Delineation of city-region boundary in Vietnam: The empirical case of 'Can Tho City-region'

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ARTICLE INFO	ABSTRACT
	In recent years, city-regional development has received increasing attention from the media, policymakers as well as the academic spheres but yet 'city-region' remains a relatively understudied subject in Vietnamese literature. Contemporary works have appealed to how city-regions are functional economic areas, but the development of Vietnamese city-regions has been rather normative and politically guided. More empirical works are much needed so that city-regional policies are more evidence-backed and, therefore ultimately, more effective. With particular scope into the delineation of city-regional boundary, this paper contributes to that growing body of literature in two ways: (1) to provide an overview of methodology to define boundaries of polarized regions - of which city-region is a special form - and (2) to present an original attempt to empirically delineate city-regional boundary in Vietnam, with 'Can Tho City-region' as a case study. The article is both empirical and experimental which, the author hopes, would ignite further interest in this growing field.

1. Introduction

'City-region' or 'Metropolitan area'[1] has been a commonly used term but a rather understudied topic in the Vietnamese literature. Various works have analyzed comprehensively multiple development aspects at the city level (Nguyen & Nguyen, 2003), at the regional level (Nguyen & Nguyen, 2006; Nguyen, 2013) and at the local level (Dam, Nguyen, & Nguyen, 2015). A small number of published works have touched on city-regional development although the scope has been very limited to the definition of a city-region (Nguyen, 2009) or a very specific definition of the Hanoi Capital Region (Nguyen, 2015) in its respective context. Yet beyond that, multifaceted city-regional development issues nevertheless remain unexplored.

Only recently in the works of Tran (2015) and Le (2020) did the City-region concept receive more pertinent attention. Three very important topics that Tran (2015) explored were the concept and classification of city-region, the methodology to delineate City-Region boundaries, and reviewing a selected set of city-regional structural models as a reference point. A wide variety of empirical methods have been suggested which has suggested very potential research pathways for city-regional research in Vietnam. The paper by Le (2020) argued that city-regions are *functional economic area* which means not only are they an object of spatial planning but also a valid economic units with distinct economic dynamics and interactions within themselves that can

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[1] The terms 'City-region' and 'Metropolitan Area' can be used interchangeably, however the former one is more straightforward, in the author's opinion, and for simplicity and consistency the term 'City-region' is used throughout the paper

be studied empirically. In other words, the *city-region* is attributed to be on par with other administrative, and territorial units in Vietnam such as the *city* and the *region*. The assertion about city-region being receptive to empirical is a very important point in the Vietnamese context because recently city-regional development policies are increasingly being promoted, therefore methodological approaches to comprehend the city-regions would lead to much needed research-based, evidence-led input that eventually enables more effective preparation and implementation of city-region scale development policies.

The purpose of this paper is twofold. *Firstly*, it contributes to the current literature on city-regional research in Vietnam with a particular focus on methodology to delineate the city-region boundary. Currently there are two formally established city-regions in Vietnam, the "Hanoi Capital Region" and the "Ho Chi Minh City Metropolitan Area", however, both were established mostly on an administrative basis, by definitively aggregating the boundaries from adjacent provinces around Hanoi and Ho Chi Minh City. While it seems logical, or even 'evolutionary', for these two special cities to expand into city-regions, the methodology to define their boundaries remained ambiguous and the lack of legal framework and development monitoring instruments for city-regions in Vietnam (Le, 2020) undoubtedly has raised certain questions on its validity and how the concept is correctly understood in Vietnam[2]. In this apparent absence of clarity, an overview of available methods for delineating the city-region boundary is necessary.

Secondly, this article presents an original attempt to empirically delineate the city-regional boundary. For this purpose, Can Tho City is an ideal candidate for a few reasons. As one of the five municipal cities[3], Can Tho receives critical and favorable support from the central government. Within the Mekong Delta Region, one distinct advantage of Can Tho compared to its neighboring provinces is that it is envisioned to be the regional socio-economic core of the region (Vietnam Central Executive Committee, 2020, p. 3):

> "Building and developing Can Tho into a regional, ecological, civilized and modern central city with rich river-and-water identity in the Mekong Delta Region is an important and meaningful task not only in economic terms but also in social, political, defense and security terms. This is a task not only of Can Tho but also of the whole Mekong Delta Region and the whole country, in which the internal resources of Can Tho are identified as the primary, and the resources from central [government] to have a a supporting role in facilitate and accelerate the development of Can Tho".

In addition to that, Can Tho has the comparative advantage in terms of urbanization and connectivity which has been shown to have significant impacts on growth even at regions with a low level of urbanization such as the Mekong Delta Region (Le & Bui, 2020). Noticeably, the term 'Can Tho City-region' has been coined by previous studies though only on the conceptual basis (Tran, 2015, p. 252) or on the basis of identifying the most suitable area for long-term habitation and economic development in the context of climate change (Tran, 2019). To the best of the author's knowledge, this article is the pioneering effort to delineate Can Tho City-region boundary based on estimated economic interactions. In this sense, the paper is therefore both empirical and experimental; selecting Can Tho as the case study has both the contributory and interpretative meaning to the current literature.

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[2] The Vietnamese media has been active and critical on both Hanoi Capital Region and Ho Chi Minh City Metropolitan Area, particularly in how they are conceptually understood. For examples, see Quang Chung (2015), Tran (2020), Quy Anh (2020); URLs are included with respective sources in the reference

[3] Municipal cities are centrally-directed or centrally-controlled cities with status equivalent to provinces - the other municipal cities are Hanoi, Ho Chi Minh City, Hai Phong and Da Nang)

The structure of this paper is as follows. The second section outlines the theoretical basis relevant to our analysis, which can be grouped into two categories: (a) empirical models that can be utilized to delineate city-regional boundaries, (b) an overview of contemporary approaches to delineate regional/sub-regional boundaries in the Mekong Delta Region and of Can Tho City-region. Analysis in this section highlights the case for boundary delimitation based on economic dynamics. The third section deplores the methodology for our analysis. A clear step-by-step analytical framework as well as a detailed walkthrough at each step is provided. The fourth section presents the research results with evidence-based delineation of sub-regions in the Mekong Delta Region, from which Can Tho City-region emerges as one of the three sub-regions proposed. The final section contains some concluding remarks.

2. Theoretical basis

Traditionally, regions have been defined, or classified, into three typical forms (Meyer, 1963): *homogenous*, *polarized* (or *nodal*), and *programming* (or *policy-oriented*) regions. Homogeneous regions share one or a combination of physical, economic, or social characteristics. The boundary delineation of the homogeneous region depends on the set of variables selected as well as the weight assigned to them in determining their similarity. Polarized regions are recognized by the presence of a central core (usually a central city) with a peripheral area linked to the core; thus, the boundary delineation of polarized region is by defining the maximum influence extending from the central city into its surrounding areas. To do this, measurement of interactions between the central city and its peripheral areas is necessary. Due to the complexity of such interactions, no single criterion can singlehandedly represent them although commuting flow has generally been adopted as a common proxy for such interchange. Programming regions "concerned mainly with administrative coherence or identity between the area studied and available political institutions for effectuating policy decisions" (Meyer, 1963, p. 22) - in other words, programmed regions are regions established by policy-makers or planner for management and administrative purposes. Obviously, in practice, regions often do not exist in purely theoretical types but a combination of, or compromise between, different types.

Parr (2005, 2008) argued that the city-region is best characterized as polarized region which comprises two components or zones. The first is the C zone, represented by the central city and the S zone represents the surrounding area or hinterland. Terminologies for these two components may vary depending on the research background and theme[4] however they are presumed to have a diverse range of economic interactions such as labor-market flows or capital movements (Parr, 2005, pp. 558-559). Interactive dynamics within a city-region are constituted of not only economic but also social, cultural and environmental activities, for instances: (a) people, (b) goods, (c) services, (d) capital and assets, (e) waste and pollution, (f) environmental resources, (g) knowledge, (h) social norms, values, lifestyles and identities (Davoudi, 2008, pp. 51-52).

Categorizing the city-region into a fitting type of region is imperative in selecting the suitable methodology for delineating its boundary, however, that is not the main focus of this paper. In the Vietnamese context, the paper adopts the perspective that city-region is characterized as a polarized region because of two reasons. *One*, in Vietnam cities have long been recognized to be the engine of growth for both regional and national economies, especially since Doi Moi in 1986 the perception of urban development has shifted from limiting urban development to city-

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[4] Research backgrounds and themes might have an influence on how these zones are addressed in the literature. For instance, the relationship between '*Urban*' and '*Suburban*' areas were commonly debated (for example see works by Blair, Staley, & Zhang, 1996; Ihlanfeldt, 1995; Helsley & Sullivan, 1991; Savitch, Collins, Sanders, & Markham, 1993; Voith, 1992) or the relations between '*Urban*' and '*Rural*' areas (for instance see works by Copus, 2013; Preston, 1975; Roberts, 2000; Stead, 2002)

centric development (Hoang, 2011). *Two*, the spatial structure of two city regions in Vietnam - Hanoi Capital Region and Ho Chi Minh City Metropolitan Area showed that there is a clear distinction made between the central core and surrounding areas (Le, 2020). This indicates that top-level political management in Vietnam places a strong emphasis on the cities as the focal point of economic growth in its immediate surrounding area. With polarized regions, three notable methods are often exercised to define the extent of their boundaries: flow analysis, density function, and gravity models.

2.1. Empirical methods to delineate regional boundaries

2.1.1. Flow analysis

The flow analysis defines the city-region boundary by assessing the dimension and strength of interactions between a center and peripheral areas. An interesting metaphor regarding flow analysis is to visualize urban centers as "having 'footprints' defined by their interaction with surrounding areas, the size and shape of these footprints inevitably differ depending upon the types of interaction involved. Thus the 'reach' of cities and towns in terms of travel-to-work patterns is not the same, for example, as that described by patterns of travel to entertainment venues or shopping centers, or the geography of business supply chains" (Marvin, Harding, & Robson, 2006, p. 13). The boundary delimited by flow analysis is the influence extent of the dominant center into its surrounding areas, and such influence extent is dependent on the type of interaction involved with varying intensity.

Green (1950) used bus services to define urban peripheries in England and Wales (Figure 1). Based on bus timetables in the cities, Green mapped bus routes with varying intensity (bold lines for routes with more buses and vice versa) and from the analysis of bus routes with the highest demand (boldest), the urban periphery for the respective city is determined. Green's approaches have some limitations such as "the actual number of bus journeys made may be varied by the introduction of relief services. Then there are other ways of traveling; by rail, for instance, by private car or by bicycle, the last-named being of considerable importance in certain parts of the country such as East Anglia" (Carruthers, 1957, p. 372).
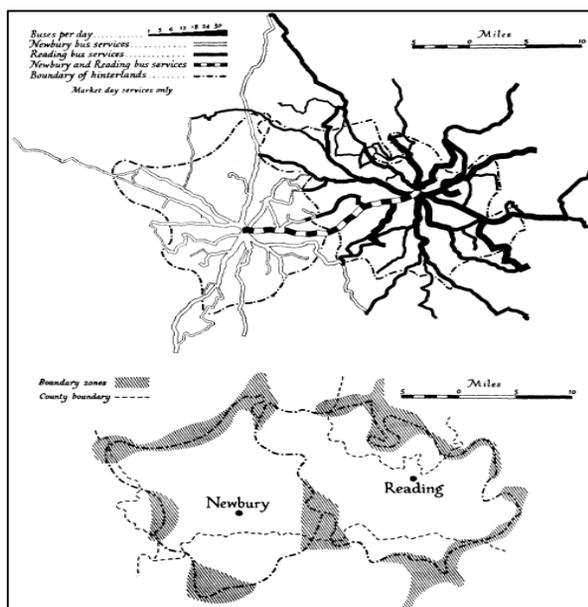

Figure 1. Reading and Newbury - radiating bus-services and overlapping hinterland
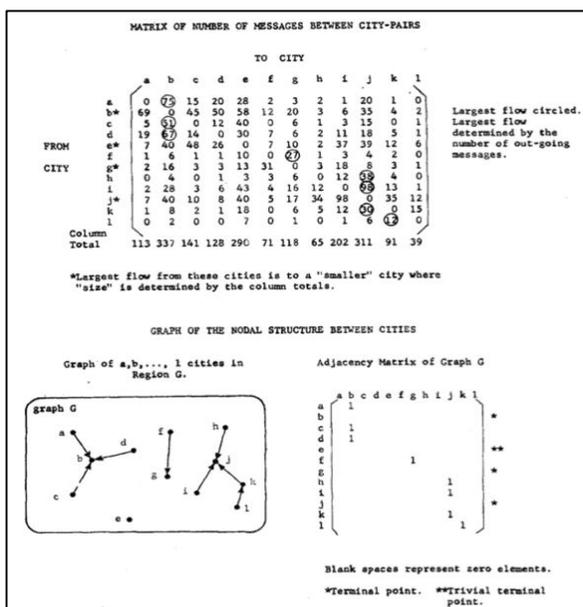
Source: Green (1950, p. 67)

Figure 2. Graph of a nodal structure in a region (hypothetical)

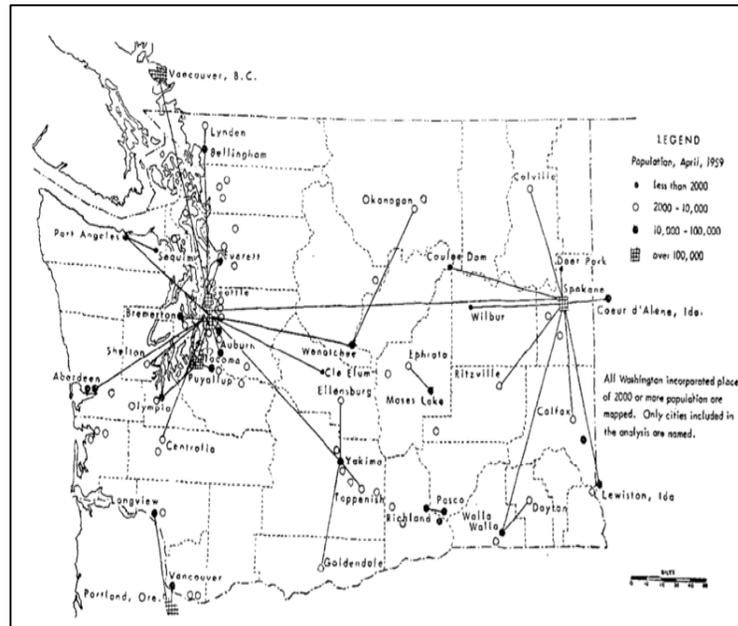Source: Nystuen and Dacey (1961, p. 35)

Figure 3. Nodal structure based on telephone data, State of Washington, 1958

Source: Nystuen and Dacey (1961, p. 39)

Alternatively, the flows can be displayed in matrix form as well. Nystuen and Dacey (1961) utilized graph theory to quantify the degree of association between city pairs in a way that enables the identification of networks of strongest association, using the State of Washington as the study area. Data on intercity telephone calls within the State was collected and constituted in the matrix form (Figure 2), from which the nodal structure and hierarchy of the State of Washington is identified (Figure 3). The types of interaction chosen for flow analysis are quite diverse, such as the flow of people moving to work (Hincks & Wong, 2009), transportation of goods (Jin, Saito, & Eggett, 2012), etc. - as long as the origin-destination data type is available. The direction and intensity of interactions between areas can be shown on a geographical map or shown in the form of a matrix table, on which the influence boundaries of the city-region are determined.

2.1.2. Density function

The density function is attributed to having been originally developed by Clark (1951) and Newling (1969) which focuses on understanding the urban population distribution to track the structural change of city and city-region expansion. Clark (1951) proposed an exponential function of urban density with the following form:

$$y = Ae^{-bx} \tag{1}$$

in which x refers to the distance from the city center (in miles); y the density of the resident population (in thousands per square mile); A and b are coefficients of the function. If the value of b is high, the population density would decrease rapidly with distance from the city center, thus the city would take the form of a 'compressed' or 'compact' city; conversely, if the value of b is low, the population density would decrease more slowly, thus the city would be more spread out. The value of coefficient A measures how much population density that can be accommodated at the city center (for instance, at the city center, the value of x is equal to 0, thus $y = A$).

By plotting the recorded average density against the mean distance from the city center, such as the case of various cities in the U.S. and in Europe at different times (Figure 4), the values

of *A* and *b* are determined. From the range of calculated *A* and *b* values, Clark (1951, p. 495) gave a simplified classification of cities as well as their trend of growth: "If a metropolitan area is to have a high total population, it must either put up with a considerable degree of overcrowding in the inner suburbs, or it must spread itself out [...] Spreading out is only possible where transport costs are low in relation to the citizens' income. A City with fairly high transport costs will have a fairly high value of *b*, and as its total population grows, the value of *A* (degree of overcrowding at the center) must necessarily rise".
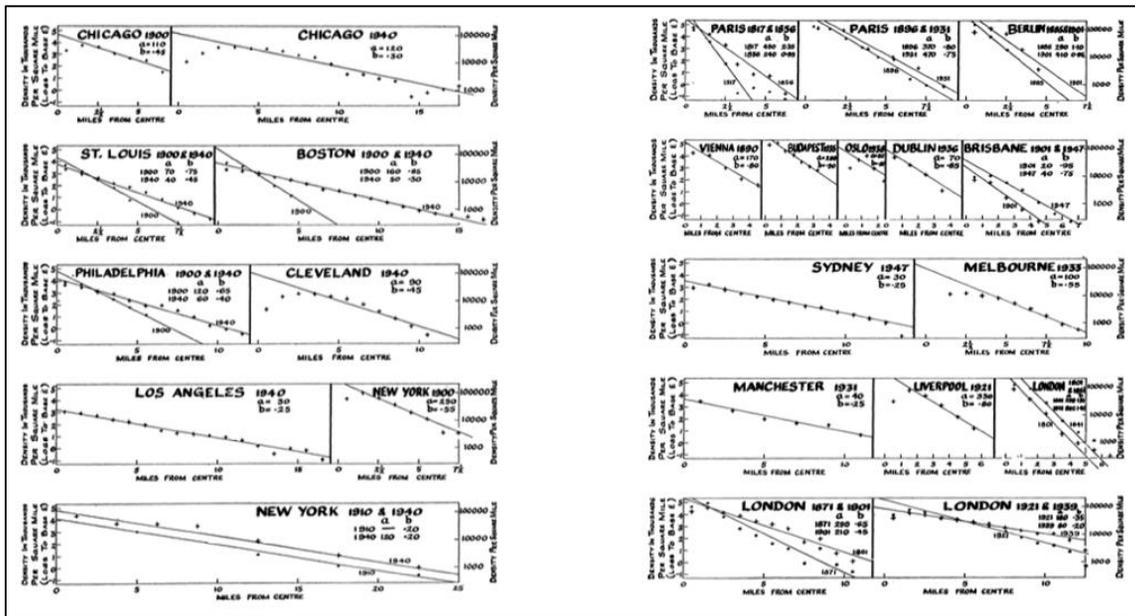

Figure 4. Plotting of density function in various cities at different times

Source: Clark (1951, pp. 492-493)

Newling (1969) proposed a quadratic exponential model of the form:

$$D_d = D_0 e^{(bd - cd^2)} \tag{2}$$

and written in the logarithmic transformation as:

$$lnD_d = lnD_0 + bd - cd^2 \tag{3}$$

whereas D_d is the population density at distance d from the city center; D_0 refers to the density at the city center; -*c* is a coefficient of change of logarithm population density with squared distance and *b* measures the instantaneous rate of change of density with distance at the city center (Newling, 1969, pp. 243-244). With different values of *b* and *c*, different urban density profiles can be plotted accordant to successive stages of development (Figure 5). With the density function, it is possible to construct the density profile of any studied city through which the spatial structure of the city is represented (Figure 6).

If plotted in different time periods, changes in the structure and extent of the city can be observed. Mogridge and Parr (1997) plotted the density function of London for the periods 1951 - 1961, 1961 - 1971, 1971 - 1981 and 1981 - 1991 and found an expansion of the city into the surrounding areas. In other words, London's boundary extended to reflect a major transition from being a large city to being a large metropolitan area. Bar-El and Parr (2003) also found a city-to-city region transition through population density function analysis in the inner and outer suburbs of Tel-Aviv, Israel between 1977 and 1998, indicating that the city boundary expanded outwards as reflecting the urban development process.
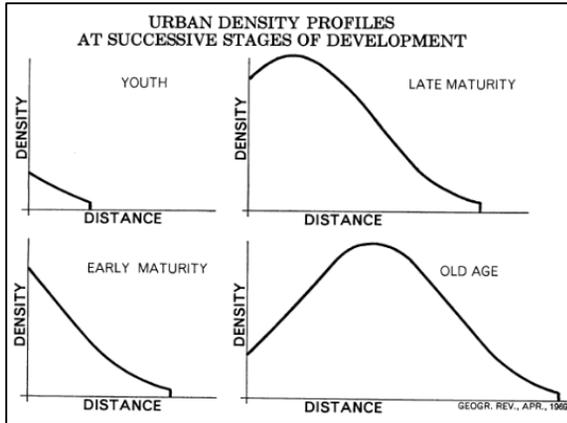
Figure 5. Urban density profiles at successive stages of development

Source: Newling (1969, p. 247)

Figure 6. Distance-density profiles for (a) U.K. regions, (b) North American regions

Source: Parr (1985, p. 293)

2.1.3. Gravity model

The main assumption of the gravity model in studying regional science and spatial interactions is that there exist attractive forces between the human populations similar to gravitational forces between matter masses in space. The name of the gravity model is based on the physicist Newton's law of universal gravitation (Newton, Cohen, & Whitman, 1687) which has the form:

$$F = G \frac{m_1 m_2}{r^2} \tag{4}$$

in which, F refers to the gravitational force acting between two objects m_1 and m_2, r is the distance between the centers of their masses, and G is the gravitational constant. Adapted to economics and regional science via a so-called 'social physics' approach (Stewart, 1948a, 1948b; Stewart & Warntz, 1958), in the broadest sense, the gravity model assumes that there exists a gravitational force between areas of human activities similar to the gravitational force between masses in space. This gravitation force is correlational to the size of the respective areas (i.e., proxied by the population size) and disproportional to the friction between them (i.e., via the distance between them). A generalized gravity model, as proposed by Carrothers (1956, p. 94) has the following form:

$$I_{ij} = \frac{f(P_i, P_j)}{f(D_{ij})} \tag{5}$$

whereas another gravity model popularized in the literature (Isard, 1956; Isard et al., 1960) has the following form:

$$I_{ij} = G \frac{P_i P_j}{d_{ij}^b} \tag{6}$$

in which i and j are areas of human settlement; I_{ij} represents the interaction between i and j; P_i, P_j respectively are population at i and j; d_{ij} refers to the distance between i and j; b is a distance parameter and G is a 'gravitational' constant of interaction between i and j. Carrothers' generalized form of gravity model can be interpreted as: the interaction between two areas i and j is proportional to the size of each and both areas and inversely proportional to the distance between them. The denoted $f()$ in the generalized model indeed enables various configurations and modifications of the model.
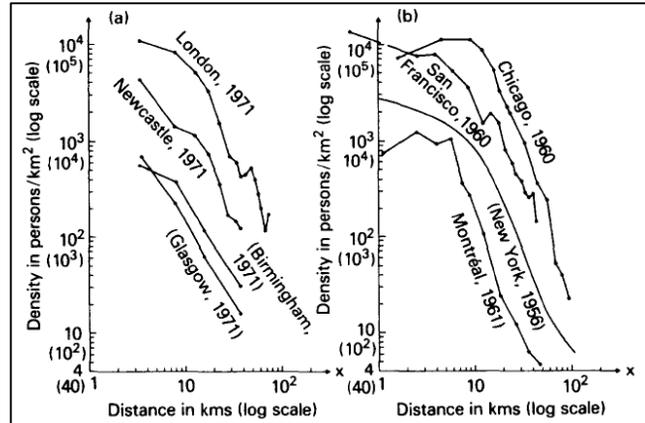
According to Isard et al. (1960, p. 497), I_{ij} is "depicts the interaction of people within the metropolitan region as a function of the populations of subareas and the distance variable when this interaction is reflected in trips". In other words, I_{ij} is the estimated pattern of trip volumes within the city-region but if the actual or expected magnitude of interaction is to be studied, other phenomena reflecting the interactions between i and j might be examined as well such as "telephone calls, telegraph messages, railway express shipments, money flows, migration, etc." (Isard et al., 1960, p. 497). Some experimental studies of gravity models have selected alternative phenomena such as population interactions (Cavanaugh, 1950), migration (Strodtbeck, 1950; Folger, 1953), and the scale of radio stations in kilowatts (Boland, 1948).

2.2. Contemporary delineation of sub-regions in the Mekong Delta region

With our scope of focus, it is worthwhile to review works that are relevant to highlight sub-regional boundaries in the Mekong Delta Region. The first approach was proposed by the Institute of Southern Construction Planning Vietnam (Institute of Southern Construction Planning - SISP, Ministry of Construction, 2015) where they argued that there existed a clear difference in urbanization rate and urban population growth between the two sub-regional areas divided by Hau River: South of Hau River and North of Hau River. For the period 1995 - 2013, the average urban population growth rate of the north of Hau River sub-regions was 2% per year compared to 3.8% per year in the South of Hau River sub-regions. In addition, in the same period, the urbanization rate of the North of Hau River sub-region increased from 12% to 16% while the urbanization rate of the South of Hau River increased from 19% to 33%. 70% of the urban population in the Mekong Delta Region is concentrated in the South of Hau River sub-regions. A recalculation with updated data reaffirms this observation.

So, from the perspective of urban population distribution and the urbanization process of the Mekong Delta Region, there are two sub-regions: provinces in the South of Hau River (An Giang, Can Tho, Hau Giang, and Kien Giang, Soc Trang, Bac Lieu, and Ca Mau) and the provinces in the North of Hau River (Long An, Tien Giang, Ben Tre, Dong Thap, Vinh Long, and Tra Vinh). Broadly speaking, this is not an attempt by the MOC to delineate sub-regional boundaries in the Mekong Delta Region but rather to showcase the North-South contrast in the Mekong Delta Region regarding urban population distribution.

The second approach is rather a combination of different related works with regards to identifying the most favorable areas in the Mekong Delta Region for habitation and economic development in the context of climate change and environmental threats, including several predictive scenarios regarding sea level rise, salination were developed for the Mekong Delta Region such as three main scenarios for sea level rise by the end of the 21st century were developed according to different greenhouse gas emission scenarios (Ministry of Natural Resouces and Environment - MONRE, 2009), four scenarios to simulate saline intrusion for the region up to the year 2050 (H. X. Tran et al., 2019). In a thematic report to Hau Giang's People Committee, H. T. Tran (2019) devised a preliminary approach to delineate sub-regional boundaries in the Mekong Delta Region in two steps. In the first step, a comprehensive evaluation of the simultaneous impacts of climate change, sea level rise and saltwater intrusion in the Mekong Delta Region was carried out to designate the most suitable area for long-term habitation and economic development. In the second step, precise boundaries of respective sub-regions were conducted using a comprehensive set of ecological, socio-economic and administrative criteria (Figure 7). As a result, Can Tho City-region is made up of total administrative boundary of Can Tho and its surrounding provinces: Kien Giang, An Giang, Dong Thap, Hau Giang, Vinh Long.

Figure 7. Delineation of urban planning sub-regions in the Mekong Delta Region in response to climate change and adaptation to the process of socio-economic transition

Source: H. T. Tran (2019), translated by the author

To this point, a couple of methodologies to delineate polarized region boundaries have been discussed as well as contemporary efforts in the Vietnamese literature to define Can Tho City-region boundary. There seems to be an existing gap here that the techniques conducted are either conceptual or non-economic based. Contemporary discussions about regional connectivity (Bui, 2017; H. T. T. Tran & Le, 2015; Vietnam Central Institute for Economic Management, & Australia Aid, 2018) demand a new approach that takes into account of economic dynamics or interactions between regional components - which coincides with the second purpose of this paper.

3. Research method

Of the three methods reviewed, the gravity model is selected as the tool for the analysis. For this section and the next, the paper utilizes a six-step approach to delineate Can Tho City-region, which is summarized in Figure 8. The colors green and red are suggestive for the tools used to carry out specific steps.
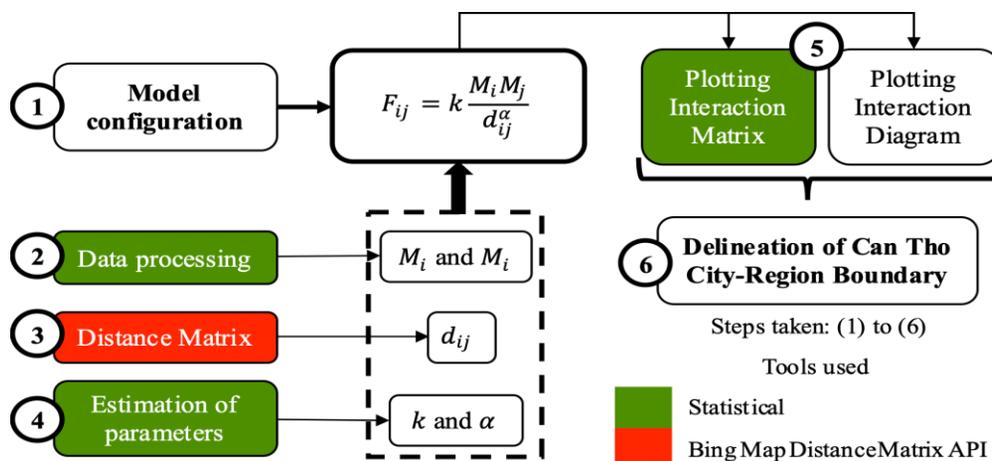

Figure 8. Procedure to delineate city-region boundary using gravity model

Source: Rendered by author

3.1. Model configuration

The first step in our procedure is to configure a suitable model for examination. In this paper, the gravity model takes the following form:

$$F_{ij} = k \frac{M_i M_j}{d_{ij}^{\alpha}} \qquad (7)$$

in which, i and j are administrative units - in this case, the provinces in the Mekong Delta Region. M_i and M_j refer to a measurement of size for i and j, in this case, the size of the predicted provincial *urban* population in 2030 (Ministry of Planning and Investment - MPI, 2020). Besides the availability of data rationale, 2030 predicted data is used for a couple of reasons: (a) the use of future data has already accounted for migration and urbanization trends in the 2020 - 2030 period and (b) there are existing issues in the quality of statistical data at the local level with regards to consistency and reliability (Hoang, 2007) and particularly with urban and spatial planning data[5] (World Bank & Ministry of Planning and Investment, 2016), resulting in economic-related data less of an ideal selection.

Table 1

Predicted population of provinces in the Mekong Delta Region to 2030

Provinces	Area (km²)	Population	Scenario I		Scenario II	
			Urban population	Urbanization rate (%)	Urban population	Urbanization rate (%)
Tien Giang	2,510.60	1,870.84	290.88	15.55%	328.40	17.55%
Long An	4,494.70	2,014.96	325.94	16.18%	367.99	18.26%
Ben Tre	2,394.00	1,325.16	135.50	10.23%	152.98	11.54%
Can Tho	1,439.90	1,288.60	1,096.46	85.09%	1,223.93	94.98%
Hau Giang	1,621.70	707.16	260.00	36.77%	295.00	41.72%
An Giang	3,536.70	1,678.81	657.08	39.14%	742.00	44.20%
Vinh Long	1,525.70	1,020.69	201.94	19.78%	227.99	22.34%
Dong Thap	3,383.80	1,528.00	345.76	22.63%	390.37	25.55%
Tra Vinh	2,358.30	1,016.98	217.52	21.39%	245.38	24.13%
Soc Trang	3,311.90	1,104.53	683.00	61.84%	771.11	69.81%
Kien Giang	6,348.80	1,762.16	582.00	33.03%	657.08	37.29%
Bac Lieu	2,669.00	996.32	294.00	29.51%	331.93	33.32%
Ca Mau	3,521.20	1,180.92	330.00	27.94%	372.57	31.55%
TOTAL	39,116.30	17,495.12	5,414.13	30.95%	6,112.72	34.94%

Note: The selected scenario used in the analysis is scenario II (highlighted)
Source: Ministry of Planning and Investment - MPI (2020)

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[5] In Chapter 4 "Managing Urbanization for Greater Economic Efficiency" of the Vietnam 2035 Report - the World Bank has criticized "inconsistent data" as one of the hindering factors to the optimization and synchronization of urban and spatial planning in Vietnam

Table 1 shows the predicted urban population data. MPI has prepared two scenarios I and II with different urbanization rates for the Mekong Delta Region. Data in scenario II is used because the urbanization rate of 34.94% closely aligns with the target of 35% set out in the Mekong Delta Construction Plan (Vietnam Prime Minister, 2018).

Data selection and processing refers to the second step in the procedure. The third step is to construct the distance matrix between the i-j pairs. d_{ij} refers to the distance between i and j, measured in kilometers. The Application Programming Interface (API) from Microsoft Bing Map was utilized to calculate the actual travel distance between every i-j pair in the Mekong Delta Region. For this technique to work, it is assumed that the central economic place of each province in the Mekong Delta Region - the location where most economic activities take place - is at their respective People's Committee location. The rationale for this assumption is that People's Committee locations are usually stable in the long-term and that local economic activities (i.e., business and commerce) are often administratively linked to the operation of People's Committee as well. The coordinates of 13 People's Committee locations were taken in according to the WGS84 standard and the distance matrix[6] is displayed in Table 2.

Table 2

Distance Matrix between provinces in the Mekong Delta Region (in kilometers)

i \ j	An Giang	Bac Lieu	Ben Tre	Ca Mau	Can Tho	Dong Thap	Hau Giang	Kien Giang	Long An	Soc Trang	Tien Giang	Tra Vinh	Vinh Long
An Giang	0	168	146	178	66	48	106	76	147	121	133	154	87
Bac Lieu	170	0	153	68	111	189	74	136	226	49	165	113	144
Ben Tre	146	153	0	217	121	108	161	197	38	102	17	47	86
Ca Mau	178	68	217	0	143	201	103	119	258	113	244	176	176
Can Tho	62	109	121	143	0	85	47	110	123	62	108	81	40
Dong Thap	48	188	108	201	85	0	125	99	110	140	95	116	50
Hau Giang	106	74	161	103	47	125	0	65	163	82	148	121	81
Kien Giang	74	136	195	119	111	98	65	0	197	145	182	184	137
Long An	148	225	38	258	122	110	163	199	0	178	25	80	88
Soc Trang	123	49	102	113	64	142	84	148	180	0	114	62	98
Tien Giang	133	165	17	244	108	95	148	184	25	114	0	59	73
Tra Vinh	154	113	47	176	81	116	121	185	80	62	59	0	66
Vinh Long	88	143	86	176	40	50	81	139	88	96	73	66	0

Note: The selected scenario used in the analysis is scenario II (highlighted)
Source: Ministry of Planning and Investment - MPI (2020)

3.2. Measurement of parameters

In the fourth step, the values of parameters are estimated. k refers to a frictional constant between i and j, meanwhile α refers to the distance parameters between i and j. Conventionally k and α are assumed to take values of 1 and 2 respectively (Isard et al., 1960), yet there are no common agreement on how to estimate them or which values they should take - it is up to the research context to determine. For the exploratory nature of the paper, precise values of k and α

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[6] The distance measured accounts for real-life distance between i and j in both directions. So, distance from i to j might be different from the distance from j to i

are estimated. The value of α is assumed to be 2.5; the value of k is thus assumed to be 1 when d_{ij} is smaller than 60km; to be 0.7 when d_{ij} is within 60 to 120km and to be 0.5 when the d_{ij} is larger than 120km.

4. Research results

4.1. Plotting interaction matrix and interaction diagram

The fifth step in our process is to plot an interaction matrix and an interaction diagram. An attractiveness matrix between provincial administrative units consists of vertical and horizontal columns representing provincial administrative units i and j, respectively. In the case of the Mekong Delta, $i = j = 13$. The values of interaction force F_{ij} between each pair of provincial administrative units are calculated according to formula (7) with the values analyzed above. The interaction value F_{ij} with $i = j$ (between a provincial administrative unit, city, and itself) is assumed to be 0.

Table 3

Interaction Matrix showcasing force F_{ij} between provinces in the Mekong Delta Region

i j	Tien Giang	Long An	Ben Tre	Can Tho	Hau Giang	An Giang	Vinh Long	Dong Thap	Tra Vinh	Soc Trang	Kien Giang	Ca Mau	Bac Lieu
Tien Giang	0	38.67	42.16	3.32	0.36	1.19	1.64	1.46	3.01	1.83	0.47	0.13	0.31
Long An	38.67	0	6.32	2.74	0.32	1.02	1.15	1.13	1.58	0.67	0.43	0.13	0.16
Ben Tre	42.16	6.32	0	1.16	0.14	0.44	0.51	0.49	2.48	1.12	0.18	0.08	0.18
Can Tho	3.32	2.68	1.16	0	23.84	30.00	27.58	7.17	5.09	31.18	6.34	1.86	3.28
Hau Giang	0.36	0.32	0.14	22.62	0	1.89	1.14	0.65	0.44	3.74	5.69	1.02	2.08
An Giang	1.19	1.04	0.44	25.66	1.89	0	2.40	18.15	0.62	3.55	9.68	0.65	0.67
Vinh Long	1.64	1.15	0.51	27.58	1.14	2.33	0	5.03	1.58	1.95	0.66	0.21	0.31
Dong Thap	1.46	1.13	0.49	7.17	0.66	18.15	5.03	0	0.65	1.30	2.63	0.25	0.27
Tra Vinh	3.01	1.58	2.48	5.09	0.45	0.62	1.58	0.66	0	6.25	0.35	0.22	0.60
Soc Trang	1.83	0.65	1.12	28.80	3.52	3.41	1.85	1.25	6.25	0	1.90	2.12	15.23
Kien Giang	0.48	0.44	0.19	6.20	5.69	10.35	0.68	2.70	0.35	2.00	0	1.58	1.01
Ca Mau	0.13	0.13	0.08	1.86	1.02	0.65	0.21	0.25	0.22	2.12	1.58	0	3.24
Bac Lieu	0.31	0.16	0.18	3.13	2.08	0.65	0.30	0.26	0.60	15.23	1.01	3.24	0
Total	**94.57**	**54.29**	**55.27**	**135.33**	**41.11**	**70.72**	**44.08**	**39.21**	**22.86**	**70.93**	**30.93**	**11.51**	**27.34**
Rank	**2**	**6**	**5**	**1**	**8**	**4**	**7**	**9**	**12**	**3**	**10**	**13**	**11**

Source: Calculated by author

For easy identification of dominant interactions, the interaction matrix is illustrated with darker colors representing stronger attraction between i and j, and lighter color representing less intense attraction. The color scales are coded according to percentile values; the order of provinces has also been rearranged to easier accentuate groups of provinces with noticeable attraction patterns. The total attractiveness of a provincial administrative unit is calculated by the total attractiveness of that unit with other units in the vertical column and summed up in the "TOTAL" row. From that basis, the attractiveness rank of each unit is ranked in order from 01 to 13. The interaction matrix is presented in Table 3.

From the interaction matrix, the interaction diagram between provinces can be constructed (Figure 9) by highlighting the most significant interactions (darkest colors), while less significant interactions are greyed out.

4.2. Evidence-based delineation of Can Tho City-region boundary

The final step in our progress is to delineate the boundary of Can Tho City-region from the interaction matrix and interaction diagram.

In terms of rankings, the top three provinces with the highest score are Can Tho, Tien Giang, and Soc Trang. In terms of interactive relations, three groups can be observed: (1) The group of strongest intensity interaction is between the three provinces of Long An, Tien Giang, and Ben Tre; (2) The group of interactions with relatively high intensity is between Can Tho and cities in adjacent provinces, including An Giang, Dong Thap, Hau Giang, Vinh Long, and Soc Trang; (3) The group of interactions of weaker intensity includes local pairs such as Kien Giang - An Giang, Bac Lieu - Soc Trang, Soc Trang - Tra Vinh.
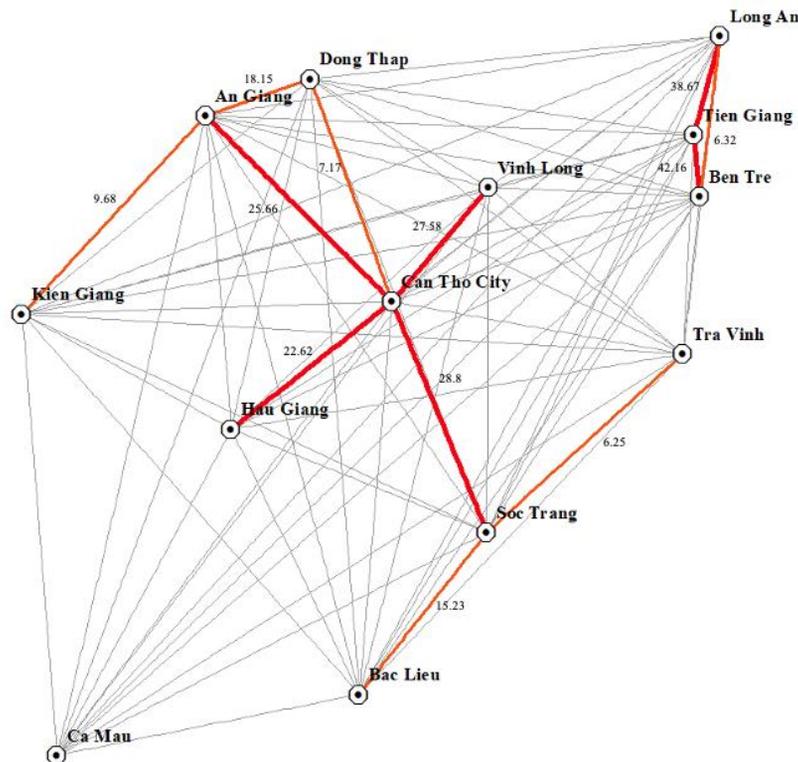

Figure 9. Interaction diagram showcasing most significant F_{ij} forces between provinces in the Mekong Delta Region

The results here somewhat align with the population and migration trends in the Mekong Delta Region and there are some possible explanations[7]. According to the 2019 Population and Housing Census (General Statistics Office, 2020), by 2019 only three provinces experienced positive net immigration rates (Long An, Tien Giang, and Can Tho) while the rest of the provinces experienced negative net immigration rates. An important factor determining leavers' decision is the increasingly difficult livelihood associated with impacts from climate change and environmental threats (Entzinger & Scholten, 2016; O. T. K. Le & Le, 2017; VCCI Can Tho branch & Fullbright University Vietnam, 2021). In other words, in the Mekong Delta Region more people are emigrating from their place of residence for a better livelihood elsewhere and within the Mekong Delta Region, other areas are emerging as more favorable for better livelihoods such as Can Tho - less prone to future flooding and impacts from climate change - as well as Long An - Tien Giang - close proximity to Ho Chi Minh City and the Southeast Region which offers employment opportunities with potentially higher income.
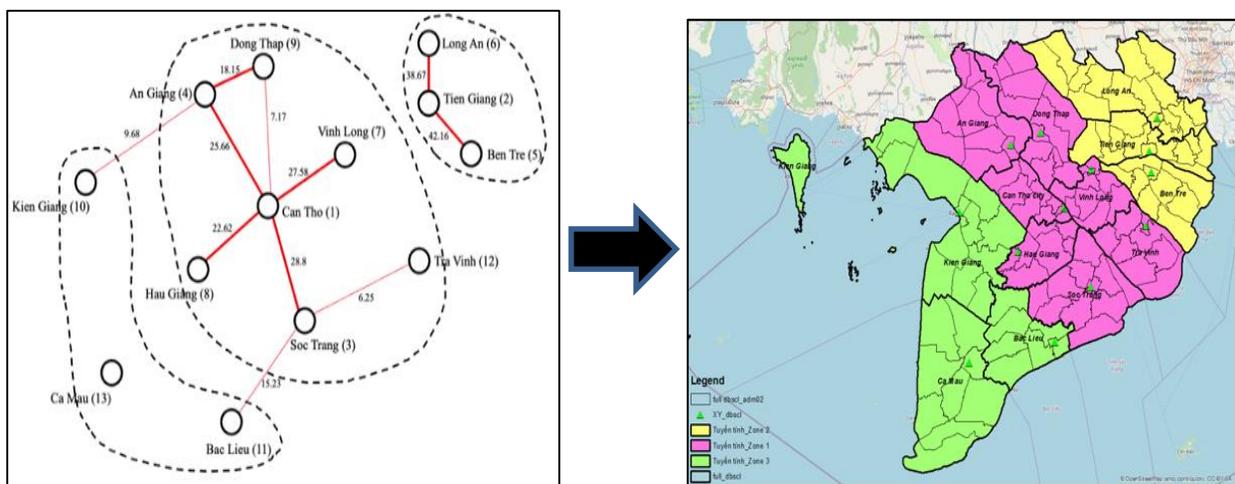

Figure 10. Delineation of major urban regions in the Mekong Delta Region

Note: Attraction rank shown in brackets, force F_{ij} shown adjacent to interaction link
Source: Rendered by author

From the results of the interaction matrix and interaction diagram, it is possible to reduce and 'filter' the prominent key relationships as the basis for identifying sub-regions as follows (demonstrated in Figure 10):

The first sub-region includes the provinces of Long An, Tien Giang, and Ben Tre. Looking at Table 3, it is evident that the interactions F_{ij} between these three provinces are more prominent than in the rest of the Mekong Delta: they have the highest values out of the table and but outside the Long An - Tien Giang - Ben Tre circle the interaction values are noticeably smaller. A possible explanation for this observation is that these three provinces have close proximity to Ho Chi Minh City and the Southeast Region from which they enjoy good economic spillovers[8]. Arguably, this propels them to both be relatively more competitive than other provinces in the Mekong Delta Region and be closely intertwined with each other (thus higher interaction values of F_{ij}).

[7] As the measurement of M_i and M_j is predicted 2030 urban population, explanation based on population and migration trends is more fitting. Alternative measurements of M_i and M_j undoubtedly call for different explanations, this is further discussed in the final section of the paper
[8] Indeed, it is particularly emphasized in the Decision No. 1065/QD-TTg dated 03/07/2014 on Approving of Task Adjusting the Ho Chi Minh Metropolitan Area Construction by 2030, with vision set to 2050 by the Vietnam Prime Minister (2014) that: Long An and Tien Giang included as a part of the Ho Chi Minh Metropolitan Area. This indicates some underlying assumptions about their economic position relative to other provinces in the Mekong Delta Region

The second sub-region includes the provinces of Can Tho, An Giang, Dong Thap, Vinh Long, Hau Giang, Soc Trang and Tra Vinh. This is the sub-region that consists of Can Tho both as the municipal city and the center of the Mekong Delta Region (with the highest rank) and the interaction is relatively equal among localities. Tra Vinh is a peculiar outlier because of its low value interaction with other provinces. If sorted by strongest interaction values, Soc Trang and Can Tho have the highest F_{ij} values (6.25 and 5.09 respectively) followed by Tien Giang and Ben Tre (3.01 and 2.48) and a 'tie' between Long Anh and Vinh Long (both 1.58). Though Tra Vinh can be sorted into either sub-region, its strong links to Can Tho and Soc Trang better imply their allegiance towards these centers. Therefore, Tra Vinh is included in this sub-region.

The third urban area includes three provinces of Kien Giang, Ca Mau, and Bac Lieu. Of the three provinces, Ca Mau is the one with the smallest interaction with the rest of the region. Kien Giang has a moderate interaction with An Giang, and Bac Lieu has a moderate interaction with Soc Trang. However, in general, the two provinces of Kien Giang and Bac Lieu have no significant interaction with other units in the center of the Mekong Delta such as Can Tho, Vinh Long, and Hau Giang. Consequently, these three are grouped into one sub-region.

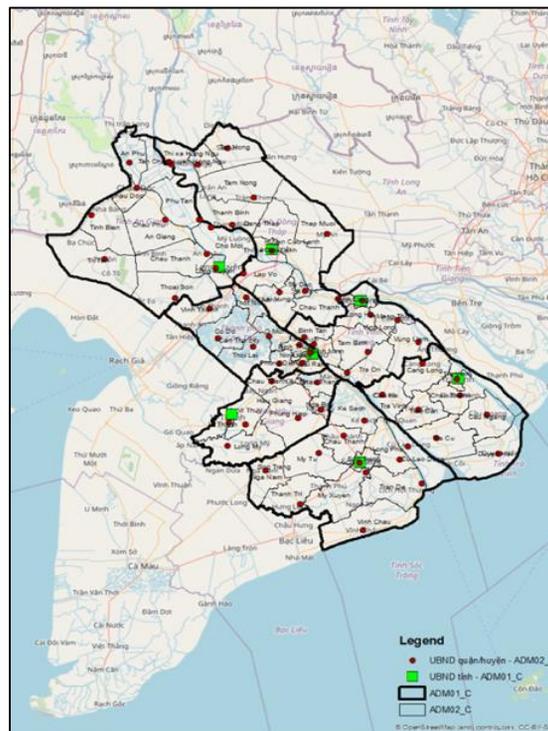And thus, the Boundary of Can Tho City-region is demonstrated in Figure 11.

Figure 11. Boundary of Can Tho City-region

Source: Rendered by author

5. Concluding remarks

Aimed to study the city-region in both an empirical and exploratory manner, this paper has focused on defining the city-regional boundary with methodological tools, using Can Tho as the case study. To do so, a six-step process has been constructed, and a detailed analysis of each step is conducted with as much clarity as possible. Except for the use of 2030 predicted urban population data, the input to the analytic framework comes from the author's computed data (i.e., distance matrix, estimation of parameters) and rendering (i.e., plotting of interaction matrix, interaction diagram). As a result, the paper has achieved its two laid-out purposes: (1) to contribute

to a growing literature body on city-regional studies in Vietnam, and (2) a city-regional boundary of Can Tho City-region is delineated and demonstrated.

Naturally enough, there are certain drawbacks to our analysis. First of all, the selection of variables M_i and M_j here is the 2030 predicted urban population of respective provinces in the Mekong Delta Region which was selected due to its availability and that it is arguably a more consistent data compared to local GDP. However, it can only reflect a part of a more complex human settlement context at i and j. Alternatively, other options can be employment (Ali, Hamidreza, & Babak, 2016) or a combination of population and GDP (Luo, Johnston, & Chen, 2008) or a composite index (Deng, Liu, Wang, Ma, & Wang, 2010) - the latter two approaches would better cover socio-economic performance of the concerned provinces.

Likewise, d_{ij} measured by real-life distance in kilometers can only reflect one mode of transportation while other forms of transport in the Mekong Delta Region (i.e., inland waterway transport) are yet to be explored. Suppose the quality and availability of data are sufficient, alternative options to measure d_{ij} could be a in terms of transportation costs or time (instead of distance) or the economic, language, and cultural distance (Wu, Fang, Huang, & Wang, 2012). The distance between i and j is calculated with i and j taking the respective provincial People's Committee locations. While this assumption enables the convenience for the model to work, it has yet to acknowledge the reality of economic activity distribution. For example, the agglomeration of firms and laborers within an industrial cluster/zone and the presence of multiple industrial clusters/zones demonstrate that economic activities can be both concentrated and dispersed in a very complexing pattern.

Secondly, the estimation of parameters k and α also call for much future research to achieve as unbiased estimated values as possible. Because of data constraints in Vietnam, conventional approaches such as OLS estimation of parameters might suffer from perfect-multicollinearity. Therefore, alternative approaches to estimate the model parameters are much needed.

These limitations stem from the fact that statistical data collection in Vietnam has emphasized *static* observations (i.e., data fixed within a time frame and bound by administrative limit) while *dynamic* observations (i.e., data on the flow of people, goods, capital, etc. between administrative units) have unfortunately remained an uncharted territory (Le, 2020). In Vietnam, this constraint is problematic not only for city-regional research but also for other fields of regional research that rely on *dynamic* for quality empirical works as well, such as the topic of regional coordination which has been hotly discussed for many years.

Thirdly, the boundary of a city-region is only a part of its spatial structure. Parr (2008, p. 3014) described that the "threshold for a city-region may depend on one or more of the following: the minimum size of the city on which the city-region is based; the minimum areal extent of the entire city-region; the maximum and/or minimum frequency range for city-regions within a nation". In other words, what is equally important about a city-region is how it is organized internally: (1) where are the core urban areas, (2) to what extent does it 'reach' out into its surrounding area and does it 'reach' out the most, and (3) the optimal size of a city-region given the size and number of other city-regions within the national economy. The definition of "core" and "peripheral" in existing city-regions in Vietnam has been strictly administrative (i.e., Hanoi and Ho Chi Minh City are assigned to be respective urban cores while adjacent provinces are assigned supporting roles). In the future, if sufficient data and tools allow for, the spatial structure of city-regions can be demonstrated in terms of economic dynamics; a comparison between *actual*

spatial structure versus *programmed* spatial structure would definitely intrigue interesting academic discussions.

On top of that, the general extent set out in this paper has been limited to the Mekong Delta Region. On the one hand, it has not considered the interaction between provinces inside and outside the Mekong Delta Region (which is likely to be the case with regards to the movement of labor, capital, and investment); on the other hand, the exercise outlined here can be replicated to other regions in Vietnam as long as the there is sufficient reliable data.

All in all, these limitations imply that the analysis in this paper is by no mean complete and that there are open rooms for modification and improvement in future research. In spite of its modest scope, this paper represents an original effort to push forward the research agenda on city-regions in Vietnam with tangible empirical evidence and clarity of procedure. A word of caution here is that the method outlined in this paper should be used in conjunction with other approaches to achieve the most practical delineation of city-regional boundary delineation. A combination of methods often allows for cross-checking and more comprehensive analysis. It is this author's hope, and perhaps aspiration, that it would eventually encourage more academic interest in the coming future and can further provide policymakers with solid references for better informed and evidence-based city-regional development policies.

References

Ali, A., Hamidreza, E., & Babak, A. (2016). Mixed method approach to delineation of functional urban regions: Shiraz metropolitan region. *Journal of Urban Planning and Development, 142*(3), 1-18.

Bar-El, R., & Parr, J. B. (2003). From metropolis to metropolis-based region: The case of Tel-Aviv. *Urban Studies, 40*(1), 113-125.

Blair, J. P., Staley, S. R., & Zhang, Z. (1996). The central city elasticity hypothesis: A critical appraisal of rusk's theory of urban development. *Journal of the American Planning Association, 62*(3), 345-353.

Boland, J. P. (1948). On the number and sizes of radio-stations in relation to the populations of their cities. *Sociometry, 11*(1/2), 111-116.

Bui, T. T. (2017). Regional and local linkages in socio-economic development. *Construction and City, 55*, 59-63.

Carrothers, G. A. P. (1956). An historical bedew of the gravity and potential concepts of human interaction. *Journal of the American Institute of Planners, 22*(2), 94-102. doi:10.1080/01944365608979229

Carruthers, I. (1957). A classification of service centres in England and Wales. *The Geographical Journal, 123*(3), 371-385.

Cavanaugh, J. A. (1950). Formulation, analysis and testing of the interactance hypothesis. *American Sociological Review, 15*(6), 763-766.

Clark, C. (1951). Urban population densities. *Journal of the Royal Statistical Society. Series A (General), 114*(4), 490-496.

Copus, A. (2013). *Urban-rural relationships in the new century: Clarifying and updating the intervention logic.* Retrieved October 10, 2021, from https://www.hutton.ac.uk/sites/default/files/files/andrew%27s%20article-%20warsaw.pdf

Dam, N. V., Nguyen, T. X., & Nguyen, C. (2015). *Curriculum on local development management.* Hanoi, Vietnam: National Political - Truth Publishing House.

Davoudi, S. (2008). Conceptions of the city-region: A critical review. *Proceedings of the Ice - Urban Design and Planning, 161*, 51-60.

Deng, Y., Liu, S., Wang, L., Ma, H., & Wang, J. (2010). Field modeling method for identifying urban sphere of influence: A case study on Central China. *Chinese Geographical Science, 20*(4), 353-362.

Entzinger, H., & Scholten, P. (2016). *Adapting to climate change through migration: A case study of the Vietnamese Mekong River Delta.* Retrieved October 10, 2021, from International Organization for Migration website: https://environmentalmigration.iom.int/adapting-climate-change-through-migration-case-study-vietnamese-mekong-river-delta

Folger, J. (1953). Some aspects of migration in the tennessee valley. *American Sociological Review, 18*(3), 253-260.

General Statistics Office. (2020). *Completed results of the 2019 Vietnam population and housing census.* Retrieved October 10, 2021, from http://tongdieutradanso.vn/12-completed-results-of-the-2019-census.html

Green, F. H. W. (1950). Urban hinterlands in England and Wales: An analysis of bus services. *The Geographical Journal, 116*(1/3), 64-81.

Helsley, R. W., & Sullivan, A. M. (1991). Urban subcenter formation. *Regional Science and Urban Economics, 21*(2), 255-275.

Hincks, S., & Wong, C. (2009). The spatial interaction of housing and labour markets: Commuting flow analysis of North West England. *Urban Studies, 47*(3), 620-649.

Hoang, T. B. (2011). Basic views of the party and government on urban planning and urbanization. *Journal of Social Studies, 3*, 28-35.

Hoang, T. T. (2007). The quality of local-level statistics information and confronted problems. *Scientific and Statistical Information, Special Issue: Quality of Statistics*, 33-38.

Ihlanfeldt, K. R. (1995). The importance of the central city to the regional and national economy: A review of the arguments and empirical evidence. *Cityscape, 1*(2), 125-150.

Institute of Southern Construction Planning - SISP, Ministry of Construction. (2015). *Adjusting the Construction Plan of the Mekong Delta Region to 2030, with a vision to 2050.* Ho Chi Minh City, Vietnam: Institute of Southern Construction Planning - SISP, Ministry of Construction.

Isard, W. (1956). *Location and space-economy: A general theory relating to industrial location, market areas, land use, trade, and urban structure.* New York, NY: The Technology Press of Massachusetts Institute of Technology and Wiley & Sons, Inc.

Isard, W., Bramhall, D. F., Carrothers, G. A. P., Cumberland, J. H., Moses, L. N., Price, D. O., & Schooler, E. W. (1960). *Methods of regional analysis: An introduction to regional science.* Cambridge, MA: The M. I. T. Press.

Jin, T. G., Saito, M., & Eggett, D. L. (2012). Developing county-level commodity-flow models incorporating land-use characteristics and economic factors for Utah. *Journal of Urban Planning and Development, 138*(1), 35-42.

Le, O. T. K., & Le, T. M. (2017). Correlation between climate change impacts and migration decisions in Vietnamese Mekong Delta. *International Journal of Innovative Science, Engineering & Technology, 4*(8), 111-118.

Le, S. M. (2020). Analysing city-regions in a Vietnamese context: An overview of concepts, definitions and development policy implications. *VNU Journal of Science: Economics and Business, 36*(2), 52-66.

Le, S. M., & Bui, A. K. (2020). Determinants of economic growth in the Mekong Delta provinces. *Can Tho University Journal of Science, 12*(1), 16-29.

Luo, S., Johnston, A., & Chen, D. (2008). Approach to delimiting metropolitan regions' boundary and grading urban hierarchy within a metropolitan region - A case study of Shanghai metropolitan region. *Chinese Geographical Science, 18*(3), 197-205.

Marvin, S., Harding, A., & Robson, B. (2006). *A framework for city-regions.* Retrieved October 10, 2021, from https://webarchive.nationalarchives.gov.uk/20070507024923/http://www.communities.gov.uk/pub/588/AFrameworkforCityRegionsResearchReportPDF814Kb_id1163588.pdf

Meyer, J. R. (1963). Regional economics: A survey. *The American Economic Review, 53*(1), 19-54.

Ministry of Natural Resouces and Environment - MONRE. (2009). *Scenarios for climate change and sea level rise for Vietnam.* Retrieved October 10, 2021, from http://www.imh.ac.vn/files/doc/KichbanBDKH/Kich%20ban%20Bien%20doi%20khi%20hau_2009.pdf

Ministry of Planning and Investment - MPI. (2020). *Report on development orientation of the urban system in the Mekong Delta region (Thematic report of the Mekong Delta regional plan).* Hanoi, Vietnam: Ministry of Planning and Investment - MPI.

Mogridge, M., & Parr, J. B. (1997). Metropolis or region: On the development and structure of London. *Regional Studies, 31*(2), 97-115.

Newling, B. E. (1969). The spatial variation of urban population densities. *Geographical Review, 59*(2), 242-252.

Newton, I., Cohen, I. B., & Whitman, A. (1687). *The principal: Mathematical principles of natural philosophy* (1999th ed.). Berkeley, CA: University of California Press.

Nguyen, D. H. (2009). *Applying the multi-criteria analysis method to assess the degree of urbanization to contribute to the construction of urban development perspectives in Vietnam to 2020, with Hanoi as an example* (Doctoral dissertation). Hanoi, Vietnam: Ministry of Education and Training, National Economics University.

Nguyen, H. D., & Nguyen, D. H. (2003). *Curriculum on urban management.* Hanoi, Vietnam: Statistical Publishing House.

Nguyen, Q. M. (2015). *Development of the neighborhood area of central Hanoi capital: Current situation and solutions.* Hanoi, Vietnam: National Political Publishing House.

Nguyen, T. X., & Nguyen, P. V. (2006). *Regional economic development in the process of industrialization and modernization.* Hanoi, Vietnam: National Political Publishing House.

Nguyen, X. T. (2013). *Regional economic development of Vietnam.* Hanoi, Vietnam: Social Science Publishing House.

Nystuen, J. D., & Dacey, M. F. (1961). A graph theory interpretation of nodal regions. *Papers of the Regional Science Association, 7*(1), 29-42.

Parr, J. (1985). A population-density approach to regional spatial structure. *Urban Studies, 22*(4), 289-303. doi:10.1080/00420988520080531

Parr, J. (2005). Perspectives on the city-region. *Regional Studies, 39*(5), 555-566.

Parr, J. (2008). Cities and regions: Problems and potentials. *Environment and Planning A: Economy and Space, 40*(12), 3009-3026.

Preston, D. A. (1975). Rural-urban and inter-settlement interaction: Theory and analytical structure. *Area, 7*(3), 171-174.

Quang Chung (2015, November 13). *Narrowing down the definition of 'Ho Chi Minh Metropolitan Area'*. Retrieved October 10, 2021, from Ho Chi Minh City Department of Planning and Architecture, Information Page website: https://qhkt.hochiminhcity.gov.vn/goc-nhin/nen-thu-hep-khai-niem-vung-do-thi-tphcm-830.html

Quy Anh (2020, February 29). *Correctly understand capital metropolitan area*. Retrieved October 10, 2021, from Electronic Newspaper of Ministry of Construction website: https://baoxaydung.com.vn/can-hieu-dung-ve-vung-thu-do-274117.html

Roberts, D. (2000). The spatial diffusion of secondary impacts: Rural-urban spillovers in Grampian, Scotland. *Land Economics, 76*(3), 395-412.

Savitch, H. V., Collins, D., Sanders, D., & Markham, J. P. (1993). Ties that bind: Central cities, suburbs, and the new metropolitan region. *Economic Development Quarterly, 7*(4), 341-357.

Sheppard, E. S. (2010). Gravity parameter estimation. *Geographical Analysis, 11*(2), 120-132.

Stead, D. (2002). Urban-rural relationships in the West of England. *Built Environment, 28*(4), 299-310.

Stewart, J. Q. (1948a). Concerning "Social physics." *Scientific American, 178*(5), 20-23.

Stewart, J. Q. (1948b). Demographic gravitation: Evidence and applications. *Sociometry, 11*(1/2), 31-58.

Stewart, J. Q., & Warntz, W. (1958). Macrogeography and social science. *Geographical Review, 48*(2), 167-184.

Strodtbeck, F. L. (1950). Population/distance and migration from Kentucky. *Sociometry, 13*(2), 123-130.

Tran, A. H. (2020, June 4). *Clarifying the concept of "Capital region" to eliminate arbitrary variations*. Retrieved October 10, 2021, from Người Đô Thị Online website: https://nguoidothi.net.vn/lam-ro-khai-niem-vung-thu-dode-loai-bo-nhung-bien-the-tuy-tien-23108.html

Tran, H. T. (2019). *Applying the new planning law in the context of climate change: Taking Hau Giang Province as an example*. Hau Giang, Vietnam: Hau Giang People's Committee.

Tran, H. T. (2015). *Regional planning*. Hanoi, Vietnam: Construction Publishing House.

Tran, H. T. T., & Le, T. V. (2015). Regional linkages and orientations for regional linkages in the process of economic restructuring in Vietnam. *Economic Review, 450*(11), 69-76.

Tran, H. X., Bui, H. N. L., Pham, T. A., Do, T. N., Vu, N. V., & Dang, L. T. (2019). Shortage of freshwater in the Mekong Delta region: Current situation and forecast to 2030 and 2050 under the impacts of climate change. *Vietnam Journal of Hydro - Meteorology, 706*, 1-9.

VCCI Can Tho branch, & Fullbright University Vietnam. (2021). *Annual economic report Mekong Delta 2020: Enhancing competitiveness for sustainable development.* Retrieved October 10, 2021, from https://fsppm.fulbright.edu.vn/download/BCKT-Mekong-Delta-Eng-Final.pdf

Vietnam Central Executive Committee. (2020). *Resolution 59-NQ/TW of the politburo on construction and development of Can Tho City to 2030, with a vision to 2045.* Retrieved October 10, 2021, from https://tulieuvankien.dangcongsan.vn/Uploads/2020/9/7/30/Nghi-quyet-so-59-Bo-Chinh-tri.pdf

Vietnam Central Institute for Economic Management, & Australia Aid. (2018). *Cooperation mechanism for development in key economic zones in Vietnam.* Retrieved October 10, 2021, from http://st.aus4reform.org.vn/staticFile/Subject/2019/03/13/sach-bao-cao-co-che-tv_13157559.pdf

Vietnam Prime Minister. (2009). *Decision No. 492/QD-TTg dated 16/04/2009 on Approving the establishment of a key economic zone in the Mekong Delta.* Retrieved October 10, 2021, from https://chinhphu.vn/default.aspx?pageid=27160&docid=85743

Vietnam Prime Minister. (2014). *Decision No. 1065/QD-TTg (dated 03 July 2014): Approving of task adjusting the Ho Chi Minh City region construction by 2030, with vision set to 2050.* Retrieved October 10, 2021, from http://chinhphu.vn/portal/page/portal/chinhphu/noidungquyhoachvung?docid=2975&substract=&strutsAction=ViewDetailAction.do

Vietnam Prime Minister. (2018). *Decision No. 68/QD-TTg dated 15 January 2018 on Approving the adjustment of construction planning in the Mekong Delta region to 2030 with a vision to 2050.* Retrieved October 10, 2021, from http://vanban.chinhphu.vn/portal/page/portal/chinhphu/hethongvanban?class_id=2&_page=1&mode=detail&document_id=192641

Voith, R. (1992). City and suburban growth: Substitutes or complements? *Business Review, Sepember/October 1992,* 21-33.

World Bank., & Ministry of Planning and Investment (Eds.). (2016). *Vietnam 2035: Toward prosperity, creativity, equity, and democracy.* Washington, D.C.: World Bank.

Wu, K., Fang, C., Huang, H., & Wang, J. (2012). Comprehensive delimitation and ring identification on urban spatial radiation of regional central cities: Case study of Zhengzhou. *Journal of Urban Planning and Development, 139*(4), 258-273.