Article

Regional Coordinated Development in the Megacity Regions: Spatial Pattern and Driving Forces of the Guangzhou-Foshan Cross-Border Area in China

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Abstract: With globalization and informatization, cross-border areas have become increasingly critical interactive spaces, experiencing rapid development and extensive changes in residents' cross-border travel, constantly changing the spatial patterns of neighboring cities. However, existing studies lack in-depth discussions of the new spatiotemporal characteristics of human activities, spatial pattern evolution, and the driving factors behind them. Therefore, taking the Guangzhou-Foshan metropolitan area as a case, this paper focus on the analysis of the cross-city travel of residents in these border areas in 2019, and investigated the evolution of spatial patterns and the driving forces in the border area during 1985–2020. We found that, instead of the previous one-way attraction pattern caused by the spread of residence, a large number of cross-city trips for leisure and entertainment purposes emerged, and the one-way unbalanced flow, "Foshan to Guangzhou", changed to two-way circulation. We also explore the scenario in which the travel behavior of urban dwellers in these two cities considerably interacts with the effect of urban structure to produce the observed mobility patterns. Second, we determined the spatial pattern of the Guangzhou-Foshan region from 1985 to 2020 to be on of spreading expansion, with Liwan District as the central core, connecting to several sub-centers. The cross-border area in the Guangzhou-Foshan region represented a compact, extremely high degree of integration and a well-matched functional space. Third, driven by the forces stemming from the planning guidelines and the improving transportation network construction in the border area, the growth points of the two cities continued to expand toward the borderline regarding integrated development, while the growth axis was mainly in the direction of the city border, urban arterial roads, and subway lines. We concluded with development suggestions for increasing travel interactions and optimizing spatial patterns to build a common vision of the whole Guangzhou-Foshan pattern of integration.

Keywords: cross-border area; regional integration; regional coordinated development; megacity regions; Guangzhou-Foshan region

1. Introduction

Each era of change and technological innovation is accompanied by the development of new urban functions, structures, and forms [1]. With the advancement of globalization, cities and regions have become more complex [2] and are now the basic spatial units for participation in global competition [3]. Urban connections range from "space of places" to "space of flows" [4], and urban space continues to break through administrative boundaries to form new functional areas and relationships [5]. In this process, time, space, and their relationship are redefined, and more and more countries and cities are aware of the construction of spatial order and the reshaping of urban spatial structure in the new

era. At the same time, the daily activities of residents have undergone changes. "Cross-border mobility" and "twin-city life" have become increasingly frequent. Border regions have gradually transformed from "depressed areas" dominated by the economy of their administrative regions into key spaces for regional development. Western countries have produced rich theoretical research and have practical experience in this area. Herzog (1990) discussed the landmark case of the Mexican–U.S. border, arguing that the emerging cross-border urban space is a specific product in the context of globalization [6].

Since the 2000s, urban agglomerations have become the main form of China's new urbanization. At present, China has approved a total of 19 urban agglomeration plans, and continues to insist on building a coordinated urban development pattern based on urban agglomerations and metropolitan areas. In 2008, the concept of city integration was first proposed by China and promoted as a national strategy in the Outline of the Reform and Development Plan for the Pearl River Delta Region [7]. City integration refers to two (or more) neighboring cities with conditions for integrated development in terms of economy, administration, ecological environment, culture, etc., that break administrative barriers and form an urban area with gradually increasing radiation and competitiveness [8]. At present, the integration strategy, with the theme of cross-border coordination and cooperation, has become an important choice in promoting coordinated regional development [9]. The Guangzhou-Foshan metropolitan area is one case. As modes for cross-border cooperation, the Guangzhou-Foshan metropolitan area has initiated numerous planning practices in the Pearl River Delta and completed the first global intra-city planning in China by the end of 2021. Currently, China's city integration has developed into a deepening stage, changing from the earlier competing model supported by industries and transportation facilities, etc., and exploring a multi-dimensional integrated development model. However, in actual practice there remain problems such as divergent local interests, uneven and backward levels of joining areas, and effective links that have not yet been formed.

Overall, driven by the development of city integration, cross-regional activities are taking shape. With the promotion of globalization and regional integration, people's cross-border travel behavior has become increasingly complex, and new features now appear in their lives, employment, recreation, and service space that may have both an active and negative impact on urban space and land use [10,11]. Residents' cross-border travel is changing the spatial layout and functional links of closely connected cities such as Guangzhou and Foshan. In the era of promoting the co-city of Guangzhou and Foshan, it is necessary to fully understand the new spatial changes and laws caused by residents' cross-border travel behavior.

Urban spatial patterns, as important components of complex systems, have been hot topics in urban geography and urban planning domains. Most research has focused on the spatial distribution of land use, population, employment, industry, and other elements in the study of urban structure [12–15], and they have been mostly based on a single city. The influence of the "border" on the expansion of urban space has been neglected, as well as the social processes and actors in the process of urban spatial structure evolution. On the other hand, the existing research on the travel behavior of residents has mainly focused on differences between groups, the urban built environment and travel behavior, and excessive commuting [16–20]. Limited by data acquisition, the existing research results have paid less attention to the regional scale, especially cross-border travel, and it is difficult to comprehensively explain the differences in residents' travel behavior on different spatial and temporal scales [21]. Human activities are the most active and dynamic elements in the urban ecological–economic–social system and are an important factor and external manifestation of the interconnection among cities. Under the influence of spatial and temporal compression, integration, and intelligence, are there any new features in the spatiotemporal relationships in residents' travel? What kinds of changes in spatial patterns are occurring? What are the reasons behind them?

This study aims to explore the spatial pattern and series driving forces of cross-border regions in China. We selected the Guangzhou and Foshan metropolitan areas as case

sites, using multi-source data, such as multi-temporal remote sensing data, mobile phone signaling, residents' travel logs, POI, etc., and adopted quantitative analyses such as spatial analysis and visualization, complex flow network, hotspot analysis, and case research methods. The research structure was as follows: after conducting the literature review section, we established an analytical framework, delineated the Guangzhou-Foshan key boundary areas, and then analyzed the temporal and spatial characteristics of residents' cross-border travel to explore its impact on the evolution of urban spatial structure (spatial layout and functional linkages) from 1985 to 2020. Then, we explored the driving forces from the perspectives of their development process, spatiotemporal effects, and local government policy responses. This paper theoretically enriches and expands the research content and perspective of urban geography, provides a scientific basis for forming a new pattern of national and regional economic development, and promotes the integrated development of the Guangzhou-Foshan region, as well as providing empirical references for the development of integration in other regions.

2. Literature Review

Border areas are places where numerous interactions and divergences intersect and are intertwined [22,23]. Types of border are divided into international, provincial, and local from top to bottom, according to the regional administrative level. According to its dominant attributes in development, the border is divided into natural, administrative, and economic boundaries [24]. The study of cross-border areas in Western developed countries emerged in the Middle Ages and has gradually shifted from the early focus on border morphology to functional analysis. The European Commission considers border areas to be "the spaces that deserve the most active attention in the European integration process" [25]. Over the years, Western countries have conducted in-depth discussions on the characteristics, functions, urbanization processes, and types of border areas at different scales, between the United States and Mexico [6], Singapore and Malaysia [26], Eastern and Western Europe [27], the interior of the Luxembourg, Basel, and Geneva metropolitan areas [28], and Minneapolis and St. Paul [29], etc. They have continuously explored cross-border integration development models, which have shown an overall diversified and dynamic development trend, with a profound impact on city–region relations.

Regional integration and city integration advanced the connection and cooperation between cities in terms of function, form, and pattern [30]. Since the beginning of the 21st century, Western developed countries, especially European countries, have provided a practical model for exploring cross-border integrated development [31]. The EU is actively exploring the opening of borders and functional integration within metropolitan areas and promoting the implementation of cross-border activities to achieve economic linkages, cross-border commuting, facility sharing [32], cultural integration [33,34], multi-level governance [35], and even meta-governance [36] in cross-border areas. For China, the development of cross-border regions has also become a regional theme. In the 1990s, Yunnan, Guizhou, and Guangxi provinces [37] developed inter-provincial border areas in Shandong Province, as early cross-border areas in China. In the 21st century, under the wave of globalization and regional integration, with the breakup of market segmentation and trade barriers in geographic regions, cross-border regions in China developed rapidly. On an international scale, Cheng (2022) studied the three spatial evolution modes of unilateral expansion, bilateral expansion, and cross-border integration between China and neighboring countries against the background of the construction of the "One Belt and One Road" cross-border economic corridor [38]. On a regional scale, there is the economic cooperation among the Yangtze River Delta cities [39]; the industry connection and development in the border area of Gansu, Sichuan, and Qinghai [40]; the cross-border governance mechanism in Guangdong-Hong Kong-Macao Greater Bay [41]; frequent population flow in the Hong Kong-Shenzhen boundary area, etc. [42]. On the other hand, under China's new urban pattern, the form and function of borders are re-characterized. As the degree of functional integration of urban areas increases, spatial mobility across

borders is frequently enhanced, which eventually helps to form integrated regions at a new territorial scale [43].

City integration promotes the high-frequency inter-city mobility of people, and high mobility is one characteristic of urban agglomerations. The movement of people across provinces and cities is a key driver for accelerating and reshaping China's urbanization process and changing the urban spatial pattern. Since the boundaries are no longer a barrier to spatial and temporal effects, new changes take place in the cross-border area of residents' activities, from fixed to flexible, from urban to regional, from local to mobile, and from hierarchical to networked [44]. In the past 20 years, the research on residents' activities in the cross-border area has become increasingly diversified [45]. Western scholars have carried out abundant research but not on cross-border travel, and there is little comprehensive research at the multi-scale. Domestic studies have mostly focused on specific spatial scales, ignoring the role of "people" in them, and there are fewer empirical studies identifying the results of cross-border travel and changes in regional spatial structure. Some existing studies have focused on the characteristics, spatial patterns, and mechanisms of urban travel behavior (cross-city commuting trips, high-frequency one-day round-trip trips, and high-frequency two-location round trips) and explored their effects on the agglomeration and diffusion of urban space [46–49]. For example, Shen (2003) found that the cross-border travel rate from Hong Kong to different cities differs significantly depending on the timing of cross-border travel, and policy, time cost, and population economy are important factors affecting cross-border travel [50]. Castells (2004) argued that cross-border travel is represented by inter-city capital investment flow, technology flow, material flow, etc. [51].

When urban integration accelerates, people's travel trajectories and travel decisions across regions become more complex. A number of scholars have studied the characteristics, spatial patterns, and driving forces of the cross-city mobility of urban residents at the regional scale, and explored ways to implement sustainable cross-border cooperation and coordinated regional development [52,53]. Taylor et al. (2010) [54], Gan et al. (2021) [55], and Wang et al. (2017) [56] summarized the expansion law of people's travel range and its impact on the connection between cities. Niu (2018) [57] found that different types of cross-city functional connections influence the spatial and temporal patterns of residential travel. At the urban scale, some scholars have explored the influencing factors of cross-border travel from the perspective of spatial activities. For example, Zhao et al. (2003) [58] analyzed travel from the perspective of urban allotments and urban spatial distance. Tang et al. (2018) [59] found that cross-city travel and regional activity space, through the mutual enhancement of technology, affect the flow of information and people, which in turn reshapes the urban spatial structure.

In the process of city integration in China, urban and regional spaces are facing drastic reconstruction and reorganization, with incrementally oriented, mixed land use close to work and home. Population flow in two or more cities increases flows to proximate cities within a region. Cross-border travel accelerates coordinated regional development and regional integration. However, the development of cross-border regions in China inevitably displays different characteristics, as the policy context and development stage are different from those of Western developed countries. Therefore, within the context of city integration, it is now necessary to explore the spatial patterns of cross-border regions by analyzing the spatiotemporal characteristics of residents' cross-border travel behavior and the mechanism of its impact on spatial evolution during the urban transition period in China.

3. Study Area, Data and Methods

3.1. Study Area

We selected Guangzhou and Foshan as the study areas (see Figure 1). The study area is located in the south-central part of Guangdong Province, China, in the hinterland of the Pearl River Delta, with a total area of 1.12 trillion km^2. The two cities belong to the core development circle of the Guangdong-Hong Kong–Macao Bay Area, and they have close geographical proximity, common roots, and close ties in economic activities. With a total

GDP of CNY 4038.851 billion in 2021 (see Table 1), it is the first "double trillion" integrated region in China and one of the most competitive regions for the future.
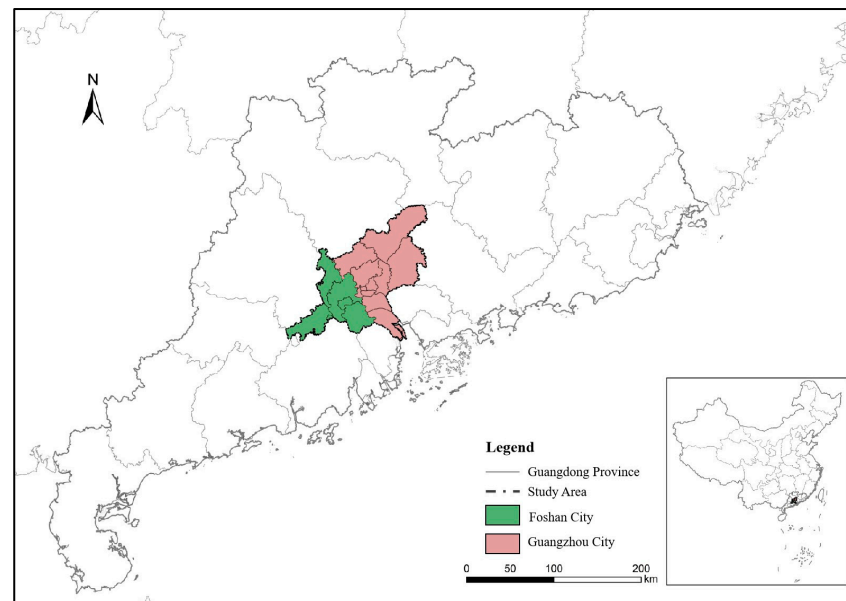
Figure 1. The study area. Source: the authors.

Table 1. Economic and social development data of Guangzhou-Foshan in 2021.

| Indicator	Guangzhou City	Foshan City	Guangzhou-Foshan	Guangdong Province	Guangzhou-Foshan Region/Guangdong Province
City area	7434	3797	11,231	179,725	6%
Population	1868	950	2818	12,601	22%
GDP	28,232	12,157	40,389	124,370	32%
Industry value	22,567	5442	28,009	37,500	75%

The promulgation of the Outline of the Reform and Development Plan of the Pearl River Delta (2008–2020) elevated the Guangzhou-Foshan co-city to a national strategic level. As a new scale of regional development, the Guangzhou-Foshan metropolitan area has become a pioneer area for the integration of the Pearl River Delta. In 2019, the Guangdong-Hong Kong-Macao Greater Bay Area Development Planning Outline officially proposed that Guangdong and Foshan jointly build a "1 + 4" high-quality development integration pilot area to explore a new development model with "functional areas" as the core carrier. On 31 December 2021, the Guangzhou Municipal Development and Reform Commission issued the 14th Five-Year Development Plan for Inter-city Integration of Guangzhou and Foshan. All these policies and planning initiatives provide an opportunity for the junction area of two cities to promote the rethinking and reorganization of the city development from a regional perspective. The Guangzhou-Foshan metropolitan area is facing new opportunities and construction requirements.

At present, Guangzhou-Foshan has basically formed an integrated spatial pattern, which is manifested in the blurring of the Guangzhou-Foshan border and the formation of the new regional center. As mentioned in the 14th Five-Year Plan, Guangzhou-Foshan has a 197-km-long boundary line and a 629-square-kilometer integration experimental area, and the towns in the bordering areas are developing rapidly with the in-depth implementation of the integration strategy. The cross-border areas have become the key to promoting the development of Guangzhou-Foshan integration [60]. In addition, the cross-border areas of Guangzhou-Foshan integration have contributed to the formation of the center of the

Guangzhou-Foshan metropolitan area and the Guangdong-Hong Kong-Macao Greater Bay Area. The two municipal governments have begun to promote the spatial layout through industrial cooperation and major infrastructure construction in the border areas, such as the construction of the Guangzhou South Railway Station, the new Baiyun International Airport, the Guangzhou-Foshan cross-city underground, etc. The border areas have become the key cooperation space for Guangzhou-Foshan, and have formed a range of border areas, including the Liwan-Nanhai-Chancheng and Panyu-Shunde integration space.

3.2. Analytical Framework

Based on the theories of urban geography and urban planning, this research framework was constructed by combing Chinese and Western scholars' studies on urban regional spatial structure, residents' cross-border travel, and city integration (see Figure 2). Then, we used long-term nighttime lights and POIs to identify the geographical scope of the core entity of Guangzhou-Foshan and delineate the key regional development boundary areas. Following this, combined with mobile phone signaling and based on complex mobility network analysis, the spatial and temporal characteristics of the cross-border travel of residents in the Guangzhou-Foshan border area were explored, and the distribution of functional hotspots, such as residence, employment, and recreation, was determined. The evolution of the spatial structure (spatial layout and functional linkages) from 1985 to 2020 combining various driving forces such as regional policies, transport facilities and intelligent technologies will be further discussed.
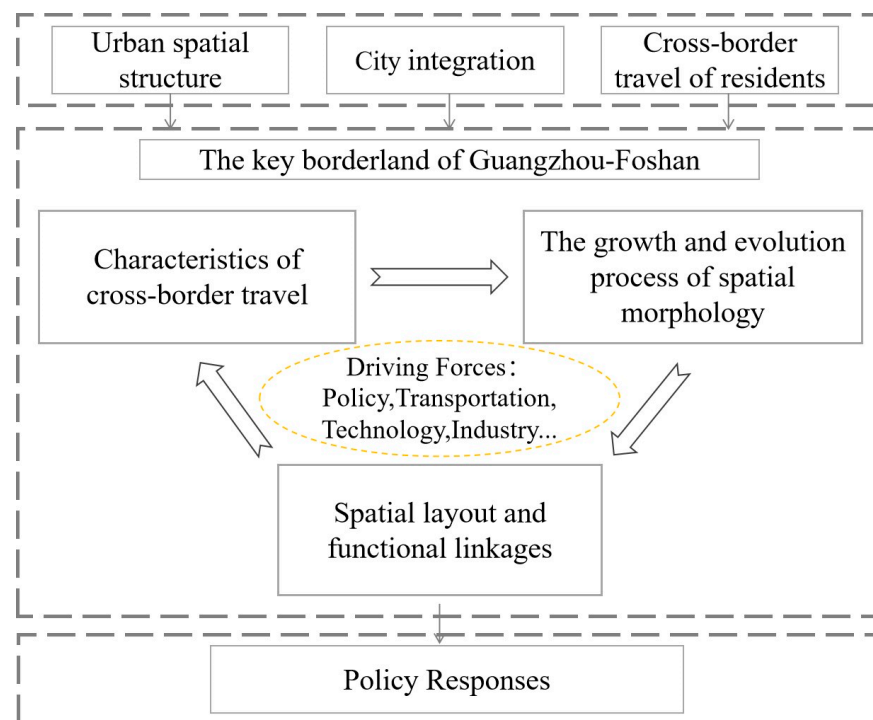
Figure 2. The analytical framework of this study.

3.3. Research Data

We mainly used the land-use data from 1985 to 2020 and mobile signaling data for two consecutive weeks in May 2019. The multi-period land-use dataset was mainly based on the US satellite Landsat MSS, TM/ETM, and Landsat 8 satellite remote sensing data and was constructed by means of human–computer interactive visual interpretation. Remote sensing image processing mainly included waveband extraction, false color synthesis, geometric correction and sub-county image stitching, mosaic, etc. The data set was provided by

the Data Center for Resources and Environmental Sciences, Chinese Academy of Sciences (RESDC) [http://www.resdc.cn (accessed on 16 Feburary 2022)] [61].

The harmonized global nighttime light data set was provided by Li et al. (2020b) [62], which includes average global nighttime light brightness for 2018 and contained lights from cities, towns, and other areas with continuous nighttime lighting. Night light data are closely related to human economic activities; the greater the gray value, the higher the light brightness in the area, which can effectively reflect the development level and spatial pattern changes of urban areas. The spatial resolution of this data set was 30 arcseconds. Its spatial resolution was a 1×1 km grid, and its brightness value was 0–63. This study used the mobile phone signaling data of Guangzhou-Foshan Unicom users for 14 consecutive days from 8 to 21 May 2019. The time recording interval of the data was 0.5 h, and the spatial unit of the data was a 500 m $\times$ 500 m grid. Based on the availability of the data, the travel data prior to 2019 were obtained from existing studies.

In addition, we also used data from sources such as statistical yearbooks, bulletins, roads, administrative maps, etc., found on government websites and in public survey reports, for better auxiliary analysis.

3.4. Research Methods

3.4.1. Spatial Analysis and Visualization

Both nighttime lighting data and POI data can reflect the intensity of regional socio-economic activities to a certain extent, and have the advantage of accuracy compared with traditional data. However, if a single source of data is used, it is easy to bring bias. Therefore, the paper uses a composite index synthesized from nighttime lighting and POI values to more accurately reflect the development of the Guangzhou-Foshan metropolitan area. First, the POI data of Guangzhou-Foshan were cleaned and analyzed by kernel density analysis, often used to measure the spatial distribution of point elements, and the calculation formula is shown in (1). At the same time, the original nighttime lighting data were preprocessed by radiometric calibration, image correction, mask extraction, normalization, etc. The purpose of this preprocessing is to solve the error of the sensor itself, and then visualize the average brightness value of the light. The POI and DMSP index was constructed from the two components using the mean synthesis method to represent the degree of urban economic and social development. Based on the equivalence analysis and natural breakpoint classification, the geographical scope of the core entities in the Guangzhou-Foshan region was finally derived [63].

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

where $f(x)$ = estimate of the kernel density at point x; h = bandwidth; n = the total number of samples within the study scope.

$$Q_{P\&N} = \sqrt{f(x) \times N_x} \tag{2}$$

where $Q_{P\&N}$ = the POI and NPP composite index, representing the economic and social development intensity of the Guangzhou-Foshan metropolitan area; $f(x)$ = the POI kernel at point x density value; Nx = the nighttime lighting brightness value at point x.

3.4.2. Construction of Complex Mobility Network

(1)   Mobile phone signaling data preprocessing

To better study the cross-city behavior on the border, the data were cleaned and initially sorted to remove incorrect or missing spatial information and passage within the same grid, yielding a daily average of over 8 million OD records.

(2)   Travel network construction

The places of residence and employment were distinguished based on the information of day and night residency between 9:00–17:00/21:00–8:00 the following day for 10 days or more in the current month. At the same time, grids with a single stay of more than one hour at a non-job-residential location were considered valid recreation destinations, and the location attributes, time, and frequency of each stay were further validated to identify leisure sites. Following this, by filtering the spatial location of the starting and ending points and determining the threshold value to construct a hotspot grid, the travel hotspots that met the following two conditions were obtained and visualized to study the travel patterns of residents in the Guangzhou-Foshan border area: (a) the start or end point fell within the boundary area of this study; (b) the OD flow that connected the "start–end" point crossed the administrative boundary of Guangzhou-Foshan.

3.4.3. Regional Core Entity Geographic Scope Identification

We used the POI and DMSP index to identify the geographic scope of the core entities of the Guangzhou-Foshan region in 2018 (see Figure 3). According to the feature of the POI and DMSP index that conformed to the trend of decreasing from the central area to the marginal area, we obtained the geographic scope of the core entities, based on the natural breakpoint grading, equivalent processing, and spatial visualization. As seen in Figure 3e, the main scope of the core entities of the Guangzhou-Foshan region in 2018, occupying an area of about 2300 km^2, included Yuexiu, Liwan, Tianhe, Haizhu, Panyu, southern Huangpu districts in Guangzhou, and parts of Chancheng, Nanhai, and Shunde districts in Foshan. In addition, there were also local sub-centers in Conghua, Zengcheng, Huadu, Nansha, Sanshui, Gaoming, and other districts. The development pattern showed a spreading expansion, with Liwan District as the main core and a number of sub-centers radiating locally.
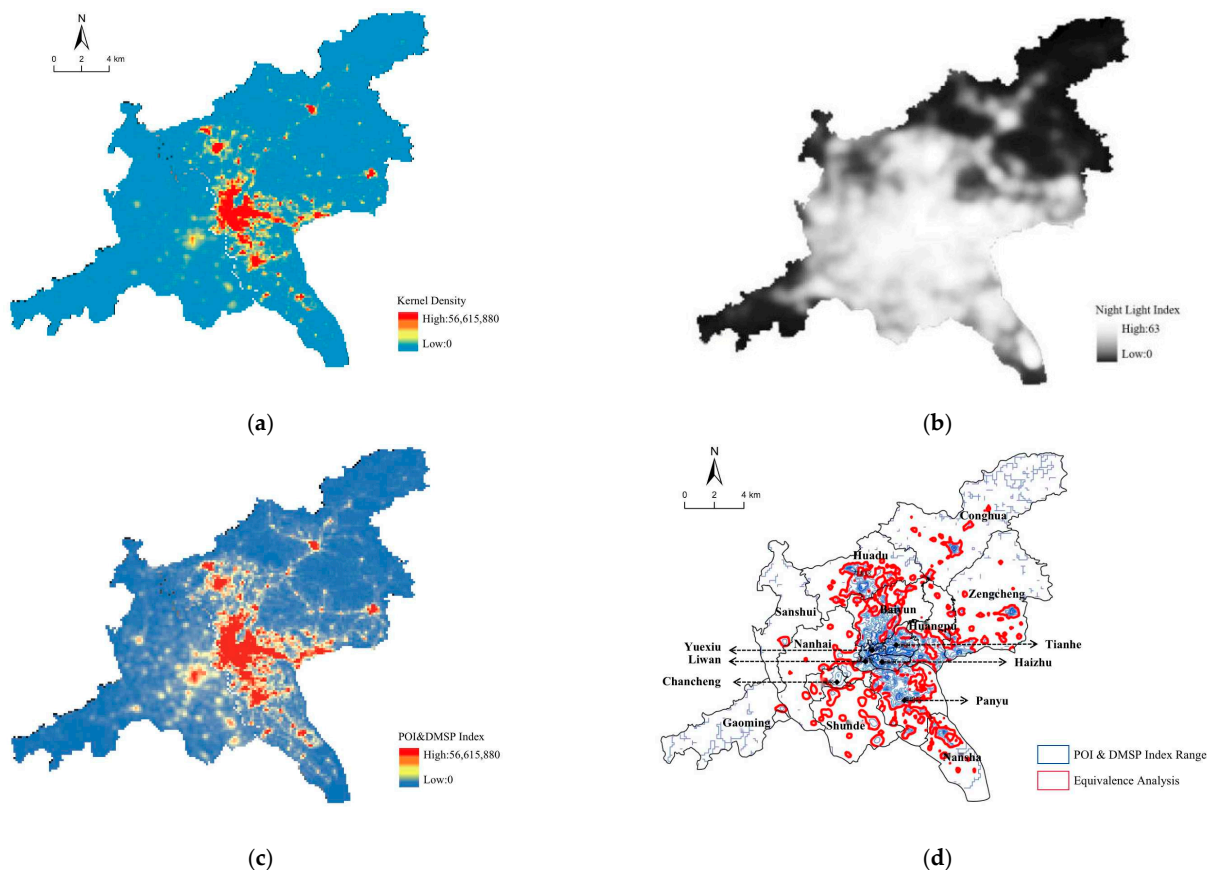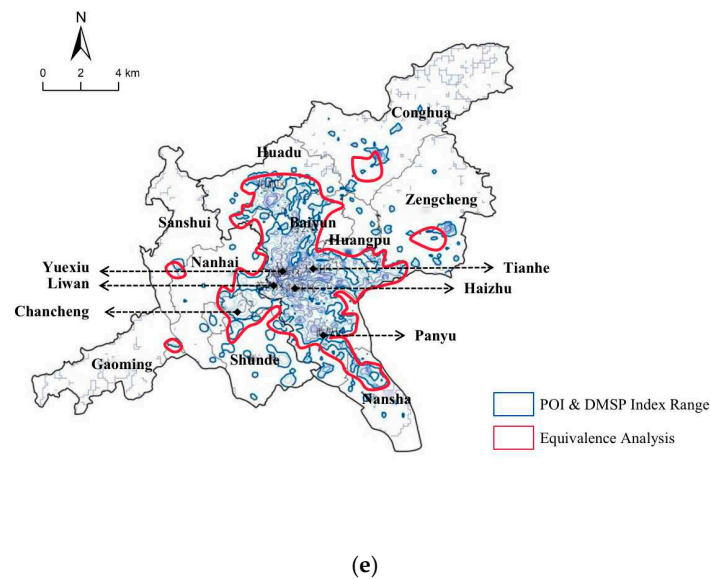

(a)

(b)

(c)

(d)

Figure 3. *Cont.*

(**e**)

Figure 3. Identification results of the geographic scope of Guangzhou-Foshan core entities. (**a**) POI density analysis; (**b**) night light index analysis; (**c**) DMSP and POI index synthesis; (**d**) equivalence analysis; (**e**) the core entities of Guangzhou-Foshan.

From the above identification of the territorial scope of an entity and the spatial planning of the border integration pilot area in the 14th Five-Year Plan for the Territorial Integration of Guangzhou-Foshan, the key border area was identified for further study. The results are shown in Figure 4.
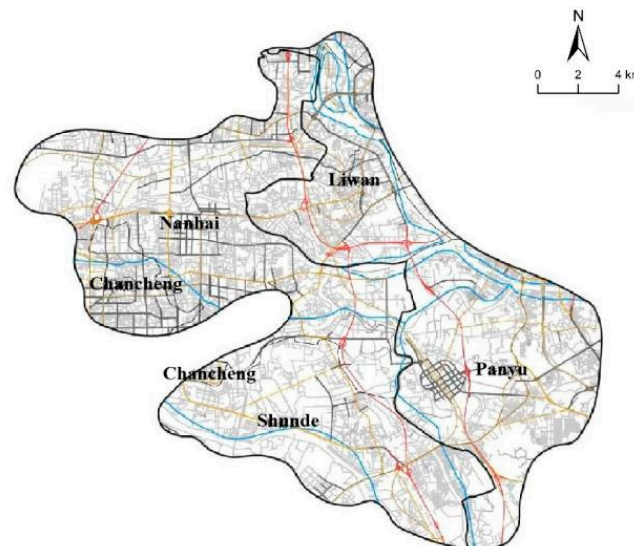

Figure 4. Delineating key border area of Guangzhou-Foshan development.

4. Results

Within the context of urban integration, Guangzhou and Foshan exhibited different patterns of population distribution. Using the reliable mobile phone signaling data in 2019, we roughly reflected the basic spatial pattern of population distribution in the Guangzhou-Foshan region. After eliminating invalid or erroneous information, a total of 6.43 million residents, 6.42 million employed people, and 4.28 million leisure travelers were identified in the entire area of Guangzhou-Foshan (see Figure 5).
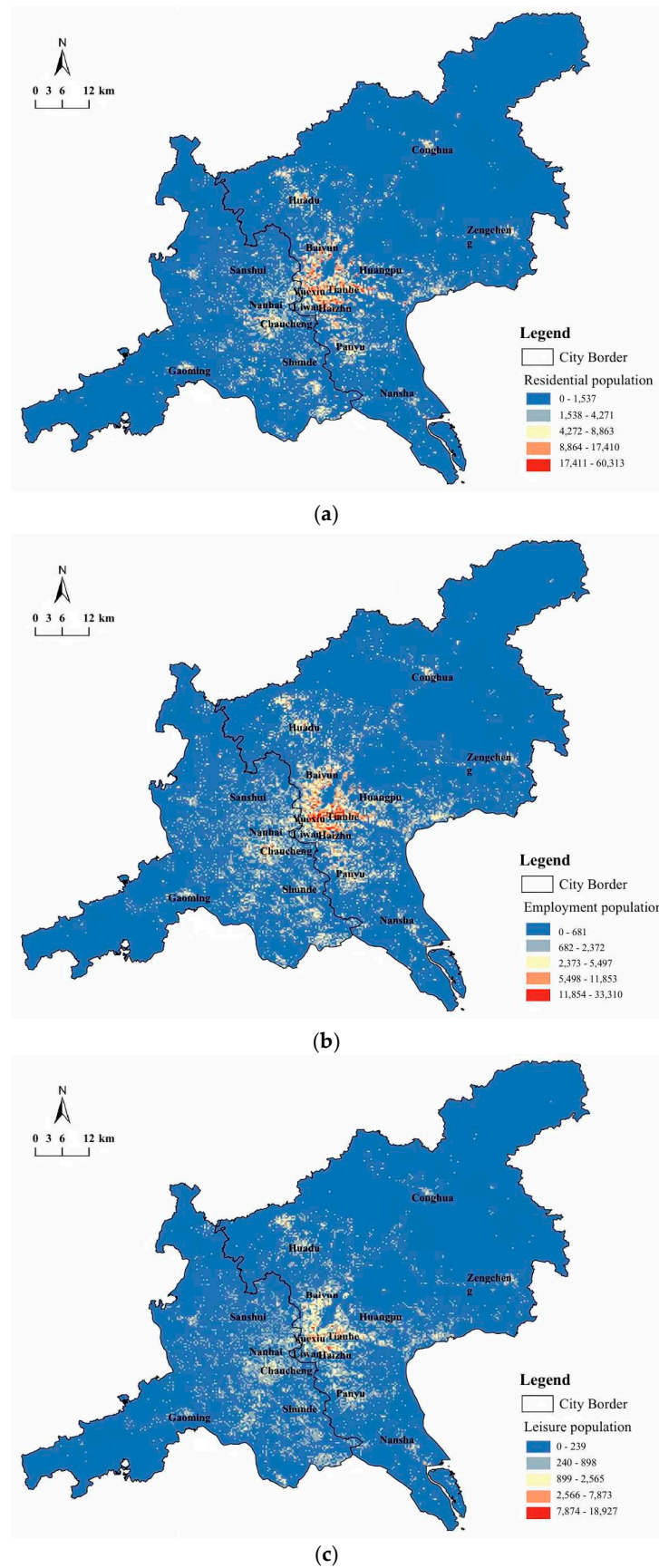
Figure 5. Population distribution of Guangzhou-Foshan in 2019. (**a**) Residential population distribution; (**b**) Employment population distribution; (**c**) Leisure population distribution.

4.1. Cross-Border Travel Characteristics of Residents in Border Areas

In terms of spatial distribution, Guangzhou's population exhibited the characteristics of the traditional central district (referring to Liwan District, Yuexiu District, Tianhe District, and Haizhu District) as the core, and gradually decreasing from the core to the periphery. The employment population was concentrated in central urban areas such as Tianhe District and Yuexiu District (see Figure 5b). Compared to the employment space, the residential and leisure populations were distributed at the periphery of the employment centers, with the circle expanding outward and decreasing from the core to the periphery, and local extreme values appearing in Zengcheng, Conghua, Huadu, and other areas (see Figure 5a,c). Foshan city showed a pattern of local concentration and overall dispersion. Most of the working population was distributed in the three districts of Chancheng, Nanhai and Shunde, while the periphery was characterized by dotted dispersion, and the difference in population density between the central area and the periphery was not large, with mixed and intermingled hot spots [10,11].

The cross-border area, especially Liwan-Nanhai in the central area, was densely populated. From the distribution map of residential, employment, and leisure populations in Figure 5, the population in the Liwan-Nanhai area basically presented an obvious "cross" structure; the population density on both sides of the border does not show significant gradient changes, and the border tends to blur varyingly.

Focusing on the key boundary areas identified above, we found clear spatial characteristics of residents' cross-city travel. Overall, about 80,000 residents in the study area chose to pursue leisure activities across the administrative boundary, while the number of cross-city travelers commuting to work reached 100,000. With the increase in cross-city trips, cross-city travel has become an important part of the daily travel of residents in the Guangzhou-Foshan border area. In terms of the flow and footfall of the OD link, people living in one part of Liwan (Area ①), Eastern New Town (Area ②), and Nanhai Guicheng (Area ③) interacted more frequently across the city. At the same time, there was also extensive cross-border traffic in Panyu (Area ④)-Shunde Beijiao and Chencun Town (Area ⑤), Huadu-Nanhai, Chancheng (Area ⑥)-Liwan and other areas, for employment, residential, and leisure purposes. The reasons behind this data will be further elaborated in the next section.

From the perspective of the residence and employment space in the border area of Guangzhou-Foshan, the distribution was relatively concentrated and frequently interacted. There were obvious local hotspots such as Nanhai Guicheng, Eastern New Town, Liwan District, and Tianhe District. As can be seen in Figure 6, Guangzhou citizens living in Area ① were more inclined to travel cross-city for employment, with destinations focusing on Guicheng and Eastern New Town in Nanhai district. In recent years, Guicheng has strived to become the benchmark of city integration in the Guangzhou-Foshan region. Diverse initiatives have been undertaken to develop the city, such as industrial optimization, the landing of corporate headquarters projects such as ZTE's new intelligent manufacturing industrial base and Tiger's global R&D headquarters, the development of Qiandeng Lake Financial high-tech zone, and the construction of a high-tech industrial park in the Nanhai area of Sanlong Bay. Additionally, the Eastern New Town connecting to the Fangcun area in Liwan District is another important part of the "Liwan-Nanhai" pilot area, where the joint construction of a prime business district has created new development opportunities. On the other hand, Beijiao and Chencun in Shunde District have attracted some residents of the Panyu District (Area ④) to work across the city [64].

Foshan citizens, especially those living in Area ③ and Area ⑤, were mainly clustered in towns near the borderline and accounted for a greater proportion of cross-city travel. This situation is attributed to the opening of Guangzhou-Foshan Metro, which has greatly improved the connectivity of two cities along the line, and directed travelers to the four central districts of Guangzhou (Haizhu District, Tianhe District, Liwan District, Yuexiu District), which have long been the focus of Guangzhou's economic growth, bringing together numerous industrial parks and corporate headquarters. Additionally, because of

the low prices and convenient transportation, many people working in Guangzhou buy houses in Nanhai [65].

(**a**)

(**b**)
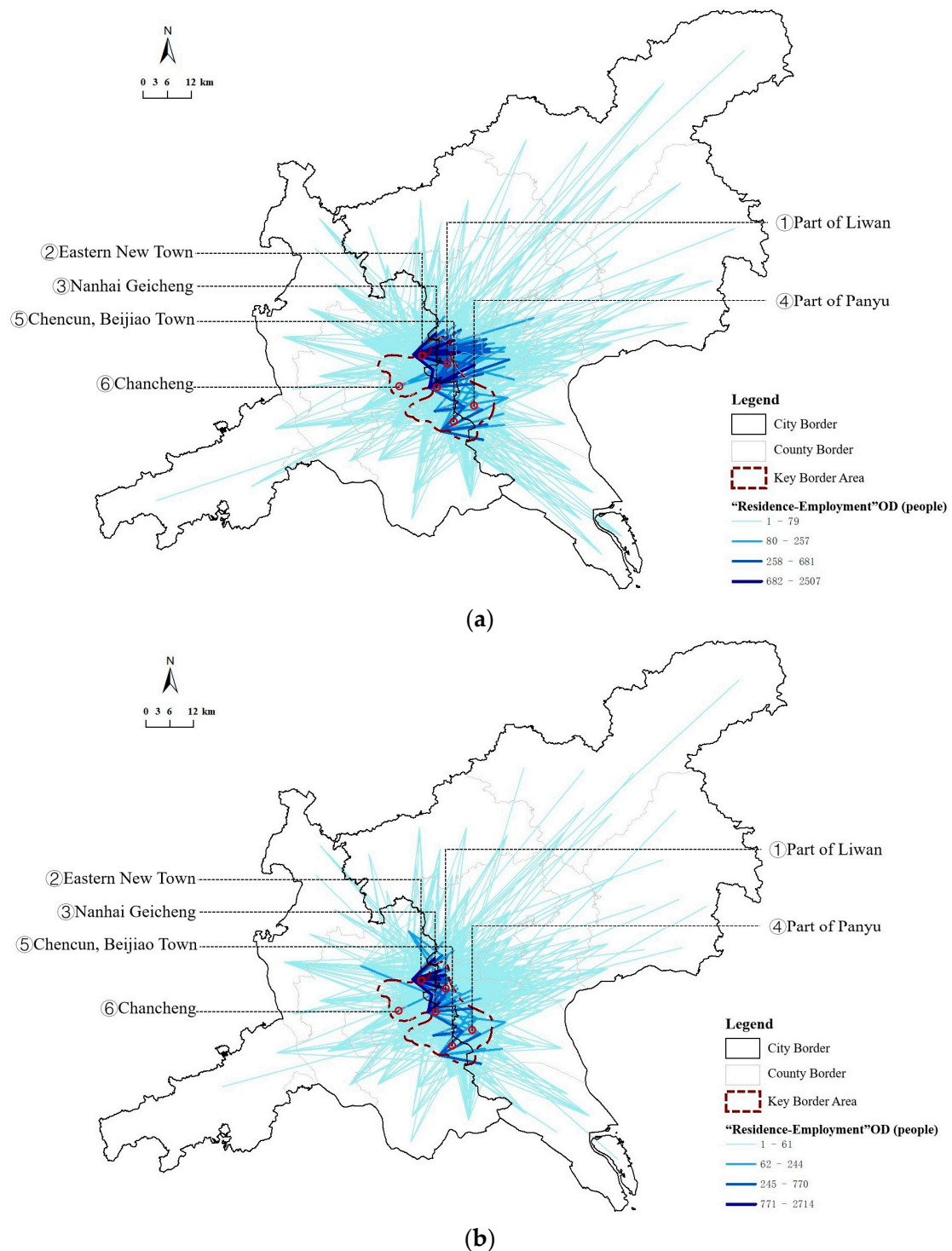
Figure 6. "Resident-employment" OD travel streamline of 2019. (**a**) The starting point (o) is in the border area; (**b**) The terminus (d) is in the boundary area.

As the core support for regional population and economic development, high-quality employment opportunities for a large number of occupations have an effect on individual's travel characteristics. In recent years, the peripheral areas of Guangzhou have grown and developed. The new urban rail transit line connects Huadu and Baiyun to the central axis of

Guangzhou City. Huadu will build the largest intelligent networked automobile industry base in the country, construct an international air–rail hub, and accelerate the gathering of intelligent electronics industry clusters. As the only national new area in Guangdong Province and a comprehensive cooperation demonstration zone for Guangdong, Hong Kong and Macao, Nansha District has grown stronger around its shipping hub, modern finance, and science and technology innovation industries, and has become more and more attractive to talent. Thus, Areas ② and ③ also had long-distance cross-city trips commuting to Huadu, Nansha, and other places. Furthermore, residents of both Guangzhou and Foshan made multiple daily cross-city trips for employment purposes. The trend of cross-city commuting in the Guangzhou-Foshan area was obvious, forming a spatial pattern of interaction and strong convection in the metropolitan area.

The spatial distribution of leisure activities across the city was relatively wide with a development trend of dispersion. As shown in Figure 7, the OD data indicated that the Liwan-Nanhai and Panyu-Shunde areas were closely connected. The Liwan Historical District and Panyu Changlong Resort in Guangzhou, and the Nanhai Ying Yuehu Cultural Center, Beijiao Forest Park in Foshan, all met the needs of residents in border areas for diversified cultural and entertainment activities and leisure facilities. In addition, these public resources in the study area also attracted residents from Huadu, Baiyun, Zengcheng, Sanshui, and other areas to travel across cities. Generally speaking, compared with job–housing orientation, the cross-city leisure range of residents in the border area had expanded significantly, with more long-distance trips. On the one hand, this spatial change is closely related to the rise of the regional leisure economy, as people pursue spiritual enjoyment under this rapid economic and social development. Guangzhou and Foshan share the same cultural roots and have been strengthening their cultural facilities in recent years, especially the integration of diverse cultures in the border areas to meet the growing needs of residents. On the other hand, the construction of the transportation network has also made cross-border travel and long-distance travel possible.
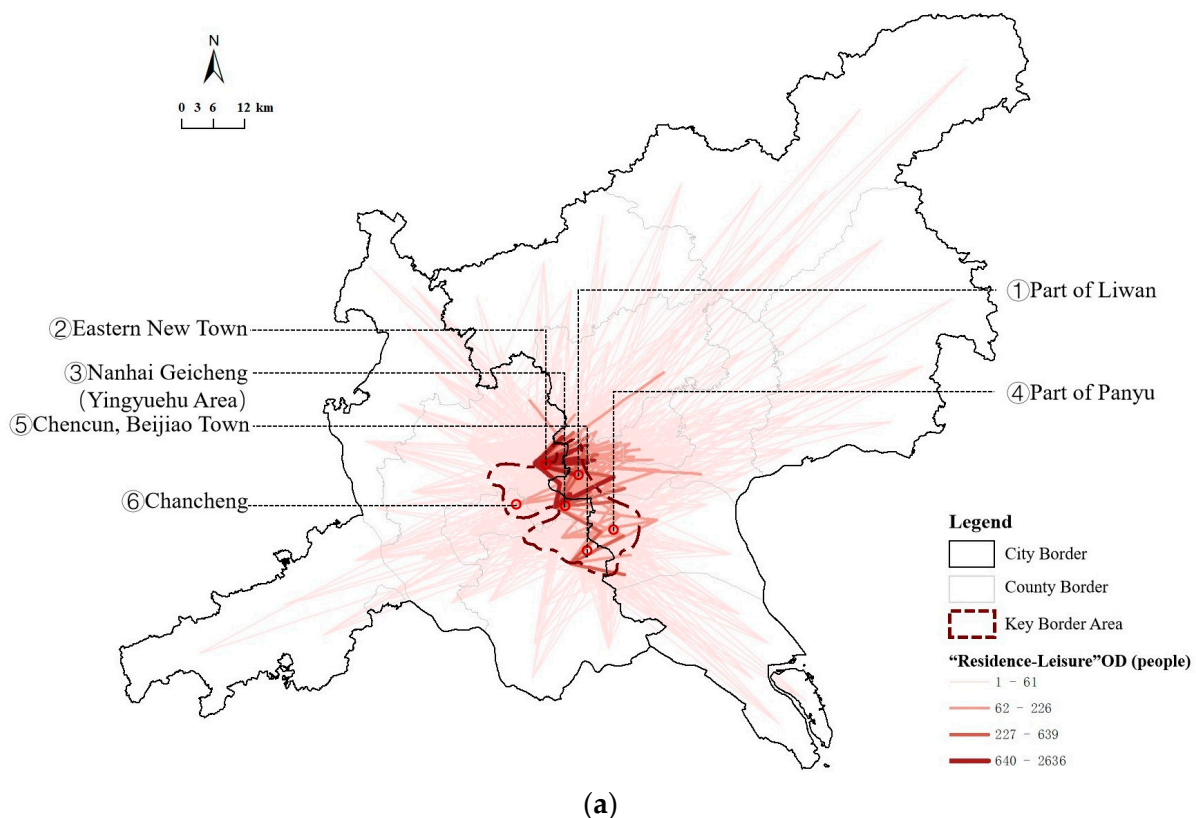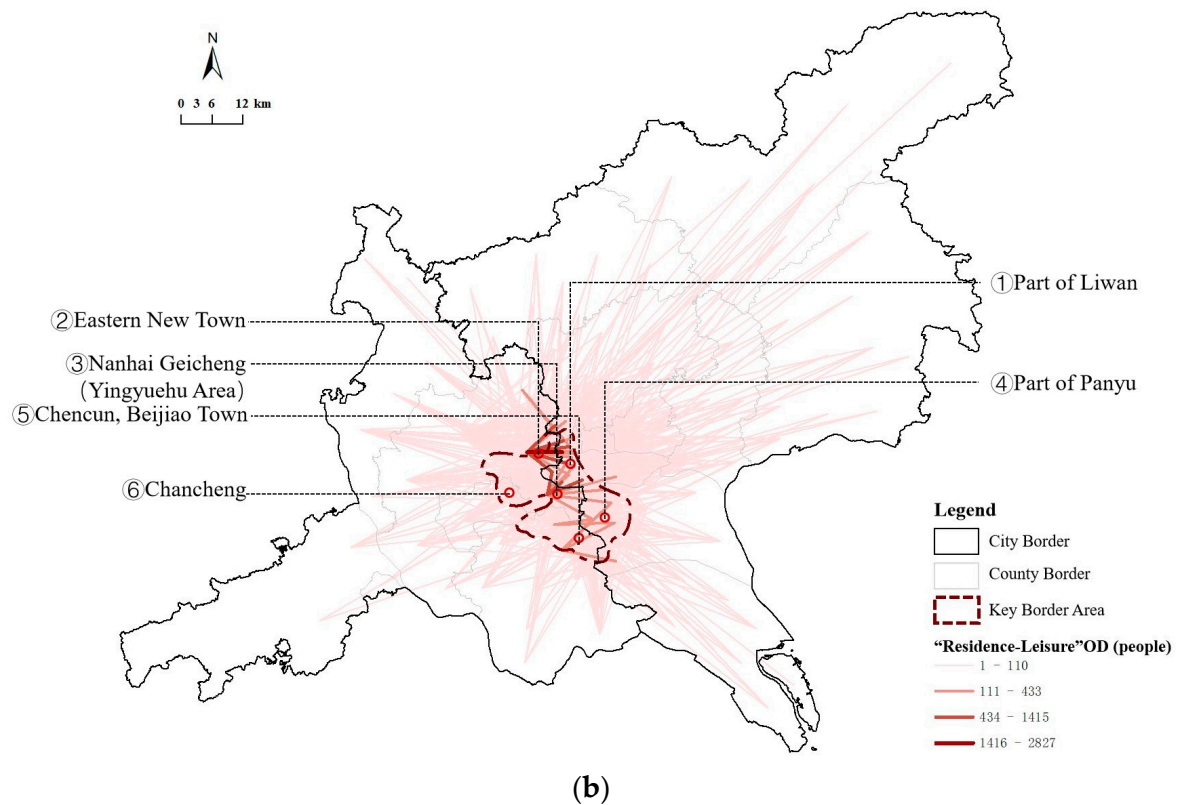

(a)

Figure 7. *Cont.*

(b)

Figure 7. "Residence-Leisure" OD travel streamline of 2019. (**a**) The starting point (o) is in the border area; (**b**) The terminus (d) is in the boundary area.

According to the distribution characteristics of residence, employment, and leisure and entertainment functions in Figures 5–7, the cross-city travel modes of residents in border areas were summarized into the following three types, as shown in Figure 8. Mode 1 signifies living and working in different cities, and having leisure activity in the neighboring city. Mode 2 indicates living in a city but working and recreating in a different city, and Mode 3 represents living and working in one city, but experiencing social life and recreation in another city. Mode 3 was predominant among border residents living in either Guangzhou or Foshan, that is, the current cross-city travel of Guangzhou-Foshan residents was mostly for leisure and entertainment purposes, which was a more significant change from the original commuter-driven cross-border behavior. Moreover, cross-city leisure activities gradually changed from the previously unbalanced one-way flow characteristics, "Foshan to Guangzhou", to the development trend of two-way circulation. This result is related to the rise of the leisure economy with the improvement of the regional economic and transportation infrastructure, as well as to the commitment of the residents from Foshan to a high-quality living environment in recent years. In short, Guangzhou-Foshan border area has developed into a fully resourced functional hub and a vibrant area with external appeal.

4.2. Spatial Patterns of the Cross-Border Area at Different Stages

Based on the above analysis, we observe that the travel behavior of urban dwellers in two cities considerably interacts with the effect of urban structure to produce observed mobility patterns. Interestingly, when looking at the interactions among urban spaces, we found that some localities (district centers or multifunctional areas) tend to interact because of location, employment opportunities, and amenities which have the potential to pull people cross the city boundary. These findings reflect the macro spatial patterns of the two cities, which have a historical origin and a realistic basis.
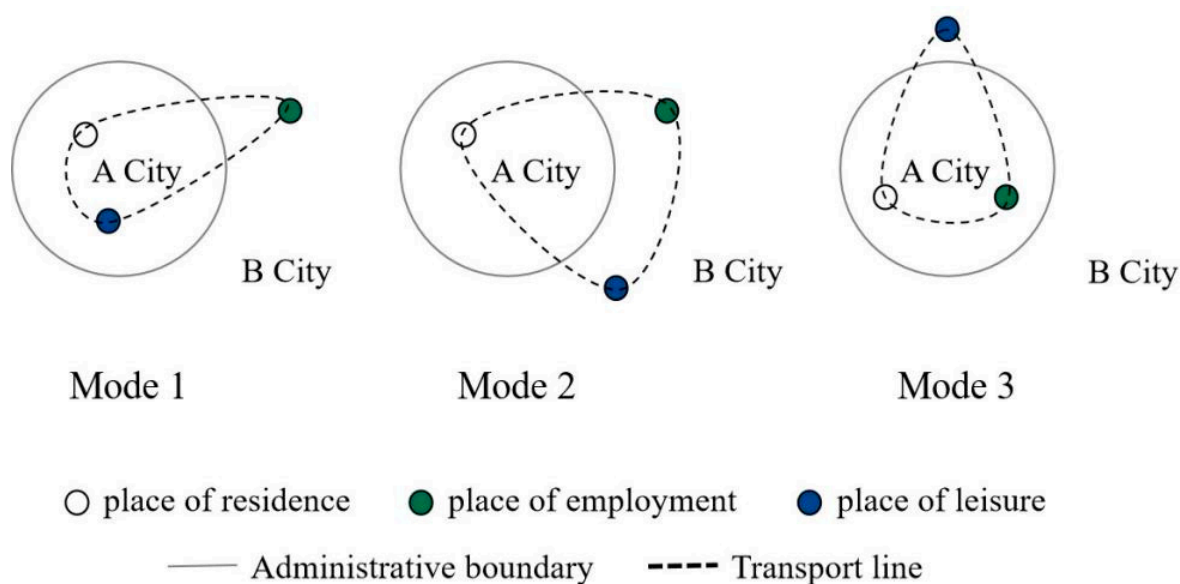
Figure 8. Cross-city travel patterns of residents in the cross-border area.

4.2.1. 1985–2000: Two Cities at the Independent and Spontaneous Development Stage

Historically, Guangzhou and Foshan have geographic proximity, with the same population and close social and economic ties. Since the reform and opening up, the Pearl River Delta has accelerated its urbanization process, with rapid economic and social development in Guangzhou and Foshan and a significant increase in urban population density. However, at this time the concept of "cross-city travel" was not yet formed because of the shielding effect of the borders under the administrative economy of market segmentation [40]. Studies on the accessibility of the Guangzhou-Foshan region have also shown that, in 1982, high accessibility areas appeared in the vicinity of Dali Town in Foshan (75.00 km^2) and in the central city of Guangzhou along G105, G324, and G107 (881.25 km^2) [66]. At this stage, residents traveled mainly along the major transportation routes of their respective cities. Correspondingly, with spatial growth in 1985, the two cities were still in the independent development stage, "each on its own."

Until 1989, the Guangzhou-Foshan Expressway was officially put into use, and the driving distance between Guangzhou and Foshan was reduced from 2 h to 20 min. The construction of the Line 1 subway and the renovation of the old city of Guangzhou brought about the overflow of residential and commercial functions, and at the peak of population out-migration, citizens began to buy properties in Huangqi and Nanhai. Cross-city phenomena such as "Sunday engineers" and "living in Foshan and working in Guangzhou" were common. The Guangzhou-Foshan Highway was also known as "Zhongshan Nine Roads." This non-governmental spontaneous cross-city travel, driven by the market economy, was also reflected in the spatial bordering of local border areas [46]. The two cities continued to expand outward around the core growth point between 1985 and 1995 (see Figure 9a–c), while, at the same time, Guangzhou Liwan-Nanhai Huangqi showed a partially contiguous spatial pattern.

In 2000, Guangzhou officially proposed new strategic planning with the concept of "Eastward, Westward, Southward, Northward", and "Westward" meant that development toward Foshan was fully launched. In June of the same year, the entire highway around Guangzhou and the eastern part of Foshan was completed and opened to traffic. During this period, new growth cores such as Shunde Dailiang and Panyu Nancun were added, and various types of construction continued to develop around the growth points (see Figure 9d). Guangzhou and Foshan began to explore the possibility of formal regional cooperation.

(a)　　　　　　　　　　　　　　　　　　　　　　(b)

(c)　　　　　　　　　　　　　　　　　　　　　　(d)
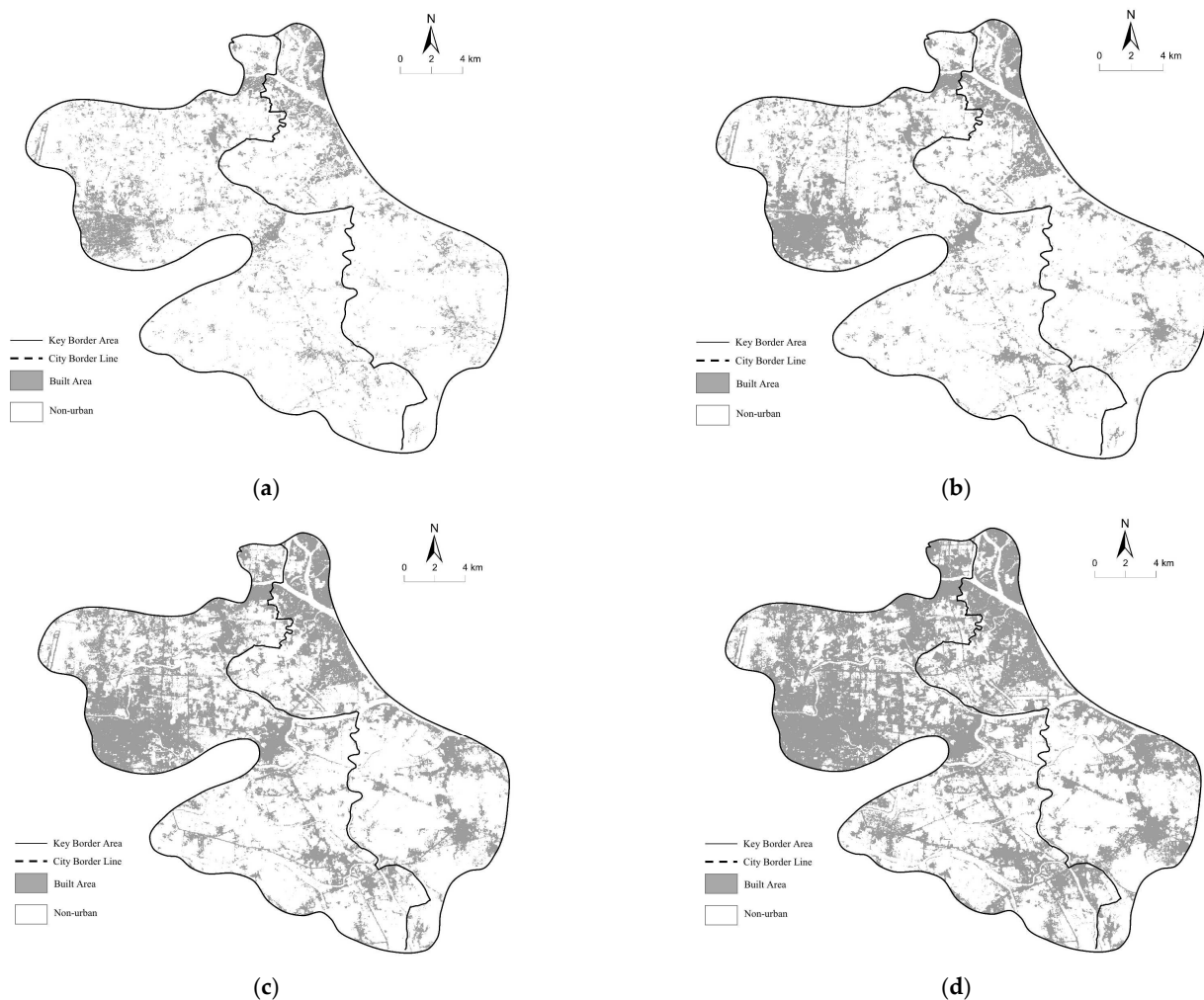
Figure 9. Spatial growth evolution of key border areas, 1985–2000. (**a**) Spatial growth in 1985; (**b**) Scheme 1990. (**c**) Spatial growth in 1995; (**d**) Spatial growth in 2000.

4.2.2. 2001–2005: Two Cities at the Planning-Led Phase

To positively respond to the planning proposed by Guangzhou city, in 2003, Foshan proposed the "East Bearing" strategy, and the concept of "Guangzhou-Foshan Metropolitan Area" took place in both cities. Guangzhou and Foshan cities continued to cooperate by relying on industrial clusters and transportation facilities. In 2003, Guangzhou and Foshan jointly organized a seminar on Guangzhou-Foshan Regional Cooperation and Coordinated Development. In the same year, after the regulation of administrative division from counties to districts, Nanhai District actively promoted the integration of the Guangzhou-Foshan region by fully exploiting its own location advantages to transform from an "industrial economy" to a "service economy", as well as from a "village economy" to an "urban economy" [67]. In 2005, the Guangzhou-Foshan Regional Cooperation Development Forum was held, in which the two cities discussed substantive issues such as industrial chains, transport connections, and environmental protection and put forward the idea of promoting regional cooperation between Guangzhou and Foshan as a common aspiration of both cities.

In terms of spatial morphology (see Figure 10a), during the period from 2000 to 2005, the growth axis was mainly oriented by river canals and traffic trunk lines, while the original growth cores of Shunde Daliang and Nanhai Guicheng all showed a trend of developing toward the boundary line. The junction area of Liwan and Nanhai grew rapidly, and the degrees of development and construction were greatly improved. During this period, the passenger flow interaction in the Guangzhou-Foshan cross-border area reached

460,000 passengers per day [68]. Clearly, the planning guidelines and industrial cooperation of the two cities were widely influencing residents' cross-city travel behavior.

(**a**)

(**b**)

(**c**)

(**d**)
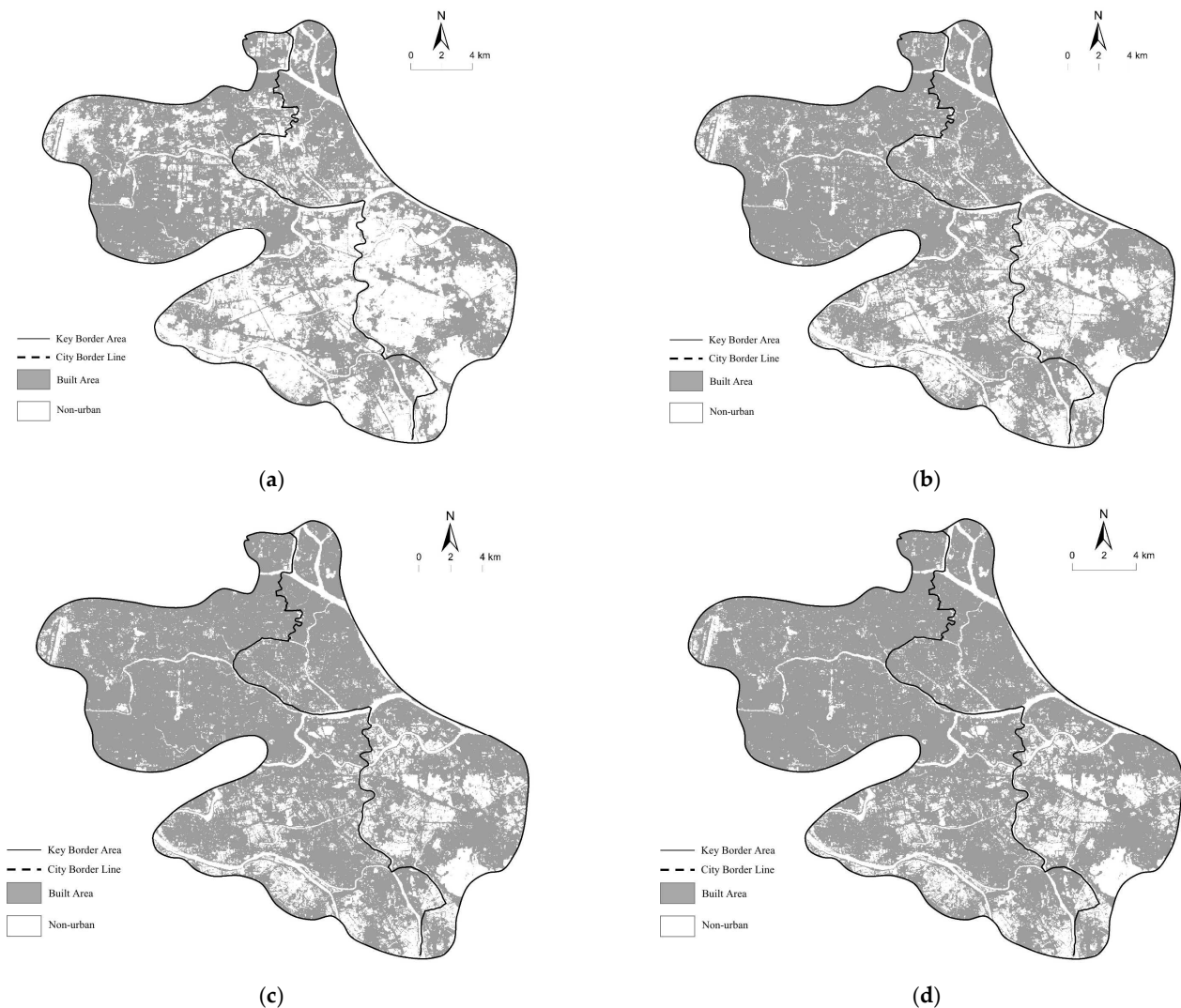
Figure 10. Spatial growth evolution, 2005–2020. (**a**) Spatial growth in 2005; (**b**) Spatial growth in 2010; (**c**) Spatial growth in 2015; (**d**) Spatial growth in 2017.

4.2.3. 2006–2010: Two Cities at Strong Spatial Cooperation Stage

The two municipal governments formally participated in the 3rd Guangzhou-Foshan Forum in 2006 and played an important role in guiding and promoting the Guangzhou-Foshan cooperation. The first special plan, the Guangzhou-Foshan Road System Connection Plan for cross-city cooperative road traffic in China that broke through administrative divisions, was promulgated. This plan assigned the 55 planned road linkage channels that were the prelude to Guangzhou-Foshan transport integration. In the same year, the Foshan First Ring Road with 17 intersections leading to Guangzhou, was officially opened to traffic, and in 2007, several Guangzhou-Foshan intercity bus lines were opened to further shorten the travel distance between Guangzhou and Foshan.

The outbreak of the global financial crisis prompted China's economic development to shift from export-oriented growth to a joint internal and external development orientation, which indirectly promoted the culmination of a new round of regional planning. The Outline of the Reform and Development Plan for the Pearl River Delta (2008–2020) clearly proposed the Guangzhou-Foshan city integration in 2009. Since then, Guangzhou-Foshan integration has been elevated to the level of national strategy. During this period, the

construction of city integration was particularly represented by the docking of infrastructure, showing a comprehensive upgrade from highways to expressways and then to urban subways [69].

The construction and improvement of the transportation network greatly promoted the cross-city travel of Guangzhou-Foshan residents. In 2009, Guangzhou Metro Line 5 opened, with the starting station Jiaokou located at the south end of the Pearl River Bridge, adjacent to Dali Town in Nanhai District. This initiative was a comprehensive deployment to promote cross-city travel and economic cooperation in the cross-border area of the Guangzhou-Foshan region. In 2010, taking advantage of the upcoming Asian Games in Guangzhou, China's first intercity subway, Guangzhou-Foshan Metro, was officially opened for operation, which marked the entry of the Guangzhou-Foshan city into the era of subway commuting. [70] The idea of rapidly advancing the one-hour life cycle in the Guangzhou-Foshan region became a reality. According to the Guangzhou-Foshan Metro Company data, the average daily passenger volume of the Guangzhou-Foshan subway was about 100,000, and the peak passenger flow was mainly during commuting hours, which meant that a large number of passengers were cross-border commuting in the Guangzhou-Foshan region. At the same time, the opening of Guangzhou South Railway Station also served the residents of the two cities and attracted some Foshan citizens to use it for travel across the cities in the Greater Bay Area. According to the Guangzhou Urban Traffic Operation Report 2010, the daytime traffic volume of Guangzhou in 2010 reached 830,000 standard vehicles in the city's entry and exit corridors, an increase of 8.7% over the previous year, reflecting the increasing connection between Guangzhou and the peripheral areas. Between them, the incoming and outgoing traffic were mainly distributed in the direction of Foshan, with an average load of about 5000 standard vehicles per lane/12 h. The traffic was mainly concentrated in the central area of Guangzhou to the west of the channel, of which the Guangzhou-Foshan Expressway bore the largest flow, close to saturation.

The mode and frequency of cross-city travel affected the growth of spatial form. During this period, the construction land in the border area of Guangzhou-Foshan increased significantly, Liwan-Nanhai basically achieved contiguous development, and the original growth points continued to expand along the city boundary, the main roads, and subway lines. In addition, the new growth points represented by the Guangzhou South Railway Station area, Shunde Leliu, and Beijiao town were developing continuously, driven by transport networks and industrial development, such as hardware and electrical appliances (see Figure 10b).

4.2.4. 2011–2015: Two Cities at the Multi-Dimensional Cooperation Stage

During the 12th Five-Year Plan period, the industrialization of the Guangzhou-Foshan region entered the rapid development stage, and the economic relationship between the two cities showed a state of competition and cooperation. Regional coordination of Guangzhou-Foshan city also made substantial progress. During this period, the traffic connection network was gradually improved, including 18 expressways, such as the Dongxin and South Second Ring Road; the Haiyi Bridge, which was jointly built and managed by Panyu District of Guangzhou and Nanhai District of Foshan, was opened to traffic; the Guangzhou-Foshan Ring Road and Haihua Bridge were under construction, etc.

The cooperation efforts of the Guangzhou-Foshan region became diversified. The two cities were effective in the fields of industrial collaboration, environmental protection, and social security and began to build a cross-border cooperation system at the district and township levels. In 2015, Liwan and Nanhai signed the Framework Agreement on Jointly Building the Demonstration Zone of Guangzhou-Foshan Integration, which delineated the pilot area of Wuyanqiao-Jiaokou as that Demonstration Zone to achieve "district-level integration;" Shunde-Panyu, Sanshui-Huadu, and other neighboring areas also demarcated industrial cooperation development zones on the scale of towns and streets and established communication channels by way of twinning between towns [71].

Driven by factors of transport, industry, and policy, the modes of intercity travel diversified. The pilot zone and industrial development zone provided a large-scale job market for residents of Guangzhou and Foshan, and the groups separated from their work and housing reached a certain scale. The starting point for travel was concentrated in the main urban areas of Guangzhou and Foshan covered by the metro network, but other districts and counties not covered by metro service also exhibited a certain inter-city travel concentration trend [72]. According to the Guangzhou-Buddhist Urban Development Report (2018), the passenger flow increased from 100,000 passengers per day at the opening to 153,200 passengers per day in 2015, with an average annual compound growth rate of 9.08%, and the average daily passenger flow increased by more than 50% in five years. From the perspective of passenger flow composition, the interactive passenger flow between Guangzhou and Foshan accounted for 51%. At the same time, some cross-city leisure populations emerged, mainly pointing from Foshan to Guangzhou and clustering in the central area of Guangzhou and Panyu District.

During this period, the area of construction land in the Guangzhou-Foshan area continued to increase and basically covered both sides of the border areas. The urban boundary line was increasingly blurring. Other surrounding areas were sporadically spreading (Figure 10c). In terms of spatial form, the growth points were obviously concentrated in the border areas and showed a trend of rapid expansion, especially in Liwan-Nanhai Guicheng, Liwan-Nanhai Dali, Guangzhou South Railway Station-Shunde, etc.

4.2.5. 2016–2020: Two Cities at the Global Integration Stage

By this stage, a higher level of integrated development was being explored. In 2016, in response to the construction of the urban agglomerations and metropolitan area, Guangzhou and Foshan held a working exchange forum, and the two cities planned to build a "super city jointly." The subsequent promulgation of the 13th Five-Year Development Plan (2016–2020) for the urban integration of Guangzhou and Foshan covered regional cooperation from the perspectives of transportation, industry, healthcare, environment, education, infrastructure, and other fields. The Guangzhou-Foshan region entered a deep integration stage. Residents also became the focus of the general trend for cross-city employment and life. According to a statistic released by Centaline Property Research in Foshan, the proportion of Guangzhou customers buying properties in Guicheng exceeded 70% from 2016 to 2017. The total passenger flow of the metro Guangzhou-Foshan line in 2018 was as much as ten times that of 2012, with a peak passenger flow of 591,600.

Liwan and Nanhai adjacent areas opened a total of 22 bus lines in 2018. The Haihua Bridge connecting Panyu and Shunde was officially opened to traffic, enabling a five-minute drive from Guangzhou South Railway Station to Chencun Town in Shunde District, bringing the people of the two cities closer together. In addition, located in the junction area of Chancheng, Nanhai, and Shunde, Sanlongwan was a typical area in the Guangzhou-Foshan region. At present, a total of 42 industrial projects with a total investment of about CNY 57 billion have been signed and introduced into Sanlongwan, creating several major landmark projects such as Guangzhou-Foshan Hui and Sci-Tech Wisdom Valley. The Sanlongwan area is shouldering the important task of building a gateway and a platform for absorbing global innovative resources and capital in the Greater Bay Area. Due to the above changes, new characteristics of the cross-city travel characteristics of residents in key border areas in 2019 were found and analyzed in the previous analysis in Section 4.1.

In 2019, the Guangdong-Hong Kong-Macao Greater Bay Area Development Planning Outline (hereinafter referred to as the Outline) was officially released, which clearly identified the Guangzhou-Foshan region as one of the three poles of the Greater Bay Area. The Outline comprehensively assessed the achievements and problems of Guangzhou-Foshan integration from the perspective of adapting inventory planning and grassroots efforts in the space of flows, and gave the two cities a new strategic mission of strong union and pole-driven development. In May of the same year, the two cities signed the Memorandum of Understanding on Building a Pilot Area for the High-Quality Development of Guangzhou-

Foshan at a joint meeting of the party and government of Guangzhou-Foshan, specifying that they would build pilot areas for the high-quality integration of the development of Guangzhou-Foshan around the 197-km boundary line, involving 37 towns and streets in nine districts of the two cities, and take the lead in preparing an integrated plan to build a "1 + 4" integrated development pattern, further implementing the Outline and becoming the pole of the Guangzhou-Foshan region.

Taking the cross-section of construction land in 2017 as an example (see Figure 10d), we found almost no incremental expansion of space in this period. With the deepening of the cooperation process, the stock of space in the border area was being used efficiently, and the intensity of land-use development was high. Combined with the actual planning project, the development of the Yingyuehu area, on the one hand, was aimed at meeting the diversified consumption needs of the border area, and on the other hand at promoting the integration of many district and village industrial parks and reserve land for Liwan and Nanhai districts. The driving force of the Guangzhou South Railway Station area was brought into play with the completion and opening of the Fanhai and Haihua Bridges and the urban expansion area of Chencun Town with integrated services, high-quality housing, and characteristic industries.

5. Discussion

To better analyze the spatial evolution process from the bird's view of cross-border travel, the study analyzed the spatial growth of the border area based on satellite images and the data of construction land in urban–rural areas at five-year intervals from 1985 to 2020. These were combined with planning documents, public policy reports, and the secondary travel data to comprehensively investigate the spatial evolution process in the Guangzhou-Foshan border area during the past 35 years.

5.1. Understanding the Spatial Evolution Process from 1985 to 2020

The urban integration of Guangzhou and Foshan began in the 20th century, moving from non-governmental cooperation to planning-led development and then to multiple cooperation. Beginning with the spatial evolution of the Guangzhou-Foshan region from 1985 to 2020, shown in Figure 11a, the Guangzhou-Foshan key border area has transformed from independent core circle radiation to contiguous faceted development. Before 1990, the city boundaries were clearly defined in the context of administrative economy, and the two cities of Guangzhou and Foshan developed separately, with the growth points mainly being A (Liwan, Guangzhou), B (Dali, Nanhai), C (Chancheng, Foshan) and D (Guicheng), and the interconnection weak. At the end of the 1990s, driven by private initiative under the market economy, Guangzhou Liwan-Foshan Huangqi was partially connected. At this time, the original growth points continued to expand, and growth points F (Daliang, Shunde) and G (Nancun, Panyu) were formulated.

In 2000, Guangzhou proposed a "Western Union" to Foshan, and the two cities began to explore regional cooperation. From 2001 to 2005, a series of Guangzhou-Foshan forums were held, and the two sides of the border came together under the guidance of planning and industrial cooperation, with growth points D and F developing toward the boundary line. The growth axis was mainly oriented by rivers and traffic arteries. The third Guangzhou-Foshan Forum in 2006 marked the official involvement of the government, while in 2008, the Outline elevated the Guangzhou-Foshan integration to a national strategy. At this stage, the original growth points continued to expand along the city boundary line and, through connecting roads and subway lines, the additional new growth points I (Guangzhou South Railway Station), Shunde Leliu, and Beijiao were presented.

(**a**)

(**b**)
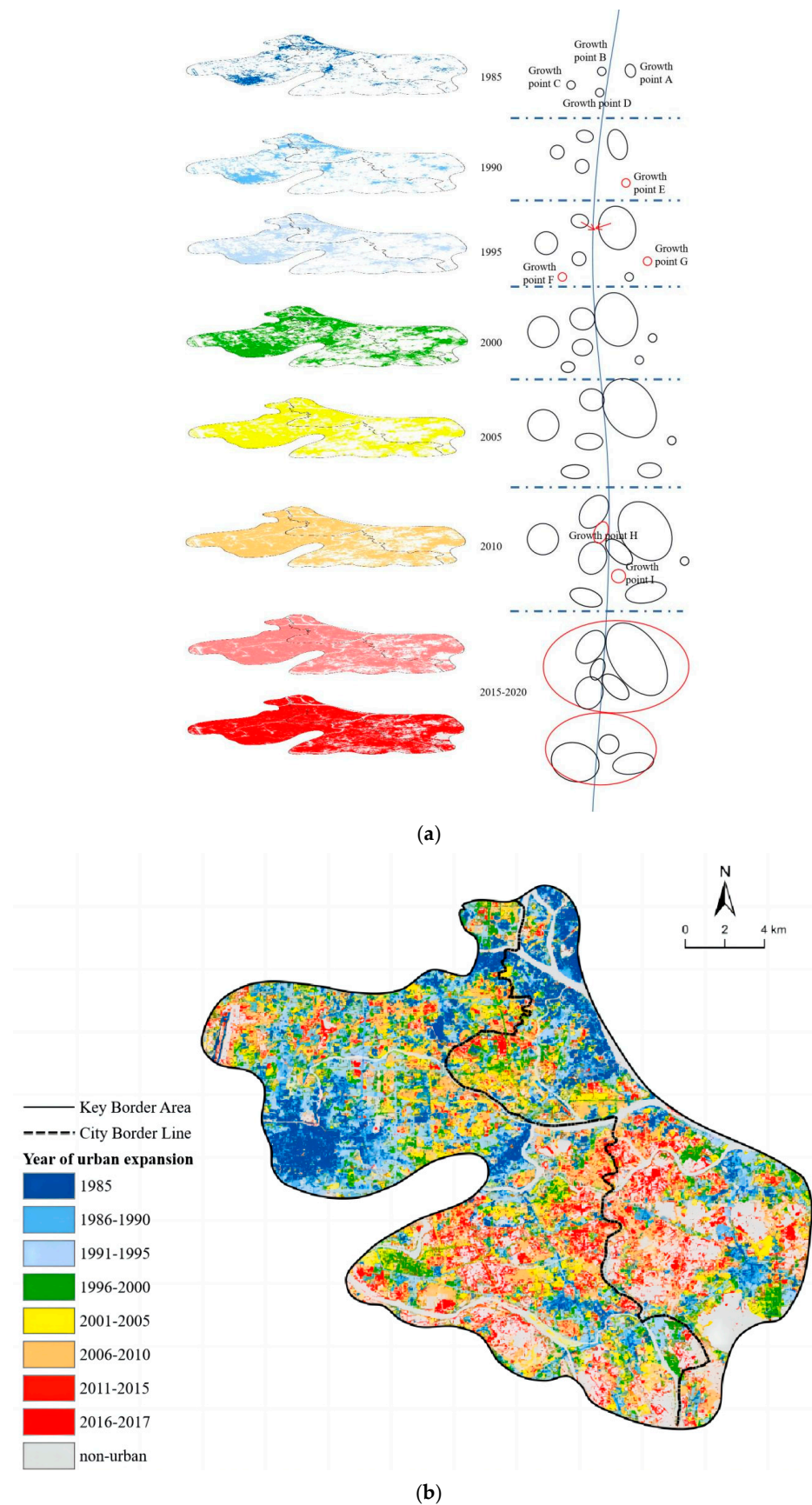
Figure 11. Spatial evolution of the border area from 1985–2020. (**a**) Spatial growth diagram of key border areas of Guangzhou-Foshan from 1985–2020; (**b**) Evolutionary pattern of spatial expansion of key border areas of Guangzhou-Foshan, 1985–2020.

Since 2010, under the influence of a series of driving forces such as policy support, planning leadership, industrial cooperation, and transportation network construction, the area of construction land has continued to increase, and the growth points were obviously concentrated in the border areas and showed rapid expansion (see Figure 11b), with blurred boundaries in Liwan-Guicheng, Liwan-Dali, Guangzhou South Railway Station-Shunde, etc.

5.2. Driving Forces of the Cross-Border Area in the Guangzhou-Foshan Region: National Policy, Local Government Cooperation, and the Market

Because of the difference between China's political system and development stage and those of Western developed countries, the cross-border area development in China will undoubtedly take on a different appearance. Border areas have different meanings and practices in different development contexts, and the boundaries between China and foreign countries under globalization and the "Belt and Road" initiative have an inclusive nature. While most cities in developed countries are built with relatively stable structures and mobility, the urban structure in China is shaped by both government and market forces and by the spatial forms according to the actual needs of residents in the process of rapid urbanization [73]. Because of the development characteristics of China, such as the wide area and significant heterogeneity of regional development, the spatial patterns and the deep-seated motives for spatial changes are unconventional. The theory of coordinated regional development created the conditions for China to break internal administrative borders and promote integrated development with the support of national policy, local government cooperation, and the market.

With the increase in interregional inequalities associated with contemporary globalization, China has paid attention to the development of cross-border areas that are adapted to national conditions and have local characteristics. Based on this study, we viewed the cross-border areas at different periods and scales. In the early days, China was influenced by cross-border studies abroad, such as from the European Union, and put priorities for government intervention and planning policies at the macro level, as, for example, in the Outline. However, the urban integration progress has developed with a considerable time lag. During the financial crisis in 2008, urban agglomerations gradually became the "new outlets" of economic growth, and city integration also became the new approach to promote efficient urban spatial development in China. The border area was positioned as a key regional economic, social, and cultural hub in a region, or between cities.

Human activities and travel in the border areas at meso and micro scales largely represent the interrelationship between cities via the cooperation between local government and the market. The dynamic changes in urban spatial structure represent the rationality of regional policy making and resource allocation capacity in the process of urban agglomeration development. The increase in human activities in the border areas facilitates the reshaping of regional economic structure and ensuring the high-quality development of urban agglomerations. Cross-city travel is an essential manifestation.

Cross-city commuting mainly stems from the unbalanced and inadequate development of cities in China. Essentially, the essence of cross-border travel is indeed a contradiction between market development logic, technological progress, and institutional design between cities, which leads to regional disparities and imbalance in the spatial distribution of population in urban and rural areas. To tackle this regional dissimilarity, local governments in China, acting up on the policy agenda of regional coordinated development, are seeking to increase city-to-city cooperation, which is an asset in the enhancement of ownership. Local governments can determine the nationwide conditions and objectives for city-to-city cooperation in industrial development, transport networks, and environmental protection. In this way, the local state is in an excellent position for joint and cooperative action to secure mutual benefits or solve common problems.

Additionally, the differences in housing prices and the growing needs of the people for a better life facilitate residential relocation and neighborhood change. Therefore, in the

context of city integration, the spatial and temporal characteristics and patterns of people's activities in the border areas are becoming increasingly complex, and the administrative boundary effects are becoming increasingly blurred.

6. Conclusions

For China, the development of cross-border regions has become a hot topic. This study explored the spatial evolution of the Guangzhou-Foshan cross-border area and the driving forces behind it during 1985–2020. The key findings were as follows: first, after detection of the spatial evolution of the Guangzhou-Foshan region, we determined its development pattern to be spreading expansion, with Liwan District as the central core and connecting to several sub-centers. The cross-border area in the Guangzhou-Foshan region represented a compact, extremely integrated degree and a well-matched functional space. Second, from the analysis of the cross-city travel of residents in the border areas in 2019, instead of the previous one-way attraction pattern caused by the spread of residence, a large number of cross-city trips for leisure and entertainment purposes emerged, and the one-way unbalanced flow, "Foshan to Guangzhou", changed to two-way circulation. Third, the spatial analysis of the border area revealed the spatial evolution patterns of the Guangzhou-Foshan cities from 1985–2020, which transformed from a circle of independent core radiation to a contiguous compact development. The growth points of the two cities continued to expand toward the borderline in the direction of integrated development, while the growth axis was mainly in the direction of the city border, urban arterial roads, and subway lines.

Planning guidelines and transportation network construction in the border area have profoundly affected the characteristics of cross-border travel. The analysis indicated that the rise and rapid economic development of the Nanhai area attracted many talented workers from Guangzhou to Foshan for employment, while Foshan citizens also tended to seek opportunities in the four central districts of Guangzhou. At the same time, a large amount of cross-city travel for leisure and entertainment emerged in the border areas. The purpose of travel tends to be diversified, and cross-city leisure travel from the previous "Foshan to Guangzhou" one-way unbalanced flow became a two-way flow, which was also related to Foshan's commitment to building a comprehensive quality area in recent years. On the other hand, the two cities shared transportation hubs. The 2020 Guangzhou Transport Development Annual Report stated that Guangzhou South Railway Station was the largest high-speed railway station in China in terms of passenger flow in 2020. Foshan passengers can reach Guangzhou South Railway Station within 45 min, making it very convenient to use the Guangzhou hub. Currently, nearly 20% of the total current passenger flow of Baiyun Airport and Guangzhou South Railway Station are Foshan passengers. Foshan city, which is close to a series of Guangzhou transport hubs, has gained a relatively obvious location advantage to attract investment and talent. With the realization of the Guangzhou-Foshan transportation network and integration, the inter-city connectivity and information exchange between these two cities would further strengthen, and the two-way travel demand also further expand.

Travel patterns are crucial for understanding humanity's role in shaping the urban space. Cross-city travel behavior has changed the spatial pattern and functional distribution of two closely connected cities. Since 2008, the national policy was aimed at reinforcing the urban integration. With the aid of both the "border effect" and "agglomeration effect" in border areas, the frequency and scope of cross-city travel have significantly increased. As a result, development of cross-border economic cooperation zones and cross-border transport infrastructure have had an impact on cross-border travel. The increase in cross-city commuting and the presence of an administrative border offer an opportunity to invent original forms of governance in the two cities, to increase the autonomy of the local authorities through different types of cooperation that transcend the institutional and territorial divides, and to promote the urban integrated character of the Guangzhou-

Foshan metropolitan center. In the context of global competition, these features represent an undeniable benefit.

The study proposed planning recommendations for increasing urban interactions and optimizing spatial patterns. To further increase cross-border travel behavior, the necessary connecting trunk lines should be added to build a comprehensive transportation network, coordinate the transportation resources between the two cities, and increase behavioral interaction. At the level of spatial optimization, it is necessary to strengthen the institutional innovation of synergistic mechanisms and achieve "one map" management in terms of top-level design, platform construction, and mechanism guarantee. Based on this, through the integration of borderland, attention to the allocation of shared spatial resources, and the construction of a cross-border flexible flow mechanism, we will promote the realization of a sustainable development model that considers the border first and drives the whole Guangzhou-Foshan region to the same city [74].

The article's shortcoming lies in using single-year mobile phone signaling travel data for analysis, and cell phone signaling itself has limitations such as lack of user social attributes, non-full sample detection, and base station positioning errors. On the other hand, the article did not conduct detailed survey interviews with governments at all levels and residents in Guangzhou-Foshan border area. However, cross-border areas are in a dynamic process of continuous development. Therefore, in the future, it is necessary to further combine new data and technologies to enable long-term dynamic monitoring and evaluation of border development. At the same time, the article needs to investigate the roles of governments, planners, residents, and other subjects in the Guangzhou-Foshan Region to gain a deeper understanding of the management mechanism of cross-border development, and to understand the cross-border barriers and development visions of residents. This can be achieved by combining multi-time series travel data analyses in order to better focus on the dynamic spatial evolution path of cross-border areas and provide a more scientific and feasible reference for the cross-border coordinated development of other integration regions in China.

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