2011). The application of e-commerce in rural China is in full swing, with rural residents selling products online based on Alibaba Group's Taobao (https://www.taobao.com/), which has

reached a large scale (Guo *et al*., 2014; Liu *et al*., 2015; Leong *et al*., 2016; Wang *et al*., 2021). Alibaba proposed the concept of "Taobao village"[1] and "Taobao town"[2] (AliResearch, 2014), which has attracted extensive attention worldwide. Taobao villages are considered an effective way to strongly promote regional transformation and rural revitalization, but they have only grown in a few places. Hence, there is an urgent need to summarize its spatiotemporal evolution characteristics and then help other areas to boost rural economic vitality and narrow the income gap between urban and rural areas.

In rural China, which has also undergone swift changes, Taobao villages are considered a new path for urbanization (Lin *et al*., 2016; Lin, 2019). The popularization of rural ICT has broken the asymmetric situation of urban–rural information and the predicament that rural resources flow to urban areas (Davies, 2021). Cities are no longer the only spatial carriers that connect global production networks and local industrial clusters; to some extent, rural areas also provide a suitable stage for the emergence, agglomeration, diffusion, and prosperity of e-commerce (Salemink *et al*., 2015; Liu *et al*., 2020; Wei *et al*., 2020). Perspectives on the relation between Taobao villages and urbanization are complex. Some studies have discussed the theoretical possibility of Taobao villages contributing to the urbanization level (Lin, 2019; Wang *et al*., 2021); others have found spillover effects of urbanization in suburban Taobao villages (Lin *et al*., 2022), and even some Taobao villages far from cities have been urbanized from below (Leong *et al*., 2016). The influence of Taobao villages on the development of urbanization is worth exploring. China is examining a new path of urbanization that can avoid the problems of overurbanization and slum formation in cities while sustaining the development of the countryside and improving the life of rural people. We must scrutinize the recent development of Taobao villages and examine forces that shape the trajectories of urbanization.

However, according to the general statistical standards of urbanization, such as urban populations, land-use area, and industrial structure (Casis and Davis, 1946; Ledent, 1980; Dewan and Yamaguchi, 2009), these measurements suffer from some limitations. In China, socioeconomic indices are typically derived from statistical data and lack country–level spatial information; therefore, they are problematic for the spatial distribution analysis of urban development (Yang *et al*., 2019). Nighttime light (NTL) remote sensing data, which use sensors to record NTLs on the Earth's surface, can detect artificial lights from cities, towns, and industrial areas (Elvidge *et al*., 2017) and have shown good performance in measuring urbanization (Zhang and Seto, 2011; Xu *et al*., 2014; Gao *et al*., 2015). Therefore, this study treats NTL data as a composite index of urban development.

The main goals of this study are (1) to better understand the spatiotemporal agglomeration characteristics of Taobao villages in a typical city and (2) to discuss the impacts of Taobao villages on urbanization. This study proposes the theoretical possibility that Taobao villages promote urbanization, but studies have not provided empirical evidence to show the extent to which such urbanization is promoted. Since Taobao villages show significant spatial ag-

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[1] As defined by AliResearch, Alibaba's research division, a "Taobao village is a cluster of rural e-tailers where at least 10% of village households engage in e-commerce or at least 100 online shops have been opened by villagers; and total annual e-commerce transaction volume in the village is at least RMB 10 million ($1.6 million)."

[2] A "Taobao town" is a higher-level rural e-commerce phenomenon developed based on the Taobao village. According to AliResearch, a town or subdistrict with three or more Taobao villages is called a Taobao town.

glomeration characteristics, the question is whether the greater agglomeration of Taobao villages promotes urbanization. To address these research goals, this study takes Quanzhou city as the empirical study area and identifies the characteristics and spatial trends of Taobao villages in the period 2014–2020. Panel regression models are used to analyze the impact of Taobao villages on urbanization level and explore the path that describes how urbanization level is driven by Taobao villages with different location characters. Finally, this study discusses the implications and limitations of the empirical results from the perspective of promoting urbanization level through rural e-commerce in other rural areas in China and even developing countries. This study hopes to broaden the scope of existing literature on new urbanization, which has not empirically examined the role of Taobao villages.

2 Literature review

2.1 New urbanization from below

After its reform and opening up, China has experienced rapid urbanization (Zhang *et al*., 2003; Gu *et al*., 2017), which has taken a unique course and is perhaps the greatest human resettlement experiment in history, unprecedentedly transforming Chinese society in an extremely short period (Chan, 2010; Tan *et al*., 2016; Guan *et al*., 2018). However, rural residents have been uninvolved in the urbanization process. The seizure of resources from rural areas via urbanization has led to a deeper regulation of rural China. This urban–rural siphonic effect has promoted city prosperity but has led to the decline of many rural villages, which have suffered from depopulation as a result (Liu *et al*., 2010), presenting a challenge to urbanization sustainability in China (Long *et al*., 2011; Li *et al*., 2018).

The last decade has witnessed China focus more on the development of small towns and propose some new urbanization models; that is, small and medium-sized towns are supposed to strengthen industry, increase income, and change their citizens' way of life as urban residents rather than concentrating the rural population in large cities through large-scale and long-distance migration (Zhu, 2010; Zhou *et al*., 2018; Zhu *et al*., 2021). The in situ transformation of rural areas has been driven by two main forces. First, urban regimes are playing a more parasitic role in generating urbanization (Murphy and Carmody, 2019). The government hopes to relocate remote rural inhabitants to nearby towns and facilitate better housing conditions and access to services (Zhu, 2010; Su *et al*., 2011; Liu *et al*., 2014). Such new urbanization often displays a significant spatial agglomeration with the combined influence of siphon and spillover effects in large cities, and its spatial scope has expanded to the periphery with large cities as the center (Li *et al*., 2018; Zhou *et al*., 2018). It also has brought about many physical changes to the previously rural landscape (Zhu, 2010; Long, 2014). Second, the development of township and village enterprises and the inflow of foreign investment have been highly effective in transforming the rural employment structure (Shen and Ma, 2005; Zhu, 2010). A weak industrial base at the origin has been identified as a major barrier to rural–urban transformation (Zhu *et al*., 2021; Yang *et al*., 2022).

The emergence of Taobao villages can be regarded as a new urbanization from below, which questions the traditional urbanization path of concentrating population and industry in (or near) large cities (Leong *et al*., 2016). A city is a place created by producers and consumers to provide transaction opportunities and reduce transaction costs (Tan *et al*., 2011).

In rapid urbanization, rural areas have been in a disadvantaged position, but the emergence of e-commerce has lifted the restrictions of "transaction opportunities" and "transaction costs" (Garicano and Kaplan, 2001) and has put forward new urbanization from below. Meanwhile, e-commerce has created a decentralization force in rural areas, which drives local economic development and improves consumption level and the quality of residents' life (Liu *et al*., 2015; Cui *et al*., 2016; Liu *et al*., 2021). Traditional urbanization is based on the idea of the centralized allocation of resources through material aggregation, and cities are the gathering places of material resources (Abdel-Rahman and Anas, 2004), while e-commerce is based on information aggregation and the decentralized allocation of resources, which enable small towns and even rural areas to be developed into new cities (Wei *et al*., 2020). In the information age, one of the keys to new urbanization is to change from a centralized urbanization path with the central city to a distributed urbanization path with small towns and even remote rural areas. E-commerce reconfigures the socioeconomic environment and physical space of rural areas. Through the Internet and logistics networks, the development of Taobao villages has directly connected a large number of scattered rural areas in China to modern society, freeing them from their isolation from or dependence on urban development for industrial and transportation reasons, thus providing a new path toward rural revitalization (Lin *et al*., 2022).

2.2   Spatial agglomeration and urbanization process of Taobao villages

Taobao villages have rapidly expanded in recent years, reflecting the regional disparity of the distribution of these villages. Most Taobao villages aggregate in Eastern China (Liu *et al*., 2020), including southern Jiangsu, central Zhejiang, southeastern Fujian, and the Pearl River Delta (Shan and Luo, 2017; Zhu *et al*., 2016), with a sharp gradient from the eastern coast to the western inland, showing significant gradient characteristics (Qian *et al*., 2017; Liu *et al*., 2020; Wang and Wang., 2020; Wei *et al*., 2020). The agglomeration Taobao villages has been positively correlated with the local economy and urban hierarchy (Wang and Xu, 2011), but local dislocation was observed (Shan and Luo, 2017). There are exceptions to this (Shan and Luo, 2017). Cheap land rents in rural areas are the fuse for Taobao villages. These villages have had a demonstrably strong effect in rural areas and are expanding rapidly, with the dramatic increase in the number of Taobao villages in suburban areas, and already showing a trend toward urban centers (Lin *et al*., 2022).

The large number of suburban Taobao villages seems to indicate that urbanization has strengthened these villages. The first and foremost factor is talent spillover, where capable people who have accumulated e-commerce experience in cities return to rural areas to start their own businesses, which is the trigger for Taobao villages. Typical Taobao villages, such as Bainiu village in Lin'an district, Zhejiang province, and Sunzhuang village in Caoxian county, Shandong province, have been driven by the return of skilled people to set off a wave of e-commerce ventures. Second, urban expansion and the extension of transportation and logistics warehousing to rural areas provided convenience for Taobao villages. Third, the industrial spillover effect of cities has helped rural areas achieve industrial transformation. The relocation of industries in the cities to the periphery and the sale of light industrial products in rural areas through the Internet were the prototypes of Taobao villages. Urban productive services, such as e-commerce, advertising, finance, and branding, have in-

dustrial spillover effects as well, allowing rural areas to engage in e-commerce.

The essence of urbanization lies in the development of the economic, social, and spatial structures of a region or country (Guan *et al*., 2018). Many studies have also reported on rural China's spontaneous urbanization under the influence of ICT.

(1) Economic structure. Information technology is a fundamental mechanism for integration into the contemporary global economy (Castells, 2011). ICT and the networked economy have accelerated the de-agriculturalization process in rural areas and have changed the rural economic model and daily life of rural societies (Sørensen, 2000; Oreglia, 2014). New urbanization that involves the role of e-commerce has deviated from the traditional development path of "primary industries, secondary industries and tertiary industries" and has opened a leapfrog path of information-driven urbanization (Liu *et al*., 2015). The rise of e-commerce has stimulated diverse employment opportunities and has broadened rural residents' income channels, which has narrowed the income gap between urban and rural citizens, and has created several rural entrepreneurs and wealthy groups (Luo and Niu, 2019; Tang and Zhu, 2020; Wang *et al*., 2021). A growing number of villages in China have experienced similar processes of economic reconfiguration of cultural pluralism (Long and Woods, 2011; Long *et al*., 2015; Leong *et al*., 2016).

(2) Social structure. ICT has become a dominant factor in reconfiguring social relations within Chinese villages and influencing the daily life of residents. ICT has empowered marginalized communities, forming a bottom–up development of rural e-commerce systems (Leong *et al*., 2016). Rural e-commerce has also attracted a large number of young laborers returning from cities and has alleviated social problems resulting from a "hollow village" (Liu *et al*., 2010). Rural residents could travel more frequently between urban and rural areas to achieve a more comprehensive personal development (Lin *et al*., 2016) and even increase their knowledge through the Internet. It has also improved the intelligence of rural residents, and the new generation is well nurtured. In addition, it has been crucial for the stability of rural society and the construction of a harmonious society (Zhou *et al*., 2021). Rural e-commerce has also promoted the modernization of rural life. With regard to rural material consumption, rural residents could consume the same variety of goods and services with better quality enjoyed by urban residents. In terms of rural cultural life, farmers have become fully motivated to connect through the Internet, which has opened up external communication channels in rural areas. Modern cultural information and ideology have laid a good social foundation for shaping modern vernacular culture and integrating urban civilization (Luo, 2020).

(3) Spatial structure. New urbanization has diminished the limitations of location conditions through ICT, and the e-commerce industry has accelerated the spatial reconfiguration process (Yang, 2022). Taobao villages involve informal land-use planning with the active participation of the grassroots. The less stringent the regulatory environment in the countryside, the higher the joint contribution of the government's tolerance and acquiescence to the development of industrialization and new urbanization. In the initial stage, farmers have fully used their self-built houses and courtyards to engage in e-commerce activities, which mix various functions such as residence, office, processing, and storage (Wei *et al*., 2020; Luo, 2020). With the continuous emergence of e-commerce, the new spatial demand for e-commerce services, such as production processing, logistics and express delivery, adver-

tising, and financial service, has grown rapidly (Tang and Zhu, 2020; Luo, 2020). Specialized division and industrial chain extension have led to a significant spatial urbanization process and have improved the intensive utilization of land. Taobao villages have helped reconfigure the rural space, with the single, chaotic spatial pattern developing into a more diversified and clustered space (Lin *et al*., 2016; Lin, 2019).

3 Methodology

3.1 Study area

Quanzhou is located southeast of Fujian province (Figure 1), and is well-known for its private economy, which is similar to the Wenzhou model. In 2020, Quanzhou's GDP exceeded 1 trillion yuan, and the city's economic development was mainly supported by textile and garment, footwear, building material and household, and food industry clusters. Quanzhou is a typical city for the deep integration and development of traditional industrial clusters and e-commerce. In 2020, even in the face of the impact of the COVID-19 pandemic and the global economic downturn, Quanzhou's online retail sales reached 257.40 billion yuan, with an increase of 34.9%, higher than the province's growth rate of 10.2%. Specifically, the retail sales volume in rural Quanzhou reached 193.93 billion yuan, up 34.7%, which is higher than the province's growth rate by 6.1%, ranking first in Fujian province. Quanzhou city operates its online retail activities mainly on Alibaba's Tmall and Taobao and also has the most Taobao villages in Fujian province with 238, accounting for 54% of the province's total.
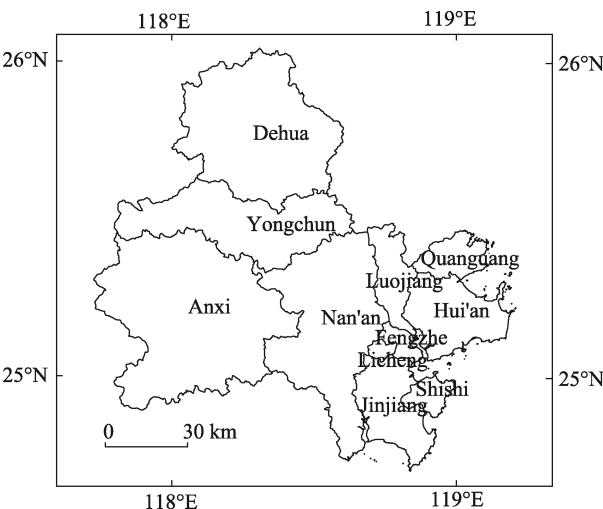
Figure 1 Location of Quanzhou city

3.2 Data

The annual SNPP-VIIRS NTL data from 2014 to 2020 were generated using the median value of each year's monthly composite data. Version 1 of the monthly SNPP-VIIRS NTL composite data (vcm version) was selected and accessed by the Earth Observation Group at the Colorado School of Mines (https://eogdata.mines.edu/). This dataset's spatial resolution is 15 arc-seconds and is in nano-W cm^{-2} sr^{-1}. It is noted that this dataset could be contami-

nated by stray light in the mid- to high-latitude regions, especially during the summer. The contaminated pixels are reassigned as 0 according to the monthly data generation scheme (Elvidge *et al*., 2017). To avoid further contamination when using these monthly NTL data to generate annual NTL data, we used each pixel's median value instead of the traditional average value among all monthly SNPP-VIIRS NTL data during an entire calendar year (Chen *et al*., 2021; Chen *et al*., 2022).

To filter and eliminate the pixels with noises and abnormal NTL intensity, we set up a two-part preprocessing model according to the previous studies (Ma *et al*., 2014; Shi *et al*., 2014; Chen *et al*., 2022). First, we set a threshold value of 1 nano-W cm^{-2} sr^{-1} to filter the dark background; that is, when a pixel has an NTL intensity lower than this threshold value, it will be excluded from further analysis. Second, following Shi *et al*. (2014), we identified and calibrated pixels with abnormal NTL intensity. When a pixel's NTL intensity is higher than the maximum value in large cities in China, it was identified as an abnormal pixel. Large cities can be selected based on their global city rankings from the Globalization and World Cities (GaWC) Research Network (Taylor, 2010). This study selected Shanghai and Beijing as the top two cities in China. These pixels were then reassigned as the maximum NTL intensity within this pixel's eight neighbor pixels.

3.3 Methods

3.3.1 Urban structure division

This study used the threshold method to divide the urban–rural structure of Quanzhou city into four areas: urban core, urban expansion, urban fringe, and unurbanized. First, we consider the urban built-up area as the urban core area. The urban built-up area refers to the location within a city administrative district that is actually developed and constructed. Usually, the built-up area is the city's economic development center, and its municipal public facilities and public facilities are perfect. It is generally believed that the higher the NTL intensity, the higher the possibility of being an urban area (Shu *et al*., 2011). This paper extracted urban built-up areas based on two assumptions: (1) available urban statistics are relatively reliable and can basically reflect the total characteristics of urban built-up areas in Quanzhou, and (2) urban built-up areas in Quanzhou are continuously increasing in the NTL data image. The built-up area was extracted by setting the threshold and comparing it with statistical data, and the threshold was constantly adjusted until the total area of the urban built-up area extracted based on NTL data was closest to the statistical data; that is, a certain threshold is considered the optimal threshold for this city in a particular year. Table 1 lists the extraction results and rates of deviation. Second, the area with an NTL less than 1 is usually characterized by a low intensity of human economic activities, which is defined as the unurbanized area in this study. To test the scientific nature of unurbanized areas, we selected typical remote rural areas in Shangqing and Lefeng Towns for verification; if the threshold is raised, some large rural settlements will be included. Third, a large area remains between the urban core area and the unurbanized area. This study analyzes the fluctuation degree of NTL; an urban expansion area is defined by a higher NTL value and a lower fluctuation degree, and this threshold is about half of the built-up area. Finally, the remaining areas can be classified as urban fringe areas.

Table 1 Extraction urban built-up area through NTL data

Year	Urban built-up area	Extraction area	Rate of deviation (%)
2014	197.6	197	–0.30
2015	206.5	198	–4.12
2016	214	205	–4.21
2017	220	212	–3.64
2018	226	228	0.88
2019	230	222	–3.48
2020	235	245	4.26

Note: Data of urban built-up area come from annual statistical bulletin of Quanzhou

3.3.2 Kernel density estimation

The kernel density estimation is a nonparametric method for calculating probability density functions, which uses a smooth peak function to fit observed data points, thus simulating the real probability distribution curve. Kernel density is estimated as follows:

$$f_h(x) = \frac{1}{n}\sum_{i=1}^{n}K_h(x-x_i) = \frac{1}{nh}\sum_{i=1}^{n}K\left(\frac{x-x_i}{h}\right) \tag{1}$$

where $x_1, x_2, \ldots, x_n$ is the independent and identically distributed n samples of Taobao villages, h is optimal bandwidth, and $K(.)$ is the scaled kernel function.

3.3.3 Panel regression models

To examine the impact of Taobao villages on urbanization level, this study developed panel regression models. We used the urbanization level in Quanzhou city as the dependent variable, and the explanatory variables include four types of independent variables: rural e-commerce, industrial base, social services, and control. Table 2 lists the descriptions of all these variables as well as the data sources used to define and quantify them. We used the mean NTL to reflect the level of urbanization as NTLs have been shown to correlate with many urban development indicators. In general, higher NTL intensity indicates higher levels of urbanization (Zhang and Seto, 2011; Xu *et al*., 2014; Gao *et al*., 2015; Yang *et al*., 2019). The model's core variable is the number of Taobao villages (TVs), and we used the number of Taobao towns (TTs) to represent the agglomeration of Taobao villages. Taobao villages have requirements for the number and volume of rural e-commerce transactions, and a large gap is observed between Taobao villages and non-Taobao villages. The number of Taobao villages can be used to measure the state of rural e-commerce within a township. Because of limitations in statistical data, we could not obtain the specific turnover of Taobao villages to measure their scale, and we used a binary classification of whether they are Taobao or non-Taobao towns. Taobao towns with three or more Taobao villages indicate a large industrial scale and agglomeration effect.

Studies have shown that a good industrial base is important in nurturing Taobao villages (Liu *et al*., 2020; Wei *et al*., 2020; Lin *et al*., 2022), and when these villages grow to a certain scale, they also produce e-commerce-related tertiary industries (Wei *et al*., 2020; Zhou *et al*., 2021), which can also enhance urbanization. Because this study focuses on township-

Table 2   Indicator selection

Variable		Indicator	Data source
Urbanization	Urb	Mean value of NTL	SNPP-VIIRS NTL
Rural e-commerce	TVs	Number of Taobao villages	Aliresearch
	TTs	Number of Taobao towns	2014-2020
Industrial base	Sec	Number of industrial enterprises above the scale	
	Ter	Number of accommodation and catering enterprises	Quanzhou Statistical
Social services	Sto	Number of stores	Yearbook 2015-2021
	Fin	Number of financial institutions	
Control variables	Pop	Population	Quanzhou Statistical
	Ass	Assets	Yearbook 2015-2021

scale urbanization, the number of industrial enterprises above the scale (Sec) was used as an indicator for industrial development level, and the number of accommodation and catering enterprises (Ter) was used as an indicator for tertiary industry development level.

Taobao village development is closely linked to public services. For example, Taobao villages have expanded the size and mobility of the population, creating greater demand for commerce (Wang *et al.*, 2021). Similarly, online transactions have increased the demand for financial services such as banking. These public services can enhance urbanization level, measured using the number of general shops or supermarkets with a business area of 50 square meters or more (Sto) to assess the level of retail services in rural areas. Also, the number of financial institutions (Fin) was used to measure the level of regional financial services.

The control variables in this study were household population and total regional assets. The data were mainly obtained from the Quanzhou Statistical Yearbook and Aliresearch.

Based on this, the following panel data regression model is introduced:

$$Y_{it} = \alpha_i + \beta_0 + \beta_1 X_{1it} + \beta_2 X_{2it} + \ldots\ldots + \beta_4 X_{4it} + \mu_{it} \tag{2}$$

where i represents the region and t represents the time, y is the vector of the town's NTL, X is the vector of explanatory variables such as industrial foundation and public services, and β is the vector of regression coefficients estimated. The overall error is denoted by ε.

4   Results

### 4.1   Spatiotemporal characteristics of Taobao villages

The number of Taobao villages in Quanzhou city has grown dramatically while showing the characteristics of significant agglomeration; spatial expansion has also undergone the three stages of sporadic growth, monocentric agglomeration, and finally, the formation of a poly-centric agglomeration pattern.

In 2014, Quanzhou city had 17 Taobao villages distributed among 11 townships, showing an overall sporadic pattern (Figure 2a), with Jinjiang city and Anxi county accounting for six and five villages, respectively. The former is an area with a highly developed garment industry, similar to the Wenzhou model, and the emergence of Taobao villages is an online

manifestation of the traditional Wenzhou model. The latter is a typical representative of remote and poor areas, with extremely weak secondary and tertiary industries; the presence of Taobao villages here also means that backward areas can make use of information technology to realize digital upgrading and industry transformation.

In 2017, the number of Taobao villages in Quanzhou city grew sharply to 124, and the number of towns covered rose to 31. The spatial clustering of Taobao villages has evolved from sporadic to monocentric agglomeration (Figure 2b). The core of Taobao villages is highly concentrated along the bay of Jinjiang and Shishi, while some small Taobao village clusters are formed in Dehua county, Anxi county, and Nan'an city. These secondary clusters were also found to be mainly distributed in the townships around the administrative center. At this stage, the development paths of new Taobao villages are both proximity diffusion in the original agglomeration cores and noncontact diffusion through the independent generation of new cores.

The Taobao villages in Quanzhou city increased to 238 in 2020, and their spatial pattern became more diversified (Figure 2c). Based on the core clustering area centered on Jinjiang and Shishi, the continuous increase in Taobao village clustering has formed a large-scale Taobao village cluster, and the clustering effect is further strengthened. The government played an important role in guiding and supporting the spatial clustering and expansion of Taobao villages along the bay area. Strong policy support, infrastructure advantages, and a strong industrial base accelerated the clustering of Taobao villages. Besides this huge agglomeration core, the original smaller agglomeration cores in Dehua county, Anxi county, and Nan'an city area also showed strong
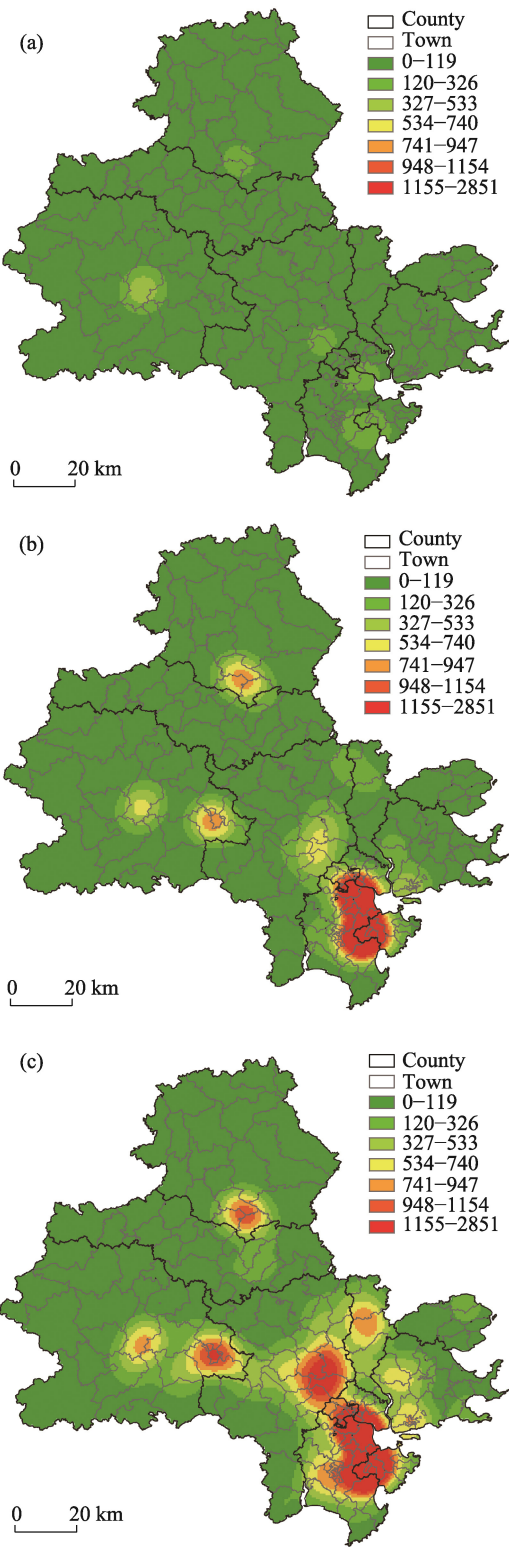
Figure 2   Kernel density estimation of Taobao villages in Quanzhou city in 2014 (a), 2017 (b), and 2020 (c)
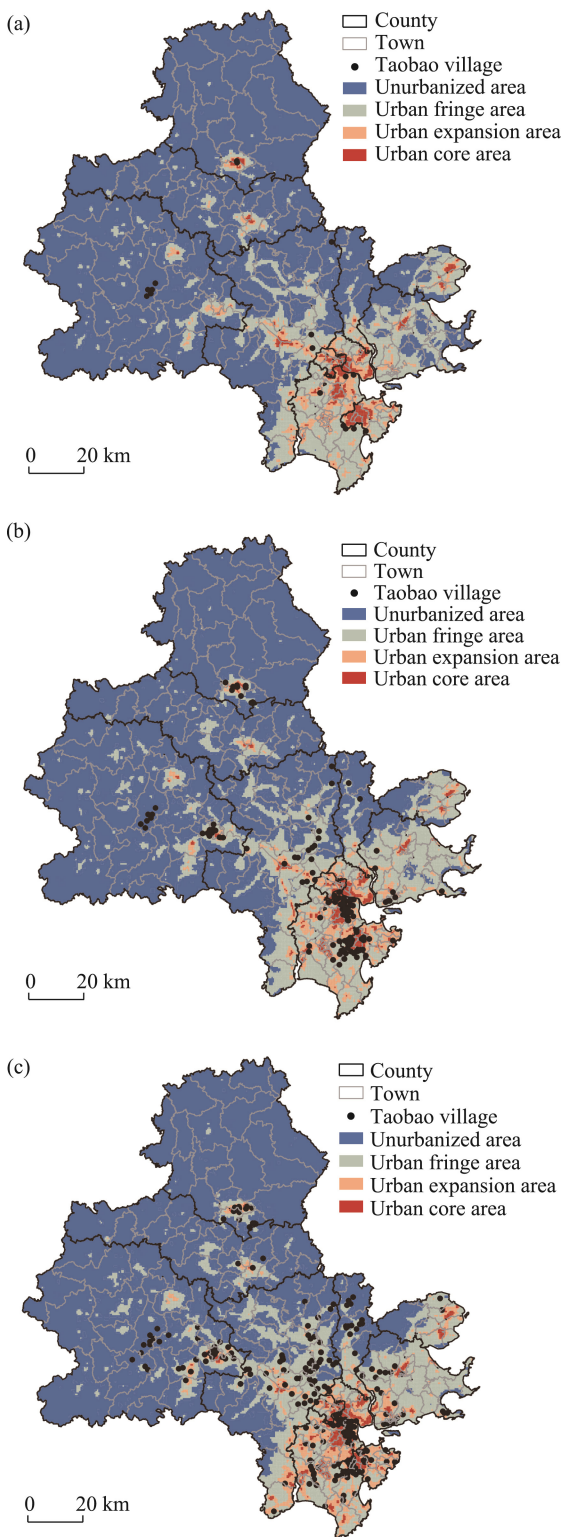
Figure 3 Distribution of Taobao villages in 2014 (a), 2017 (b), and 2020 (c)

agglomeration effects during this period, and the core tended to be obvious. Secondary agglomeration centers remained densely distributed near the old city but with a tendency toward peripheral areas. During this period, with the increase in the clustering effect of Taobao villages along the bay and the improvement of the rural e-commerce infrastructure system, some e-commerce industrial parks even emerged, and the distribution of Taobao villages became free from the constraints of old urban areas and spread to the more peripheral regions.

4.2 Pattern of Taobao villages in urban development

According to the NTL data, Quanzhou city was divided into four area types: urban core, urban expansion, urban fringe, and unurbanized. Figure 3 shows the classification results in 2014, 2017, and 2020. Meanwhile, Figure 3 presents the distribution of Taobao villages in the same period. Generally speaking, Taobao villages tended to be closer to the urban center when they grew rapidly.
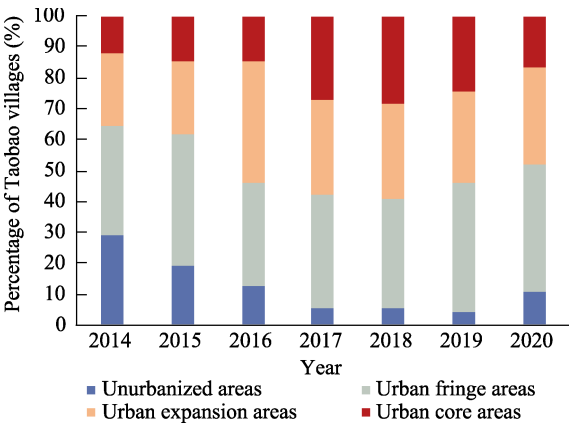
To further study the relation between rural e-commerce and new urbanization, we calculated the proportion of Taobao villages in the four urbanization types from 2014 to 2020, as shown in Figure 4. In the early stage, Taobao villages mostly grew spontaneously and were primarily distributed in the urbanization fringe and unurbanized areas. In 2014, Taobao villages in the urban core accounted for only 11.76% of the total, while those in unurbanized and urban fringe areas accounted for 29.41% and 35.29%, respectively. In 2015, Taobao villages in the urban fringe area increased rapidly to 42.55%; in 2016, those in the urban expansion area increased to 39.13%. In 2017 and 2018,

Taobao villages in the urban core area grew to 27.42% and 28.57%, respectively. It could be observed that the expansion path of Taobao villages was highly consistent with the spatial path of urbanization. In 2020, the number of Taobao villages in unurbanized areas increased, but the tendency to be closer to the urban center did not significantly change. On the one hand, Taobao villages in the urban core area decreased in 2020 because a proportion of these villages were integrated into the urban sphere, which no longer meets the requirements of rural location. On the other hand, the rapid increase in Taobao villages in unurbanized areas suggests that these villages can form spontaneously even when the influence of urbanization is weak. The urban expansion and urban fringe areas were conducive to the growth of Taobao villages, with advantages of cheap land rent and convenient logistics. Of course, it cannot be ruled out that the urbanization degree improved as the number of Taobao villages increased.
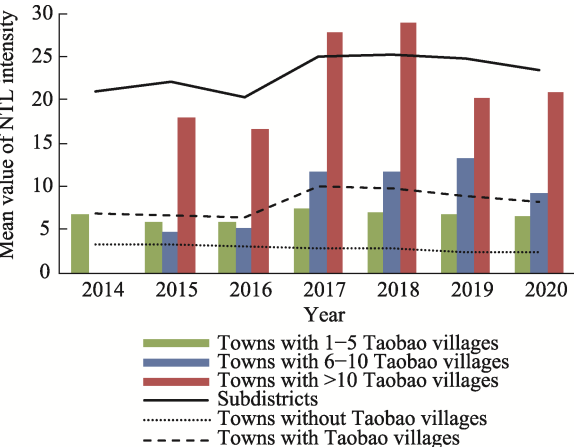
The results based on NTL from 2014 to 2020 revealed that the urbanization level of the subdistrict in Quanzhou city

Figure 4   Distribution of Taobao villages in different urban areas

Figure 5   Relationship between NTL and Taobao villages

was much higher than that of township areas and that the NTL of the former was more than twice that of the latter. Towns with Taobao villages had a higher urbanization level than those without them, and the NTL of the latter towns had a slight downward trend from 3.22 in 2014 to 2.47 in 2020. To explore the relation between the number of Taobao villages and level of urbanization, we divided the towns with Taobao villages into three categories and found a positive correlation between the Taobao village count and urbanization level. Overall, the higher the number of Taobao villages, the higher the NTL, especially after the number of Taobao villages exceeded 10, and the mean NTL was close to the value for the subdistrict, even exceeding the average level for the subdistrict in 2017 and 2018.

4.3   Impact of Taobao villages on urbanization level

Before the panel data regression, the results of the Hausman tests showed that the fixed-effect model was more effective than the random-effect model. Therefore, the former was used to test the effect of Taobao villages on urbanization level, and the regression results are shown in Table 3. The models passed the F test, indicating that the econometric

models were acceptable. The following is a specific analysis of the impact of each explanatory variable on urbanization level.

Table 3 Panel fixed effects model

Variable		All towns		Towns near city		Towns far from city	
		Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Rural e-commerce	TVs	0.124***	0.04	0.128*	0.08	0.80	0.05
		3.26		1.85		1.11	
	TTs	0.823***	0.16	0.965*	0.52	0.769***	0.15
		5.05		1.85		5.24	
Industrial base	Sec	0.015***	0.01	0.004	0.16	0.021***	0.01
		2.72		0.27		4.47	
	Ter	−0.001	0.01	0.001	0.01	−0.013***	0.01
		−0.65		0.14		−3.48	
Social services	Sto	0.001***	0.01	0.014	0.01	0.008***	0.01
		3.69		0.63		5.67	
	Fia	0.036***	0.02	0.015	0.04	0.457***	0.14
		2.32		0.37		3.29	
Control variables	Pop	0.018**	0.02	0.037*	0.02	0.008	0.01
		2.29		1.73		1.08	
	Ass	−0.001	0.01	0.001	0.01	−0.001	0.01
		−0.74		0.38		−1.38	
	_cons	3.896***	0.41	8.011***	1.24	2.376***	0.34
		9.60		6.45		6.95	
Samples		1029		301		728	
F		191.95***		173.16***		130.39***	
R^2		0.18		0.13		0.31	

Note: *, ** and *** respectively mean significance at the level of 5%, 1% and 0.1%.

The regression coefficients of rural e-commerce on township urbanization level were positive; the elasticity coefficients for Taobao villages and Taobao towns were 0.124 and 0.823, respectively, and were significant at the 1% level, indicating that Taobao villages had a significant positive effect on urbanization level.

Taobao villages could promote urbanization level because of their industry transformation. In fact, these villages represent the private microeconomy. Rural e-commerce injected a strong economic vitality into the region, with increased factor mobility and urbanized economies. Industrial goods, especially light industrial products, had a broader market for online sales. Individuals working in the industry were likely to transform into rural e-merchants their exposure to the concept of e-commerce to sell the items they produce (Liu et al., 2020). In some towns, the Internet and e-commerce helped many villagers return to their hometowns to start their own businesses and created a large number of nonfarm jobs by

promoting upstream- and downstream-related industries. Population was the second important driver of urbanization. The past 20 years have witnessed the movement of young and strong laborers to cities for work, creating the problem of left-behind children and elderly people, and the urban–rural dichotomy seemed difficult to resolve. Rural e-commerce was likely to alleviate this problem because it encouraged young people to return to their hometowns and start their own businesses. Rural e-commerce not only increased their income but also reunited them with their families, allowing for a vibrant countryside. Indeed, the Internet may be saving rural society. Third, cultural improvement turned villagers into citizens. The Internet provided rural areas with a window to global connections, and villagers communicate with suppliers, partners, and customers worldwide on e-commerce platforms, immensely improving cultural exchange. In addition, driven by the returning youth and entrepreneurs, the villagers' lives and ideas were closer to those of citizens with the e-commerce industry as a carrier.

In addition, we found that the elasticity coefficient for Taobao towns was greater than that for Taobao villages, indicating that the further agglomeration of rural e-commerce had sharply increased its role in promoting urbanization level. Many Taobao villages could even take on the role of a county's economic engine, allowing for a peculation phenomenon of China's urbanization. Taobao villages were easily replicated with a certain industrial base, and the externalizations released via industrial clustering were significant, providing an endogenous drive for urbanization development.

In terms of industrial base, the regression coefficient for industrial enterprises above the scale was significantly positive, indicating a clear effect of industrialization on urbanization in the rural areas of Quanzhou. To a large extent, the industrial economy was the main support for industrial development in Quanzhou. Usually, the development of a tertiary industry, mainly the service industry, had a positive impact on urbanization level, but in Quanzhou's rural areas, the regression coefficient for accommodation and catering enterprises was not significant, and the development of a tertiary industry was not high. The regression coefficients for the general store and financial institutions, which reflect the level of social development in the townships, were statistically significant at the 1% level at 0.001 and 0.036, respectively. Simply put, social services were also a key factor in propelling urbanization.

Considering the geographical features of Taobao villages, we considered another question: do Taobao villages with different location features show the same impacts on urbanization? Numerous Taobao villages are distributed around cities and can improve urbanization level under the synergistic spillover effect. However, whether Taobao villages in marginal areas can stimulate in situ urbanization is another question. For this reason, we divided the sample into two categories: "near city," including townships adjacent to urban areas, and "far from city." If the result remained significant in the latter, we could conclude that Taobao villages facilitate in situ urbanization. We reran the model to obtain models 2 and 3 to check the robustness of the model results.

For model 2, we found that rural e-commerce was still significant in these "near-city" areas although the industrial base and public services were no longer significant. The variables were no longer significant in the "near-city" areas because the indicators we used to measure industry and tertiary industry at the township scale were limited. However, we found that the elasticity coefficients for Taobao villages and Taobao towns were 0.128 and 0.965, respec-

tively, which were even higher than those in model 1. This suggests that Taobao villages played a more important role in enhancing urbanization level if they are located close to cities.

For model 3, we distinguished the townships that were "far from city," and the results for the industrial base and public services were closer to those in model 1. However, we found that Taobao villages were not significant in model 3, while the elasticity coefficient for Taobao towns was 0.769 and significant. This indicates that Taobao villages stimulate urbanization under certain conditions. In areas far away from cities, not once did the emergence of Taobao villages improve urbanization level unless they developed into Taobao towns and the agglomeration effect became apparent. In situ urbanization was harder in areas far from cities, but this does not mean that rural e-commerce played a small role in in situ urbanization. In fact, Taobao villages could be an efficient way to reduce location disadvantage. Taobao villages in Quanzhou city were closely associated with local resource endowment and a block economy, and once the town acquires a relatively complete industrial chain, it is likely to be in the course of urbanization.

5   Conclusion and discussion

5.1   Conclusion

The rapid development of rural e-commerce has profoundly changed the socioeconomic structure of rural China, and the rural e-commerce industry agglomeration represented by Taobao villages has reshaped the traditional urban–rural relation and proposed a new urbanization path. This study collected NTL data and Taobao villages from 2014 to 2020 in Quanzhou, Fujian province, to examine the impact of these villages on urbanization at the township level. First, this study used spatial analysis methods to analyze the agglomeration characteristics of Taobao villages, and the results showed that the number of Taobao villages in Quanzhou city increased dramatically from a sporadic pattern to a polycentric agglomeration pattern. Second, after measuring urbanization level using NTL, we found a positive correlation between the number of Taobao villages and urbanization level. Third, the panel fixed regression models showed that Taobao villages had a positive effect on urbanization level. Taobao villages' proximity to cities had a greater urbanization impact, while Taobao villages in remote rural areas can facilitate in situ urbanization unless an agglomeration effect emerges. It suggests that Taobao villages can promote urbanization, with a certain complexity. The effect is closely related to the scale and location of Taobao villages. The positive effect of Taobao towns on urbanization indicates that the spatial agglomeration of Taobao villages is conducive to urbanization level. The rise of Taobao villages negates the traditional thinking of urbanization, and the benign interaction between the two reshapes the spatial structure of towns. Rural e-commerce will become an important direction for remote rural areas, providing a certain reference for the development of new urbanization in China.

5.2   Discussion

Rural e-commerce accelerates the flow of people, goods, information, and capital between urban and rural areas and reconfigures the urbanization path and urban–rural relations. ICT provides rural areas, which have been disadvantaged in all three previous industrial revolu-

tions, the opportunity to join to the global production network. The clustering of virtual and physical factors brought about by ICT will drive economic development and employment growth in specific regions. Concurrently, the grassroots elites in Taobao villages who start businesses in the countryside cause widespread replication to accelerate the urbanization process. Driven by an increasingly powerful globalized economy, e-commerce will gradually weaken the constraints of administrative boundaries within urban and rural areas, and rural areas may even be the center of production and management. All these will reconfigure the structure of traditional urban systems and force changes in both urban and rural governance systems.

While rural e-commerce has broken the boundaries of traditional geography, and information technology has eased the information dilemma of remote rural areas, large urban areas continue to be the main beneficiaries of the digital economy based on the advantages of agglomeration, scale, and skills under the market mechanism. The development of rural e-commerce does not mean that traditional infrastructure such as railroads, highways, and airports are no longer important, nor does it mean that new infrastructure such as cloud computing, mobile Internet, and the digital economy can lead to a "death of distance." However, because of the obstacles caused by the small size and scattered distribution of villages, ICT plays a relatively limited role in boosting rural economic development. To maximize the role of ICT in helping rural revitalization, rural areas should join the dual network of mobile Internet and highway to enhance the accessibility of China's huge online market for rural products. With the development of rural e-commerce, the traditionally weak rural economy is evolving into a strong economy and is greatly enhancing its ability to adapt to the flexible needs of the online economy.

This study's positive conclusion does not necessarily indicate that urbanization based on Taobao villages is a model that can be widely promoted. First, Taobao villages seem to appear only in specific locations in China, especially in the developed eastern coastal areas. Although the western regions have many Taobao villages, the number is far less than in the eastern regions. Quanzhou is a typical city with a strong industrial foundation, and our conclusions are only applicable to similar cities. Second, while the number of Taobao villages has rapidly increased in the past decade, a few have disappeared, which means that rural e-commerce is not a magic bullet for urbanization and economic development. The sustainable development of rural e-commerce is an important issue as well. Finally, the development of rural e-commerce in China largely depends on a perfect logistics and express delivery system, and this new urbanization model has great limitations in Africa or Latin America.

This study has some limitations. First, rural e-commerce is in a boom stage, with new Taobao villages emerging every year; therefore, its spatial pattern is not yet final. Based on the 2014–2020 data, this study cannot reflect the evolution of the development and the final distribution pattern of Taobao villages in China. Second, this study used NTL data to measure urbanization level; although this was not a new attempt, it will ultimately be biased to some extent. The ability of DMSP/OLS NSL data to characterize urbanization levels is limited because of the relatively coarse spatial resolution, especially in some regions with weak NTL (Liu *et al*., 2012). Furthermore, urbanization is influenced by diverse and complex factors, and while this paper focuses on the impact of Taobao villages on urbanization

level, data were insufficient to support the scale of such villages. Hence, only the number of Taobao villages and towns was used to arrive at an approximate description. The industrial base and public service indicators mentioned in relation to Taobao villages and Taobao towns are only part of the general picture, and conditions of scientific innovation, human capital, investment, and many others must be further considered with the availability of more precise data.

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