

## Article

# Coupling Coordination of Urban Pseudo and Reality Human Settlements

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**Abstract:** Urban pseudo and reality human settlements (PHSs and RHSs) are important components of the human–land relationship regional system. To explore the coupling and coordination relationship and principle among them is an important approach to high-quality coordinated urban development. Based on the three-dimensional development of human settlements, the theoretical system of a “three states” dynamic frame diagram is constructed. The spatio-temporal heterogeneity and driving principle of coupling coordination among PHSs and RHSs in 34 prefecture-level cities in northeast China from 2011 to 2019 were explained by using the coupling coordination degree, spatial trend surface analysis and geographic detector techniques, and the evolution principle of spatio-temporal coordination was revealed. The results show that: (1) in the temporal dimension, the coupling coordination degree among PHSs and RHSs in the three provinces shows a smooth growth from “slight disadjustment” to “near disadjustment”; (2) With Shenyang, Dalian, Changchun and Harbin as the center, the coordination degree shows a circular pattern decreasing from the transition area to peripheral area. In the direction of south and north, the spatial evolution trend shows a gradual change from a “—” shape to “U” shape. There is spatio-temporal variation of the trend surface from an inverted “U” shape to “—” shape in the east–west direction; (3) The socioeconomic situation is an important driving factor, and the tool system is a new driving system for the coupling and coordinated development of urban PHSs and RHSs.

**Keywords:** pseudo and reality human settlements; coupling coordination; spatio-temporal heterogeneity; driving principle; tool system



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## 1. Introduction

In the information age, Wechat, news media, online shopping and other emerging activities have a profound impact on people’s daily work, leisure and life, which is changing the development and construction of cities, forming a pseudo and information environment. In the face of scientific and technological change, research of advancing with the times needs to keep pace with it. The RHS is a space for human beings to work, live, rest, play, and socialize. It is visible and tangible. The pseudo and information environment is an important part of three-dimensional urban human settlements. The PHSs from the perspective of geography is based on the RHSs, which are real, deviant and false human settlements with functions and services such as life, social contact, shopping, travel and entertainment created through websites and applications [1,2]. Imagery of human settlements is psychologically, the human brain perceives the human settlements, such as satisfaction and evaluation. The study of the “three states” human settlements is all for one

purpose: “to create a more pleasant human settlements for mankind”, which is of great theoretical and practical significance.

In terms of national policies, The United Nations World Habitat Day has moved from the theme “Housing, My Right” in 1986 to the theme “Accelerating Urban action for a Carbon-free world” in 2021. The “14th five-year plan” proposed to improve the large- and medium-sized city’s livability and suitability for work. These are all aimed at identifying the importance of urban human settlements [3]. At the same time, in the 14th five-year plan, the characteristics of development were changed from “yes” to “good”. The proposed promotion of deep integration of big data has promoted a new generation of information technology in the context of network and artificial intelligence. Therefore, grasping the development principle of PHSs is of great significance for maintaining the coordination among PHSs and RHSs and promoting its high-quality coordinated development.

Based on this, in order to enrich the existing stage of human settlement research, promote the development and improvement of the coupling and coordination of the complex systems of human–land relationship, provide theoretical support for the coupling principle of the “three states” urban human settlements, and provide decision support with the times for a new round of high-quality coordinated development in northeast China during the 14th Five-Year Plan period, a theoretical system of coupling and coordination among PHSs and RHSs is constructed, which is supported by the data of PHSs and RHSs in 34 cities in the three northeastern provinces. The methods of coupling coordination, spatial trend surface and geographic detector are comprehensively used to calculate, simulate and analyze the reality and pseudo influencing factors affecting the human settlements, so as to explore the three-dimensional human settlements.

Human settlements began in the 1950s, starting from the human settlements theory of Doxiadis, which started the pursuit of human beings for better human settlements. (1) In the study of the RHSs, international research hotspots initially focused on the conceptual and technical complexity [4], and later, the scholars conducted in-depth studies on the factors and principles of urban development [5–8]. In China, scholars emphasized the ecological and social views of scientific development of human settlements [9], then there was interdisciplinary and integrated development [10–12]; the research content covers index system, various reviews and theories [13–15], and studies range in size [12,16–18], data material diversification [19–22], diversification of research methods [23–32], and so on; (2) Research on PHSs may favor the impact of the development of the Internet and information society [33–36]; some scholars have explored the pseudo space and behavior based on imagery tags [37], then the concept of PHSs and the theoretical framework of coupling coordination of “three states” human settlements are given [38], research data from traditional data to big data; the theoretical framework of coupling coordination among PHSs and RHSs is explored [39], which may lay a theoretical foundation for further perfecting the principle of action among PHSs and RHSs.

The word “coupling” comes from physics. In electronics, it refers to the transfer of energy between circuits. Geography mainly deals with the relationship between man and land, such as resource and environment carrying capacity and human settlements [40], sand dune and human settlements [41]. Geographers use the term to solve the problem of the interaction of many factors in geography. The representative ones are as follows: urbanization and ecological environment coupling [42], green governance and ecological performance [43]. The coupling coordination in human settlements are as follows: (1) coupling coordination of elements—the scholars have analyzed the influence of artificial landform development on urbanization in the RHSs [44]; (2) coupling coordination of systems—researchers emphasized the coupling coordination within the five systems of human settlements and constructed the evaluation index system of coupling coordination within the system, which provided a method for macro-scale exploration [45]; (3) coupling coordination of subjects—in the face of the paradigm shift of geographical research, the study of human settlements has evolved from the single state of reality to the high-quality and coordinated development of “three states” human settlements, which was conducive to



the diversified development of human settlements and other interdisciplinary subjects. The coupling coordination of human settlements involves the superposition of many fields, and related scholars have explored the correlation of human settlements, which mainly focused on the coupling between the built environment and human–earth in the Yellow River Basin [46], and the coupling between real-estate development and human settlements [47] and have made a series of achievements in exploring and developing human settlements.

Existing research mostly focuses on the correlation and coupling relationship between human settlements and another index. The reality requires that the development of human settlements cannot stay in a single state. At present, geography is undergoing a transformation from simple elements to a complex human–land relationship regional system with high-level, orderly, coupled and coordinated development [48], the traditional RHSs have been unable to perfectly interpret the new changes brought by the increasingly updated and iterative network in the current stage. Under the background of the Internet era, the development of the PHSs is ahead of the local economic development in the development of the RHSs, and the development of the two is not synchronous, not matching, and not coordinated. For example, in the information age, some online popular tourist attractions are very popular and highly concerned in the Internet community, but the actual economic conditions are slightly backward, and the regional development is insufficient. Therefore, in order to facilitate the coupling coordination among PHSs and RHSs, it is necessary to supplement the principle and principle analysis. Northeast China is a characteristic region of China’s economic development. In the 14th Five-Year Plan, the goal of integrated development of digital and physical development and common development of online and offline is clearly put forward. The 14th Five-Year Plan period is an important time node when the urban human settlements of the three northeastern provinces is in the comprehensive transformation and development.

However, in the era of urbanization, the development level of urbanization in the RHSs always lags behind, the industrial structure is not proper, and the distribution of economic development is imbalanced. (1) In the information age, the PHSs of some cities are not synchronized, unmatched and uncoordinated with the development of RHSs; (2) In the context of epidemic, the PHSs and RHSs interfere with each other for the object of human settlements; (3) In general, the activity of the RHSs is blocked, the activity of the PHSs is increased, and on this objective condition, it is very important to study the spatio-temporal heterogeneity and principle of the coupling coordination among PHSs and RHSs. In addition, in order to provide scientific decision-making for the high-quality development of the urban human settlements, it is necessary to clarify the current situation of shrinkage of RHSs and development lag of PHSs, find the reasons for their mismatch and disharmony, and analyze the development characteristics of disharmony among them.

(1) The northeast region is a characteristic area of China’s economic development. The “14th Five-Year Plan” period is an important time node for the comprehensive transformation and development of the urban human settlement environment in the three northeastern provinces; (2) The three northeastern provinces are located in the northeast region of China and are representative of location in regional studies; (3) As an old industrial base, it is typical. Therefore, selecting the three northeastern provinces as research objects is representative in regional studies. Through objective cognition, the transformation principle of urban human settlements in the three northeastern provinces can be scientifically solved. Exploring the relationship between man and land to revitalizing the northeast and promote the balance and heterogeneity of national economic development is of great significance to the further development of the spatio-temporal coordinated evolution principle of urban PHSs and RHSs systems in the three northeastern provinces and the revitalization of the northeast and the high-quality development of its urban agglomeration. Therefore, selecting the three northeastern provinces as research objects is representative in regional studies. Through objective cognition, the transformation principle of urban human settlements in the three northeastern provinces can be scientifically solved. Exploring the relationship between man and land to revitalizing the northeast and promote the balance

and heterogeneity of national economic development is of great significance to the further development of the spatio-temporal coordinated evolution principle of urban PHSs and RHSs system in the three northeastern provinces and the revitalization of the northeast and the high-quality development of its urban agglomeration.

The first chapter of the paper introduces the academic background, national policies, subject introduction, existing research review and research gap, and research purpose. The second chapter is the theoretical basis. The third chapter presents the space–time pattern characteristics, type analysis, trend surface and driving mechanism of coupling coordination degree. The fourth chapter is the discussion part, and the fifth chapter is the conclusion part.

## 2. Materials and Methods

### 2.1. Theoretical Connotation

The coupling coordination of the human settlements system is a nonlinear dynamic evolution process, which shows a high-quality coupling coordination development law from single to multiple, from simple to complex, from element to system, from disorder to order, from low to high spiral [49].

- (1) The coupling coordination among elements refers to the fact that elements within each subsystem in the five major systems are related to each other and influence each other through interaction, which are the full and unnecessary conditions of human settlements system coupling coordination. Elements and coupling coordination refers to the human settlements system internal relations between single and multiple elements, such as the RHSs within the state in the social system of urban social and economic development level and the coupling coordination interaction between the on-the-job worker average wage level, or the environment in the state system and coupling coordination relation between residential system [50].
- (2) The coupling coordination among system and system refers to the relationship between the whole human settlements system and another system, such as the coupling coordination between social system in reality state and travel of life system in pseudo state. For example, the coupling coordination of five subsystems in human settlements [45].
- (3) The coupling coordination of the two states refers to the interactive relationship of mutual integration and mutual stress in the urban human settlements system at different states, which can be divided into reality and pseudo, reality and imagery, and pseudo and imagery. For example, the relationship between informatization and economic society represents the coupling between pseudo and reality [38].
- (4) The coupling coordination among the three states, the interaction among reality, pseudo and imagery, which not only has the coupling stress between the single system and other elements but also includes the coupling stress between the system and the external system. The process of “three states” from single element or single state to multi-element and multi-state does not exist in isolation but is a spiral development process from disorder to orderly arrangement and combination between various states, which jointly affects the urban human settlements.

### 2.2. Theoretical System

Based on the theory and paradigm of a complex system, and from three dimensions of time scale, space scale and content scale, the human settlements are put forward as a polymorphic and complex framework, including PHSs and RHSs.

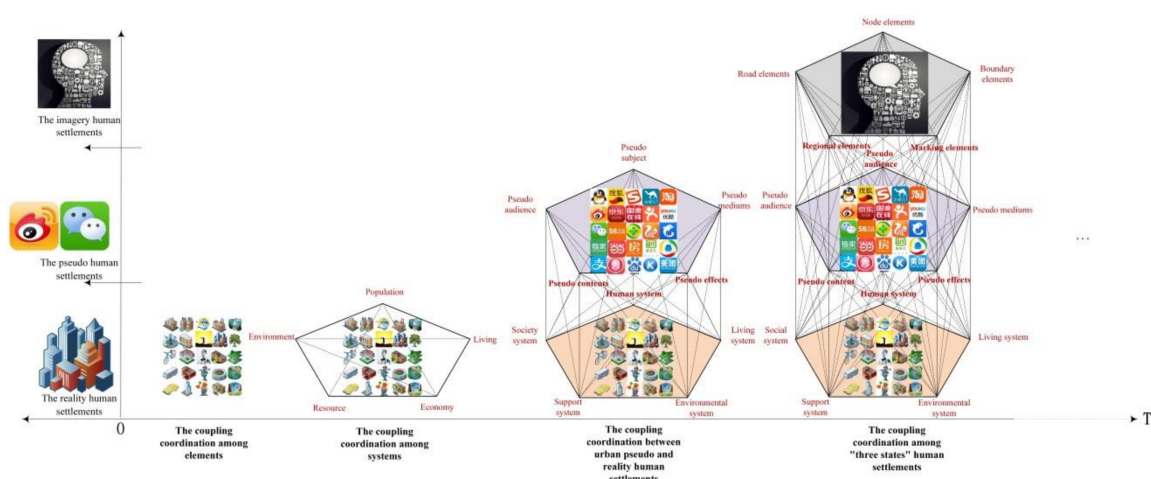
On the time scale: (1) progressively coupling coordination, element→system→state coupling coordination; (2) Jump coupling coordination, element→state coupling coordination, system→state coupling coordination; (3) Retrograde coupling coordination (special case), the state of coupling regressed to only element coupling coordination.

At the spatial scale: (1) coupling coordination at the micro or macro geographic scales, and coupling coordination at the reality, pseudo and imagery geographic scales are as

follows [33]: narrow range of micro scale such as human settlements, streets pseudo and reality community human settlements, macroscopic scales such as urban PHSs and RHSs, regional pseudo urban agglomerations and RHSs, in a broad sense of PHSs and RHSs and the city or the country RHSs, mountain PHSs and RHSs and so on; (2) Single scale, multiple scales, and single scale such as coupling at the scale of a specific object [51–54]; (3) Coupling coordination between near distance and long distance is as follows: driven by external elements of the system, coupling coordination of human settlements has remote relevance in geographical space [55].

On the scale of content: (1) strong coupling coordination and weak coupling coordination, the coupling coordination of PHSs and RHSs can be divided into strong and weak coupling coordination according to spatial intensity, corresponding to strong coupling coordination and weak coupling coordination; (2) Coupling coordination between dominant and recessive. In one area, the coupling of RHSs is dominant, but the dominant position of PHSs is not obvious. In another area, the PHSs are highlighted, but the RHSs are inferior or not prominent.

In the face of the continuous development of the third paradigm of geography, it is necessary to shift from a human–land relationship to human–land system, human–land-network and other complex regional systems, which can form the network pattern of multi-index level cooperation of element to element, element to system, system to system, and the overall complex coupling coordination theory system of reality–pseudo–imagery (Figure 1).



**Figure 1.** The dynamic frame diagram of coupling relationship among “three states” human settlements.

### 2.3. Data Sources

The 34 prefecture-level cities in the three provinces of northeast China were selected as the case regions in the study area, while Yanbian Korean Autonomous Prefecture and Da Hinggan Ling were not included in the case regions due to a lack of data. Considering the comparability among urban PHSs and RHSs and the continuous consistency of pseudo big data in time, the research period is from 2011 to 2019 (Figure 2).

The urban PHSs and RHSs coupled coordination index system mainly includes two parts: one is about the pseudo level, which is based on the sciences of human settlements, urban geography, journalism and communication, etc., mainly including social, information, entertainment, tool and life subsystems, such as news reading, tourism, travel, work and study, such as the middle tier of the 14. According to the spatio-temporal attributes, representativeness and operability of geography, indicators such as Weibo, News, Dangdang and Map, which are highly related to the principal part of urban residents in human settlements are selected. The data source is Baidu Index open-source data, in which the time series is from 1 January 2011 to 31 December 2018. The basic data of 32 indicators in 34 cities were obtained through Baidu Index website, and the mean value of the basic

data was used to reflect and measure the development trend of the PHSs in 34 cities in that year. A total of 32 indicators, including Wechat, Sina News and Ctrip, 1088 items of data in 34 cities were obtained. The other is about the reality level, which is based on the scholar theories. The indexes of urban human settlements was chosen according to the theory and reality condition of the geography and society, which mainly include five subsystems such as human and living, fourteen interlayers such as population, land resource, society finance, the science–education–culture–health and so on, and indexes such as GDP per capita in terms of social assets and number of beds in medical institutions in science–education–culture–health (Figure 3). The data are from the China Urban Statistical Yearbook, Heilongjiang, Jilin and Liaoning Statistical Yearbook from 2011 to 2019.

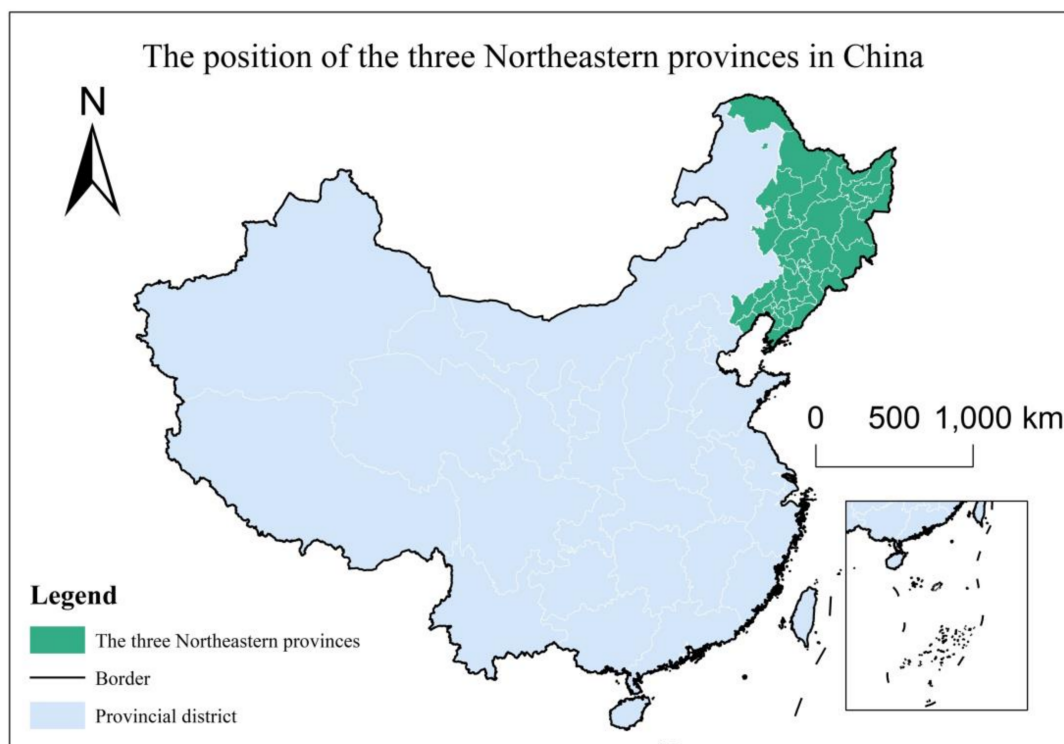


Figure 2. The position of three northeastern provinces in China.



Figure 3. The coupling coordination index system diagram of urban PHSs and RHSs.

## 2.4. Methods

### 2.4.1. Data Preprocessing

In the following formula,  $x_i$  and  $x_j$  are the original numeric value,  $X_i$  and  $X_j$  are the normalized numeric value,  $x_{max}$  and  $x_{min}$  are the maximum values in the matrix with the minimum value:

$$\begin{aligned} \text{Positive indicators : } X_i &= \frac{(x_i - x_{min})}{(x_{max} - x_{min})} \\ \text{Negative indicator : } X_j &= \frac{(x_{max} - x_j)}{(x_{max} - x_{min})} \end{aligned} \quad (1)$$

### 2.4.2. Coupling Coordination

Coupling coordination is used to represent the degree of benign coupling and coordination in the interaction relationship [56]. Combined with the actual situation of the research area of regional PHSs and RHSs, the coupling coordination operation model of the two is constructed, and the formula can be calculated as follows:

$$C_2(PHS, RHS) = 2 \times \left[ \frac{(PHS \times RHS)}{(PHS + RHS)^2} \right]^{\frac{1}{2}} \quad (2)$$

In the formula, HS is the comprehensive index of human settlements, which is calculated by entropy method [50],  $HS_1, \dots, HS_n$  is the subsystem of human settlements.

In order to further study the coupling coordination level among urban PHSs and RHSs, the coordination degree  $D$  among them is comprehensively calculated based on coupling degree  $C$ , the specific formula can be calculated as follows:

$$T = k \times PHS + b \times RHS, D = \sqrt{C \times T} \quad (3)$$

In the formula,  $D$  is the coupling coordination degree among urban PHSs and RHSs,  $k$  and  $b$  are undetermined coefficients. Based on the actual and uniform distribution function of the study region, the coupling coordination degree is divided into 10 research types (Table 1),  $T$  is the comprehensive measure index of them.

**Table 1.** The grade standard of coupling degree and coordination degree.

Coupling Degree	C	Coordination Degree	D	Coupling Degree	C	Coordination Degree	D
High level coupling	$0.8 < C \leq 1$	Advanced	$0.90 < D \leq 1.00$	Antagonism phase	$0.3 < C \leq 0.5$	Basic	$0.40 < D \leq 0.50$
		Good	$0.80 < D \leq 0.90$			Mild	$0.30 < D \leq 0.4$
		Moderate	$0.70 < D \leq 0.80$			Moderate	$0.20 < D \leq 0.30$
Running-in stage	$0.5 < C \leq 0.8$	Primary	$0.60 < D \leq 0.70$	Low level coupling	$0 < C \leq 0.3$	serious	$0.10 < D \leq 0.20$
		Barely	$0.50 < D \leq 0.60$			Extreme	$0.00 < D \leq 0.10$

### 2.4.3. Spatial Trend Surface

The spatial trend aspect is used to simulate the spatial pattern and evolution trend of geographical elements; assuming that  $Z_1(X_1, Y_1)$  represents the actual coordination degree among urban PHSs and RHSs, the spatial trend surface can be calculated as follows [57]:

$$Z_1(X_1, Y_1) = z_i(a, b_i) + \varepsilon_i \quad (4)$$

In the formula,  $(a, b_i)$  is the spatial coordinate,  $\varepsilon_i$  is the residual among the actual value of coordination degree and the trend value. Common polynomials in ArcGIS are 1 (prior), 2 and 3 orders. In this paper, the spatial trend surface fitting of pseudo and reality coordination degree is achieved based on the second order.



### 2.4.4. Geographic Detector

Geographic detector is a statistical method used to measure spatial stratified heterogeneity and factor interaction [58]; it can be calculated as follows:

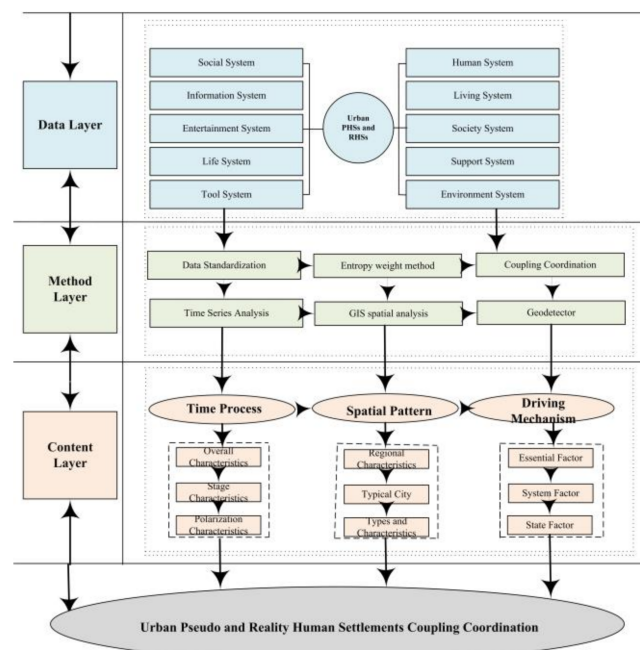
$$q = \frac{N\delta^2 - \sum_{h=1}^L N_h\delta_h^2}{N\delta^2} = \frac{SST - SSW}{SST}, \quad SSW = \sum_{h=1}^L N_h\delta_h^2, \quad SST = N\delta^2 \quad (5)$$

In the formula,  $SSW$  is the sum of variance within the layer;  $SST$  is the total variance of the whole region;  $0 \leq q \leq 1$ , the larger the  $q$  value is, the stronger the explanatory power of the driving factor  $X$  on the coupling coordination degree  $Y$  among urban PHSs and RHSs is, and the weaker it is otherwise.  $q = 1$  means that the driving factor completely controls the spatial distribution of the coupling coordination degree  $Y$ , and the explanatory power reaches 100%.  $q = 0$  means that there is no relationship between the two factors.

## 3. Results

### 3.1. Spatio-Temporal Characteristics of Coupling Coordination Degree

Based on the coupling coordination of urban “three states” human settlements as a theoretical support, starting from the state of PHSs and RHSs. Based on the above research methods, the characteristics and principle of spatio-temporal coupling coordination among PHSs and RHSs of 34 cities in northeast China from 2011 to 2019 are explored, providing valuable reference for the high-quality orderly coordinated development of the three provinces in northeast China (Figure 4).

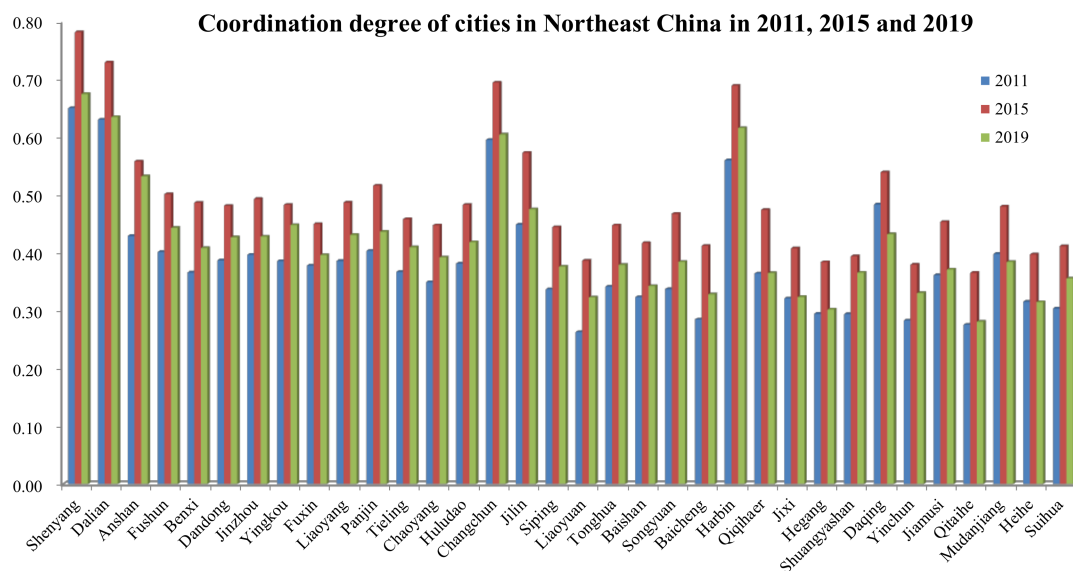


**Figure 4.** The technology framework of coupling coordination of urban PHSs and RHSs.

#### 3.1.1. Time Process Characteristics of Coordination Degree

In terms of time dimension, the coupling coordination degree among PHSs and RHSs in the three provinces of northeast China shows a smooth growth characteristic from “slight disorder” to “near disorder”. Overall, from 2011 to 2019, the average coordination degree among them shows an upward trend, and the coordination degree level fluctuates and increases, indicating a good development trend on the whole (Figure 5). (1) The polarization of time distribution is serious. The coupling and coordination degree among PHSs and RHSs in the three northeastern provinces shows a smooth growth characteristic from “slight imbalance” to “on the verge of imbalance”. The overall trend is that from 2011

to 2019; the average coordination degree among PHSs and RHSs in 34 cities in the three northeastern provinces showed an upward trend, the coordination degree level fluctuated and increased, and the overall development trend is good; (2) With 2015 as the node, the time development shows a “small hill” trend of steady rise and then gentle decline. The coupling coordination degree threshold of each city from 2011 to 2015 is [0.39, 0.49], and from 2016 to 2019 is [0.42, 0.47]. The average coordination degree among PHSs and RHSs in 34 cities in northeast China is 0.44, which is on the edge of disharmony, indicating that the RHSs has a strong mutual influence on the two systems of PHSs, but they still have not reached the coupling coordination level; (3) At the city level, the coupling coordination degree of each city shows an upward trend over time, but the development rate is different. In the past nine years, the coupling coordination degree of Anshan rose the fastest, and the coupling system degree of Jilin, Yingkou and Liaoyuan rose, while that of Daqing, Mudanjiang and Heihe increased further. Of the 34 cities, only Shenyang maintained the “intermediate coordination” stage.



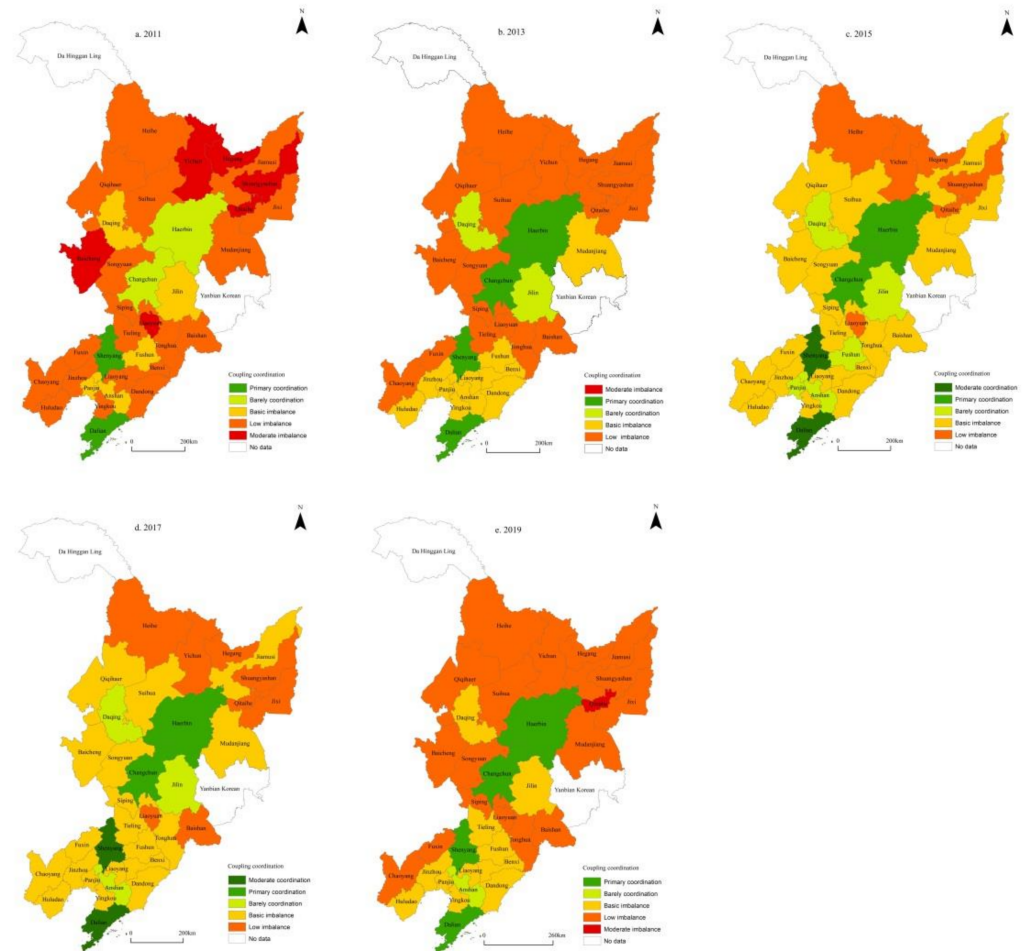
**Figure 5.** The evolution of coupling coordination degree of urban PHSs and RHSs of cities in northeast China in 2011–2019.

On the one hand, the northeast cities attracted a large number of foreign enterprises to invest with the support of national policies. On the other hand, by virtue of massive exploitation and processing of superior natural resources, the depletion of non-renewable resources is accelerated and the excellent natural environment is polluted at the same time. Therefore, in order to promote the evolution of urban PHSs and RHSs system elements in the three northeastern provinces from the primary disorder to the higher level of orderly coordination coupling coordination, it is necessary to accelerate urban transformation and structural improvement, vigorously promote talent introduction and curb reverse urbanization.

### 3.1.2. Spatial Pattern Characteristics of Coordination Degree

- (1) In terms of spatial dimension, the coordination degree of urban PHSs and RHSs in the three provinces of northeast China has significant spatio-temporal heterogeneity [59], showing a typical north–south spatial heterogeneity characteristic of “low in the north and high in the south” (Figure 6). Regarding the overall characteristics, from 2011 to 2019, the coordination degree among PHSs and RHSs in 34 cities in northeast China shows a sharp upward trend, with a total growth rate of 3.05%. From 2011 to 2015, the growth rate reaches 2.26%, and the cities with a large growth rate are mainly distributed in Shenyang and Songyuan, with a growth rate of 31.43% and 30.24%,

respectively. From 2015 to 2019, a large area of negative growth occurs, with a growth rate of  $-5.19\%$ . Anshan city has the largest growth rate of  $0.84\%$ , and Qiqihar city has the lowest growth rate of  $-10.56\%$ . There is a big difference in the coordination degree among PHSs and RHSs.



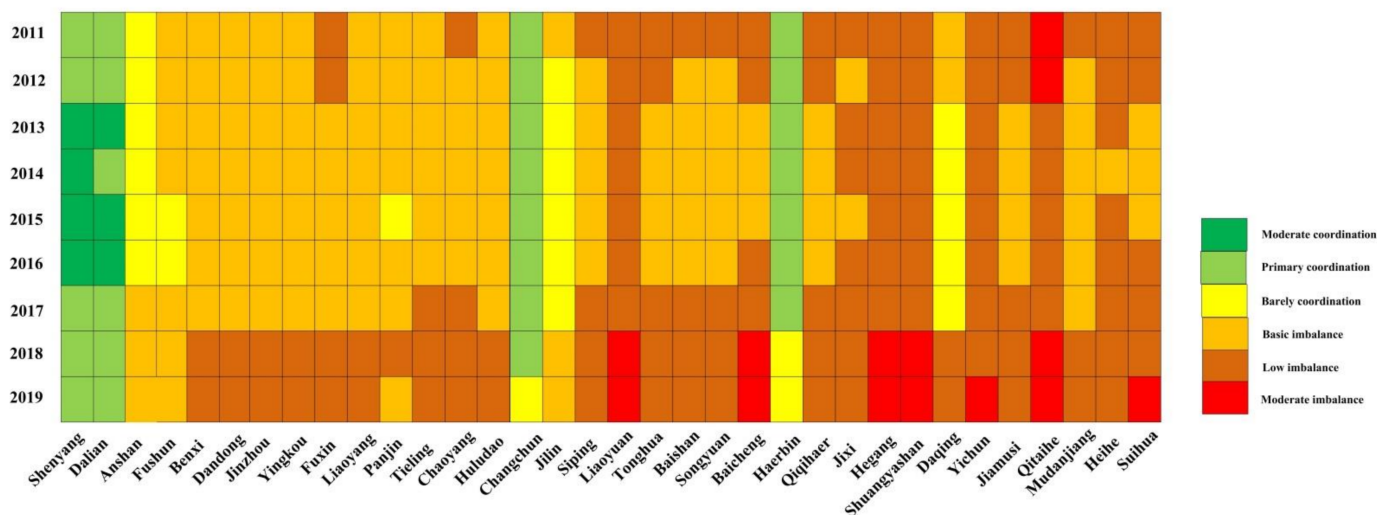
**Figure 6.** The spatial pattern of urban PHSs and RHSs coordination in northeast China in 2011–2019.

- (2) Regional characteristics: from 2011 to 2019, the coupling coordination degree among PHSs and RHSs and the political center exists in spatial alignment. The coupling coordination degree among urban PHSs and RHSs shows a “southward advance” phenomenon, presenting a typical north–south spatial heterogeneity characteristic of “low in the north and high in the south”. From 2011 to 2019, the average coordination degree of urban PHSs and RHSs is Liaoning (0.47) > Jilin (0.43) > Heilongjiang (0.40), and the average coordination degree of provincial capital cities is Shenyang (0.70) > Changchun (0.65) > Harbin (0.64). Although all provinces and cities increased in different degrees in the past 9 years, the provincial characteristics of “low in the north and high in the south” remained relatively stable and showed a spatial evolution pattern of accelerating “southward advance”.
- (3) Typical features of typical cities: through coupling system degree analysis, the coupling coordination characteristics of typical urban PHSs and RHSs are revealed. The results showed that the threshold values of urban coupling coordination degree of Shenyang and Dalian in Liaoning Province from 2011 to 2019 are [0.60, 0.80], both at the coordination level. Shenyang is the most typical among the typical cities, and the mean value of coupling coordination degree in 9 years is 0.70, which is 0.02 higher than the mean value of Dalian. It ranks first in the coupling model of PHSs and RHSs in 34 cities, among which 2011–2013 belonged to primary coordination,

2014–2017 belonged to intermediate coordination, 2018–2019 belonged to primary coordination, and it is still in high-level coordination despite a certain period of fluctuation. Shenyang leads other cities in the province to good coordination, intermediate coordination and the majority of the primary coordination.

### 3.2. Type Characteristics of Coupling Coordination Degree

The coupling coordination degree among PHSs and RHSs in 34 cities in northeast China shows a circle pattern with Shenyang, Dalian, Changchun and Harbin as the center, decreasing from the transition zone to peripheral zone (Figure 7). The coupling coordination degree among PHSs and RHSs of 34 cities in northeast China shows a circle pattern, with Shenyang, Dalian, Changchun and Harbin as the center, decreasing from the transition zone to periphery zone, which is related to the difference in resource endowment and connection intensity among cities. Every city has the connection between people and human settlements with other cities, so the spatial dimension on the contact strength is weak. Cities with a developed economy or close proximity to resource-rich cities have a higher degree of center and large scale and effective efficiency; the output capacity of these cities in the core area obviously has guiding capacity for other cities. The transition region is located in the core region and the edge region, which has the cohesion ability, while the edge region is relatively separated.



**Figure 7.** The proportion of each type of urban PHSs and RHSs coordination in northeast China in 2011–2019.

#### 3.2.1. The Core Zone

In the northern part of the three northeastern provinces, a coordinated development block-shaped “core area” dominated by Heihe, in the central part, a strip-shaped “core area” dominated by Harbin, Changchun and Jiamusi, and in the south, a block-shaped “core area” dominated by Shenyang and Panjin. The temporal evolution characteristics of each core region were further discussed. The blocky “core region” in the south of Shenyang first reached the PHSs and RHSs coupling coordination, and with the change in time, the differences of each core region gradually narrowed from southeast to northwest, and the coupling coordination degree gradually increased. The coordination degree of the central stripline “core area” such as Changchun rose from barely coordination to primary coordination, followed by the fluctuation in the coordination degree of a northern mass “core area” such as Heihe. Most of the core areas are provincial capitals and their surrounding cities, indicating that the urban coordination along the administrative service center tends to be stable.

### 3.2.2. The Transition Zone

The transition zones of coordinated development among PHSs and RHSs in the three provinces of northeast China are mainly distributed in the periphery of big cities and the developed coastal areas. The coordinated development “transition zone” was formed in the northern cities, with Qiqihar and Hegang as the main cities. The “transition zone” in the central region was mainly centered on the belt “core zone” in the central region, with Jilin, Daqing and Suihua as the cities, and Fushun, Benxi, Anshan and Liaoyang as the coordinated development “transition zone” in the south. With the deepening of inter-city cooperation, some regions are abandoning the disharmony and coupling coordination. For example, Suihua has obvious advantages in traffic accessibility and resident accumulation in recent years. It is close to Harbin and enjoys more advantages and opportunities. There are also some areas showing fluctuating changes, such as Qiqihar, which changed from basic imbalance to low imbalance at the beginning and then developed to low imbalance again, because the remote geographical location is not conducive to the play of original advantageous resources.

### 3.2.3. The marginal Area

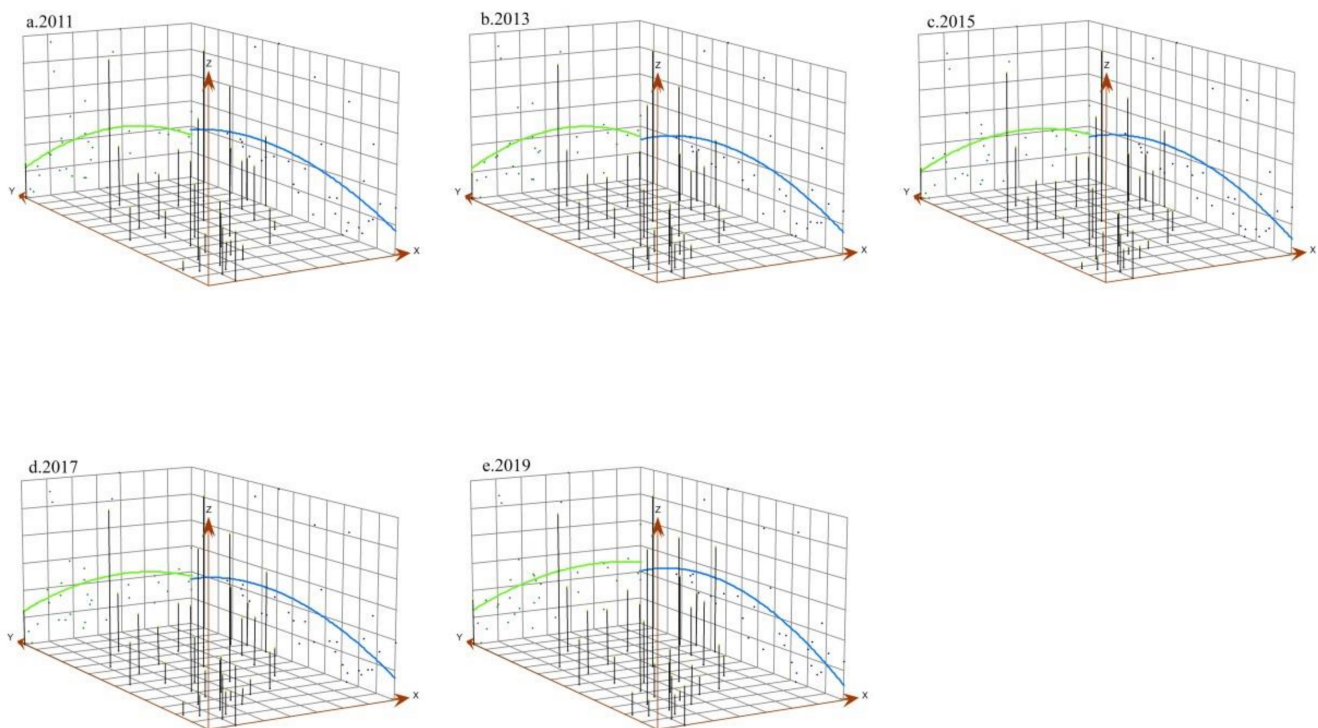
The “marginal” areas are mainly distributed in Jixi, Qitaihe, Baishan, long-withering and other cities, urban PHSs and RHSs coordination degree values are relatively low, on the one hand, due to its downtown location deviation, together with cold weather, low efficiency of production and living activities, and on the other hand, because the facilities of small cities are not complete, the population composition is complex, the population composition is complicated and the community policing is poor, which may lead to a certain proportion of social contradictions. Some residents immigrate to big cities with more opportunities, which may further lead to more prominent problems in small cities, resulting in the deterioration of social environment quality, and further restricting the improvement of human settlements quality in cities in “marginal areas”.

### 3.3. The Trend Side of Coordination

The trend surface is used to view data in a three-dimensional state to reflect the three-dimensional trend of data in a large geographical space. We selected the entropy weight method and annual index data of 34 cities in northeast China to present the overall spatial and temporal distribution law of urban PHSs and RHSs, using ArcGIS to simulate the overall distribution (Figure 8). The arrow of the X axis points due east, indicating east–west direction; the arrow of Y axis points due north, indicating north–south direction, the z-axis represents coupling coordination degree value, the blue and green curves represent fitting curves of coordination degree, longitude and latitude, respectively, reflecting the trend changes of north–south and east–west directions.

- (1) In general, the spatial distribution pattern is low in the east and west, high in the middle, showing an inverted “U” shaped spatial trend, and gentle in the north and south directions. Except for the existence of one or two poles, the coupling coordination degree of urban PHSs and RHSs has a balanced influence.
- (2) In the direction of south and north, the spatial evolution trend shows a gradual change from “—” shape to “U” shape, indicating that the gap among urban PHSs and RHSs is gradually narrowing in the south, north and central regions. The spatial trends in 2011, 2013, 2015, 2017 and 2019 were relatively consistent, indicating that the spatial variation range of coordination degree of human settlements in northeast China was small, showing a stable development trend.
- (3) In the east–west direction, the trend surface changes from inverted “U” shape to “—” shape, which shows that the coupling coordination degree of the northern region is gradually lower than that of the southern region, indicating that the coordination degree of PHSs and RHSs in the three provinces of northeast China presents a stable north–south spatial heterogeneity characteristic of “low in the north and high in the south”.





**Figure 8.** The trend surface analysis of urban PHSs and RHSs in northeast China in 2011–2019.

In terms of time dimension, the overall achievements of urban human settlements construction in the three northeastern provinces from 2011 to 2019 are remarkable. The coupling coordination values of all regions show a gentle upward trend, and the average value of urban human settlements coordination in all regions reaches 0.44. The reason is that the national strategy of “Revitalizing Northeast China” promotes the synchronous improvement of urban human settlements level.

### 3.4. Driving Principle of Coupling Coordination Degree

The spatial and temporal heterogeneity of urban human settlements in the three provinces of northeast China is affected by the two dimensions of pseudo and reality. Pseudo and reality are the result of the comprehensive action of multiple driving factors. This paper comprehensively analyzes the multi-driving factors, multi-systems and multi-states of urban PHSs. In order to find out the law of urban PHSs and RHSs and provide ideas for the discussion of related principles, it further discusses its internal driving principle.

#### 3.4.1. Factor Analysis

Based on the results of comprehensive factor analysis in reality (Table 2), the dominant driving factor in 2011 was social assets, followed by science, education, culture and health. The most powerful driver in 2013 was social assets; in 2015 and 2017, the dominant driving factors were social assets and social security, the most important driving factor in social security was per capita investment in fixed assets. The core driving factors in 2019 were land resources and social security, and the leading driving factor in social security in this period was the proportion of urban basic endowment insurance participants.  $RHS_1$  to  $RHS_{12}$ , respectively, represent the driving factors of urban RHSs, such as per capita industrial sulfur dioxide emissions and proportion of real-estate investment.

According to the results of pseudo comprehensive factor analysis, the core driving factors in 2011 are social networking, online shopping, financial planning, beauty photography, etc. In 2013, they are online shopping, video, work and study, weather, etc. In 2015, the core factors were online shopping, video and news reading. In 2019, the core

drivers are online shopping, music, work and study, etc. In recent years, China's tourism services industry has developed rapidly, profoundly changing people's lives and thinking. PHS<sub>1</sub>~PHS<sub>12</sub>, respectively, represent the driving factors of urban PHSs, such as Sohu News and Meituxiuxiu.

**Table 2.** The driving forces of urban PHSs and RHSs in 2011–2019.

Pseudo	2011	2013	2015	2017	2019	Reality	2011	2013	2015	2017	2019
PHS <sub>1</sub>	0.7446	0.9795	0.9783	0.9721	0.9564	RHS <sub>1</sub>	0.2121	0.2685	0.2319	0.3752	0.2542
PHS <sub>2</sub>	0.9759	0.9743	0.9798	0.9718	0.9507	RHS <sub>2</sub>	0.4544	0.3342	0.5422	0.4734	0.1462
PHS <sub>3</sub>	0.7978	0.9729	0.9806	0.9757	0.9651	RHS <sub>3</sub>	0.2466	0.2804	0.4479	0.4877	0.6068
PHS <sub>4</sub>	0.9628	0.9832	0.9888	0.9714	0.9582	RHS <sub>4</sub>	0.3921	0.3865	0.2232	0.3406	0.4514
PHS <sub>5</sub>	0.7377	0.9516	0.9928	0.9850	0.9478	RHS <sub>5</sub>	0.5052	0.5903	0.4936	0.3510	0.1816
PHS <sub>6</sub>	0.8052	0.9547	0.9826	0.9755	0.9206	RHS <sub>6</sub>	0.2716	0.3048	0.2361	0.2953	0.3097
PHS <sub>7</sub>	0.9661	0.9801	0.9873	0.9774	0.9563	RHS <sub>7</sub>	0.3720	0.4463	0.4676	0.3745	0.4357
PHS <sub>8</sub>	0.9554	0.9655	0.9728	0.9690	0.9503	RHS <sub>8</sub>	0.3008	0.3206	0.3264	0.3301	0.3858
PHS <sub>9</sub>	0.8637	0.9295	0.9283	0.9526	0.9353	RHS <sub>9</sub>	0.5505	0.4527	0.3996	0.4778	0.3667
PHS <sub>10</sub>	0.9694	0.9828	0.9880	0.9887	0.9700	RHS <sub>10</sub>	0.4845	0.4047	0.3540	0.2889	0.2119
PHS <sub>11</sub>	0.9926	0.9847	0.9860	0.9708	0.9836	RHS <sub>11</sub>	0.2436	0.0835	0.1095	0.1810	0.3275
PHS <sub>12</sub>	0.9833	0.9847	0.9807	0.9724	0.9340	RHS <sub>12</sub>	0.2909	0.2257	0.2800	0.2613	0.3292

### 3.4.2. System Analysis

In terms of RHSs, the order of driving factors of RHSs from 2011 to 2019 was: social system (0.39) > supporting system (0.37) > residential system (0.36) > human system (0.31) > environmental system (0.23). The driving system of urban human settlements varies significantly along with the time (Table 3). According to the natural breakpoint method, during 2011–2012, the supporting system was the dominant system, and the ratio of q value of the supporting system was the largest, which was 0.45 and 0.40, respectively, indicating that the quality of urban human settlements during this period was more influenced by the city's public infrastructure and medical and health level. Analysis results show the urban human settlements of the public service and economic reality dimension directivity, the reason perhaps being that social services and the economy can provide more convenience for human living conditions. The number of practicing doctors per thousand people, and per capita urban road area are important factors of residential location, which can fully enjoy the superposition effect of supporting living facilities and public service system and enhance the sense of living happiness through the city space layout in the related area. From 2013 to 2015, the dominant system was the social system; the second was the per capita GDP; the third was per capita investment in fixed assets in the social system. In 2016, the supporting system had the strongest ability to explain the RHSs, with an explanatory strength of 0.38, indicating a close relationship among the RHSs and the supporting system. In 2017, it was the human system, because population changes began to have a profound impact on the urban RHSs. From 2018 to 2019, it was the residential system. It is 0.45 and 0.50, respectively. With the improvement of people's living standard, people's focus shifted from satiety to housing quality, which means they added more requirements for the comfort of living conditions.

**Table 3.** The driving system of urban PHSs and RHSs in 2011–2019.

Pseudo	2011	2013	2015	2017	2019	Reality	2011	2013	2015	2017	2019
Society	0.8024	0.9782	0.9787	0.9720	0.9550	Human	0.2928	0.2904	0.3354	0.4079	0.2515
Information	0.8671	0.9788	0.9833	0.9769	0.9646	Settlement	0.3436	0.3511	0.2981	0.3896	0.5032
Entertainment	0.7714	0.9531	0.9877	0.9803	0.9342	Society	0.3941	0.4628	0.4248	0.3491	0.3230
Living	0.9208	0.9554	0.9591	0.9650	0.9460	Support	0.4508	0.3944	0.3591	0.3547	0.3058
Tool	0.9769	0.9838	0.9842	0.9775	0.9615	Environment	0.2791	0.1902	0.2374	0.2413	0.3007

In general, the supporting system is the core driving system of the urban human settlements system, leading the spatio-temporal evolution of 34 cities in northeast China. The environment system is not always dominant; the possible reason is that the study area has a lack of a large area of green environment of the city, while tall buildings are the main landscape, and urban human settlements have not become the dominant driving system. In the future, the environment will gradually bring far-reaching influence as people become more attuned to the environment.

Regarding the PHSs level, the system of urban human settlements of the influence of the ratio of not less than 0.7, shows that PHSs by networking, information, entertainment, life and tools influence is bigger, the layout of the main reason lies in the information age background. The Internet penetrates into people's daily work, study and life, network service to the general public. As the principal part of human settlements, it means that people are affected by the pseudo dimension. Tool system is the main drive system of urban PHSs, Mobile Banking, Office Software, Imagery Editing, and Mobile Phone Dictionary are the core positive factors. Mobile phone users are also the most dramatic change, especially in the elderly population, which has a growing demand for tools. Other factors during this period had low explanatory power, whose change is leveling off.

#### 3.4.3. State Analysis

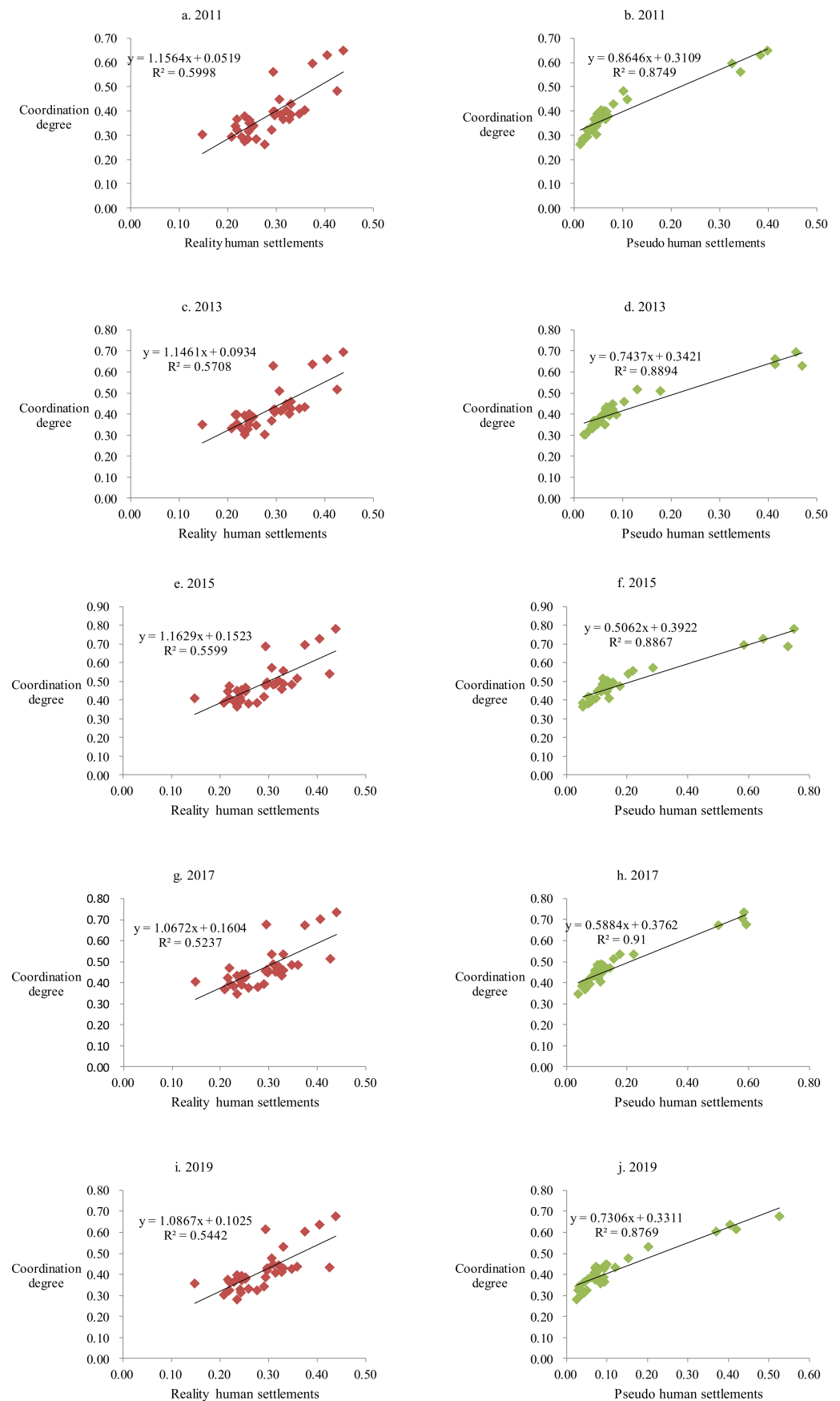
The relationship among urban PHSs and RHSs is further discussed and the index and coupling coordination degree of the two kinds are standardized. It can be seen from the two types of PHSs and RHSs that there is a good correlation among their coordination degrees in the three northeastern provinces (Figure 9).

From 2011 to 2019, the comprehensive mean value of RHSs is 0.56, and the comprehensive mean value of PHSs is 0.89, which passes the significance test of 0.01. It shows that there is a positive correlation among PHSs and RHSs and coupling coordination degree of 34 cities in northeast China. The higher the urban PHSs and RHSs index in northeast China is, the higher the coupling coordination degree is. From the trend line of the PHSs, it can be seen that the future development of the PHSs is closer to the direction of its trend line.

#### 3.4.4. Research on Principle

The social and economic situation is an important driving factor for the coupling and coordinated development of urban PHSs and RHSs. In the dimension of RHSs, the ratio of explanatory power to social and economic data and public utilities ranks the top, indicating that the RHSs of cities is greatly affected by the layout of public services, and social and economic conditions are closely related to the public service input. On the other hand, the "core area" of the spatial distribution of the coordination degree among PHSs and RHSs is mostly provincial capital (sub-provincial level) and its surrounding cities, which also shows the connection among economic development, urban PHSs and RHSs.

The tool system (0.9979) is a new driving system for the coupling and coordinated development of urban PHSs and RHSs, which is higher than the social system (0.9521), information system (0.9370), entertainment system (0.9353) and living system (0.9389). As a profound change in the Internet age, the birth of the emerging industries state of human settlements, the impact of office (0.9835), China construction bank (0.9832), and other emerging social software such as service life and tourism travel activity have grown only in recent years. PHSs system levels contact more frequently, which is helpful to exert the advantages of urban market to generate regional attraction, and then inject fresh vitality into the city.



**Figure 9.** The trend line of urban PHSs and RHSs with coordination in northeast China in 2011–2019.

#### 4. Discussion

This paper comprehensively analyzes the multi-driving factors, multi-systems and multi-states of urban PHSs. In order to find out the law of urban PHSs and RHSs, and provide ideas for the discussion of related principles, it further discusses its internal driving principle. This paper sorts out the relevant research on the element layer and index layer of urban pseudo and reality “two states” of human settlements. Facing the transition of the third paradigm of geography, the research needs to transition from one state to two states, and finally to the coupling and coordination direction of “three states”. The theoretical principle and principle of the interaction and coordination of “three states” human settlements are systematically discussed.

##### 4.1. Contribution of This Study

1. Theoretical contribution: this paper constructs the dynamic framework of the “three state” urban human settlements in order to enrich the existing research on human settlements, promote the development and improvement of the coupling and coordination of the complex system of human land relations, and provide theoretical support for the coupling mechanism of the “three state” urban human settlements.
2. Empirical contribution: northeast China is a typical region with unbalanced and insufficient development in China. There are old problems of RHSs and a new pattern of new changes in pseudo human settlements. At the same time, pseudo human settlements are seriously incompatible with reality. Therefore, choosing the three northeastern provinces as the research object is representative in regional research. Through objective understanding, we found targeted local empirical suggestions to promote the revitalization and high-quality development of northeast China.

##### 4.2. The Limitations and Research Trends of the Article

- (1) This paper only studies the coupling and coordination among PHSs and RHSs, but it does not accord with the development prospect of three-dimensional reality, pseudo and imagery. In the future, the research form tends to be polymorphic, the research content is deepened vertically, and the coupling and coordination between pseudo and reality is transformed into reality–pseudo–imagery coupling and coordination.
- (2) The research only involves 34 cities in northeast China and does not involve meso and micro scales such as Liaoning Province and Dalian. In the future, fine research will be carried out. There will be more detailed research. The scale tends to be more micro, and the research object is oriented to the needs of specific groups.
- (3) The research only pays attention to theory and does not discuss it closely with practice. Based on theory, pay attention to the theoretical connotation of research, integrate the theoretical framework and system structure, promote the practice and innovative development of new theories such as interdisciplinary and polymorphic coupling theory, and realize a multi-scale and three-dimensional urban PHSs and RHSs non-linear interactive coupling network system facing urban practical problems.
- (4) The research data are missing in two regions. In the future, take the data as the support, promote the high-quality integration of multi-source data, and extract key and accurate information.
- (5) The research should be guided by the actual problem needs, improve the information integration logic, scientifically layout the industrial structure, develop an intelligent service platform, make urban governance smarter and urban planning more accurate, and provide decision support for the high-quality development of urban human settlements.

##### 4.3. Policy Implication

According to the theoretical principle of human settlements interaction and coordination, some targeted development countermeasures for the revitalization of the three northeastern provinces have been put forward.



- (1) Coordination and cooperation, reality and pseudo industry integration development. According to the “14th Five-year Plan”, the revitalization of northeast China should speed up the way of urban transformation, strengthen the ability of regional cooperation, close contact and cooperation with surrounding cities in the information age, stimulate the potential of consumer market, and drive economic development. In southeast coastal areas with a high coupling coordination degree, coastal cities should continue to give full play to their advantages and eliminate industries with high consumption and low efficiency. They should also intensify the development of financial industry, give full play to the advantages of eco-tourism and high-skilled labor agglomeration, and improve the coupling coordination level of urban PHSs and RHSs local and surrounding areas.
- (2) Multi-regional linkage promotes the coordinated development of PHSs and RHSs in the three northeastern provinces. Make use of the “core area”, drive the “transition area”, improve the “marginal area” environment, and promote inter-provincial cooperation. Strengthen the multi-party linkage between people and information flow, data flow and artificial intelligence, and build a high-quality coordination relationship between people and cities.
- (3) Collaborate across regions to reduce regional differences. The region in the transition period of coupling coordination in the central region, adjacent to the southern provincial capital and the economically developed coastal cities, is in an awkward transition region. Internally, it should give full play to its development advantages of abundant labor force, carry out cross-regional cooperation, improve the level of urbanization, and reduce regional differences. A lower area northwest coupling coordination degree should vigorously improve the transportation infrastructure facilities, according to introspection on the development of the present situation, the corresponding urban planning and policy, adjustment of measures to local conditions for their building of characteristic industry, taking urban PHSs and RHSs, the interaction of the two systems and the regional development, bringing city attraction, and gradually narrowing provincial differences for the revitalization of the northeast China to make a beneficial contribution.

## 5. Conclusions

The urban human settlements coupling system principle of impact factor analysis found that human settlement characteristics and regional heterogeneity, studies help dig urban PHSs and RHSs coupled coordination, driving factors and the relationship between driving principle, promote the long-term development of human settlements science, and further enrich the urban human settlements in the state of different regional heterogeneity and genetic research. It also provides good empirical evidence for interpreting the spatio-temporal evolution rules and influencing factors of the coupling coordination among urban PHSs and RHSs, and provides an important direction for future research. The main conclusions include:

- (1) In terms of time dimension, the coupling coordination degree of PHSs and RHSs in the three provinces of northeast China shows a smooth growth characteristic from “slight imbalance” to “near imbalance”. In terms of spatial dimension, the spatial heterogeneity of coordination degree is significant, showing a typical north–south spatial heterogeneity characteristic of “low in the north and high in the south”; (2) The coupling coordination degree among PHSs and RHSs of 34 cities in northeast China shows a circle pattern. In the northern part of the three northeastern provinces, the coordinated development block-shaped “core area” dominated by Heihe, the strip-shaped “core area” dominated by Harbin, Changchun and Jiamusi, and the block-shaped “core area” dominated by Shenyang and Panjin were formed in the south; (3) The spatial distribution of the trend surface of coordination degree is as follows: it is low in the east and west, high in the middle, presenting an inverted “U” shape, and gentle in the north and south directions; (4) The socioeconomic situation is an important driving factor for the coupling and coordi-

nated development of urban PHSs and RHSs, and the tool system is a new driving system for the coupling and coordinated development of urban PHSs and RHSs, in which the PHSs is more affected by the layout of social, information, entertainment, life and tools.

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