A MODELING OF CONVERSION PARAMETER OF URBAN TEMPORAL-SPATIAL STRUCTURE BY TIME GEOGRAPHIC THEORY

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ABSTRACT

Due to the continuous development and modernization of cities, urban space is not constructed by a fixed and definite distance. The most obvious changes in urban Temporal-Spatial construction are ‘Temporal-Spatial compression’ and ‘Temporal-Spatial expansion’. This research is based on the principles of urban geography theory and utilizes the Temporal-Spatial map to show urban space construction. In other words, the use of length to describe distance is converted to the use of time. Ultimately, we can figure out the twisted phenomena upon urban space which the “Temporal-Spatial compression” and “Temporal-Spatial expansion” have exerted such significant influences through the use of urban Temporal-Spatial map.

This research uses Globe Position System as the measuring instrument and chooses car and mass transportation as two different ways of movement. Based on the historically traffic-related investigation data, the study estimates the cost of time which transportation devices spend while passing each road and block of Taipei City, deduces the way to calculate the Temporal-Spatial coefficient, explores how the compression coefficient of Urban Temporal-Spatial construction comes into being, further investigates into how the Temporal-Spatial compression and Temporal-Spatial expansion have influenced Taipei city and hopes the effects can be the references for future spatial decisions.

Keywords: Urban Geography Theory, Globe Position System, Temporal-Spatial Map, Temporal-Spatial Coefficient, Urban Construction.

1. THE SEARCH BACKGROUND, MOTIVATION AND GOAL

Faced with the development of technology and growth of city, the patterns of human activity tend to diversify which also influences the relationship between human moving distance and time. The result is that the relationship between time and space doesn’t continue in a linear development, causing this non-linear relationship to transcend the spatial territory. Space isn’t independent and obviously limited anymore. As far as time is concerned, space only shows the interrelationship between one event and another. Out of the real length, the resulted plan only takes the pattern of activity and area into consideration, easily neglecting the mutually moving conditions between two areas. Therefore, in the cities of information era, the meaning of the amount of time taken to reach a specific distance has gradually exceeded the length of distance itself.

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This research collects all the time-consuming investigation data of Taipei's main roads and blocks and through the use of ArcView software it converts all the physical length into the temporal distance so as to transform Taipei City's temporal and spatial construction pattern and visually present the Temporal-Spatial Map of Taipei City. After establishing the equivalent line of temporal data, we can define the scope of one single, specific area, regard the practically temporal consumption as the cost of movement, view the amount of time taken while moving on this very road as road's friction to substitute for the road's distance as the cost of movement. In this way, we can simulate the Temporal-Spatial map of one single spot.

Observing the Temporal-Spatial map of one single, definite spot in Taipei city, we can discover these equivalent lines show various scales of compression or expansion phenomena. These phenomena represent the contain areas affected by the friction of roads, which make time and space result in some scales of compression and expansion. If we convert the Equivalent Temporal-distant Map into a temporal map united by time as its distance, we can even more clearly present the spatial and temporal compression and expansion of a city. This research aims at exploring the transformations of the spatial and temporal construction of a city so as to deduce the Compression Coefficient of the spatial and temporal of construction of a city as the basis for later deduction and research.

2. THE ESTABLISHMENT OF RELATED THEORIES AND RESEARCH METHOD

2.1 The conception of temporal geography theory

The research principle is based on the temporal geography theory and the basic goal of the temporal geography theory is to develop a social behavior mode. This mode simulates the behavior (or activity) in the range of time, space and area and also gives this behavior a flexibility, which functions as the balance between the complicated life locus and constantly changing place (The movement of time and space). The temporal geography has some concepts below:

(1) The concept of constraints

The temporal and spatial behavior of human activities. The Temporal Geography theory emphasizes that people should have goals. In order to accomplish these goals, people should plan for some projects. These projects mean that in restricted circumstances some consecutive activities must be undertaken at some times and in some places. To achieve these projects, human beings must overcome the constraints of environment.

A. Capability constraints: Under the constraints of physiology, the range of distance people can move by means of some transportation devices.

B. Coupling constraints: The combination of one individual with others or with some things to reach the goal of production, consumption and social harmony. In order to reach these goals, there must be some places to stop and gather.

C. Authority or regulating constraints （John R.Short, 1991）

(2) The Temporal and Spatial development map:

The temporal geography theory emphasizes the concept of restriction and utilizes the temporal and spatial map to express this idea. The so-called Temporal and Spatial map is to use development map to indicate one single object's path of movement in space and time. Basically, time-space map is a three-dimensional development map, which consists of two-dimensional space and a temporal axis. Fundamentally, the temporal and spatial map illustrates how people demonstrate the spatial behaviors in the specific budgets of time and space by means of people's moving path, station and activity bundle.

2.2 The phenomena of time-space compression and expansion

Time-space compression is one of the concepts proposed by Harvey. Why the concept is called compression is because the history of capitalism sometimes makes us feel like the world seems to come tumbling down upon us which is characterized by the tendency to overcome the spatial obstacles and the tendency to accelerate the pace of life. This concept also indicates that with the process of modernization time and space are interrupted, reduced and differentiated to become fragmentary, abstract, balanced, widespread and objective. However, in order to control and organize space, national authority must produce fixed, unmovable space. That is place. In fact, this is the same with the capitalism system. In order to pursue the effect of using time to eradicate space, the need isn't merely to produce a fixed space (personal house, transportation and communication devices) but also to accelerate the revolving time of main capital.

Simultaneously, the capital system has to undertake a long-term investment for the equipment, which undergoes a slower business turnover. (Harvey, D. 1989)

Temporarily, the research excludes the effects of time-space compression and expansion upon the politics, economy and humanities from consideration but only aims at deducing the Temporal-Spatial Construction Coefficient as far as this phenomenon is concerned which will be the illustrations for the possibly operating directions in the near future.

2.3 The establishment of research method

This research uses Temporal Geography Theory as the foundation of its principles and makes use of GIS information analytic device to visually present the concepts of time-space compression and expansion, which would be the basis for estimating the mode of the urban Temporal-Spatial Construction Compression Coefficient. As far as the measurement of temporal points are concerned, this research utilizes the GPS to proceed the measurement which makes use of the synchronous satellites globally to measure the temporal data of Taipei City's main intersections. After establishing the related data of every intersection, this research uses the ArcView software for its successive analysis for time and distance, which is finally converted into a temporal map.

3. ACTUAL EVIDENCE RESEARCH

3.1 The illustration for the method of investigation

(1) The illustration for the area of investigation

The research mainly aims at investigating the Jungieng District, Datung District, Jungshan District, Sungshan District, Daan District and Wanhua District in Taipei city and mainly aims at the intersections of main roads as its investigation spots. The following is the investigation equipment:

Holux GM-100.2.Garmin GPSⅢ Plus. Two kinds of GPS.

(2) The process of investigation:

A. To investigate the numeration of data

The method of measurement is to put GPS on the car and to choose major roads in Taipei city for measurement. To use GPS for measurement in Taipei city, we can get GPS's record of measurement. (MPS official file)

B. The transformation of the time and distance linear data

To linearize the time-related definition between two spots and to convert the distance of the previous spots into linearization, this part mainly aims at recording the locus of the main users' movement, which uses the width of the line to represent the force of friction while moving on this road. Therefore, the research can calculate the speed while driving on one specific road. With the assistance of Taipei city map, we can show the driving speed of Taipei city's streets.

C. The conversion time-distance surface data

With the use of Create TIN from Features in ArcView software, we convert the patterns of linear data into the equivalent lines of the surface data.

D. The calculation of the urban time-distance map

With the function of the Network in the ArcView software, we define the expense of time as the cost of consumption while moving on the roads to calculate the equivalent time-distance map of one single spot.

E. The calculation of urban equivalent distance map

This equals the method for calculating 4. However, it uses the actual length of the road to calculate the consuming cost while moving on the road.

F. The establishment of the temporal map

The established temporal map here by this research is to use time to substitute for the map united by the actual length. Which means, in this temporal map, the amount of time consumed while moving from the center of one circle to the edge of that circle should be equal.

G. The deduction of urban spatial and temporal construction compression coefficient

This research defines the variations between Euclid's an area of the equivalent time-distance map of a plane and an area of equivalent time-distance map on the temporal map as the urban temporal and spatial construction compression coefficients.

3.2 The transformation of the temporal and spatial construction pattern

With the use of Create TIN from Features in the ArcView software, it converts the pattern of the linear data to the surface data of the equivalent lines. Like the Fig1.

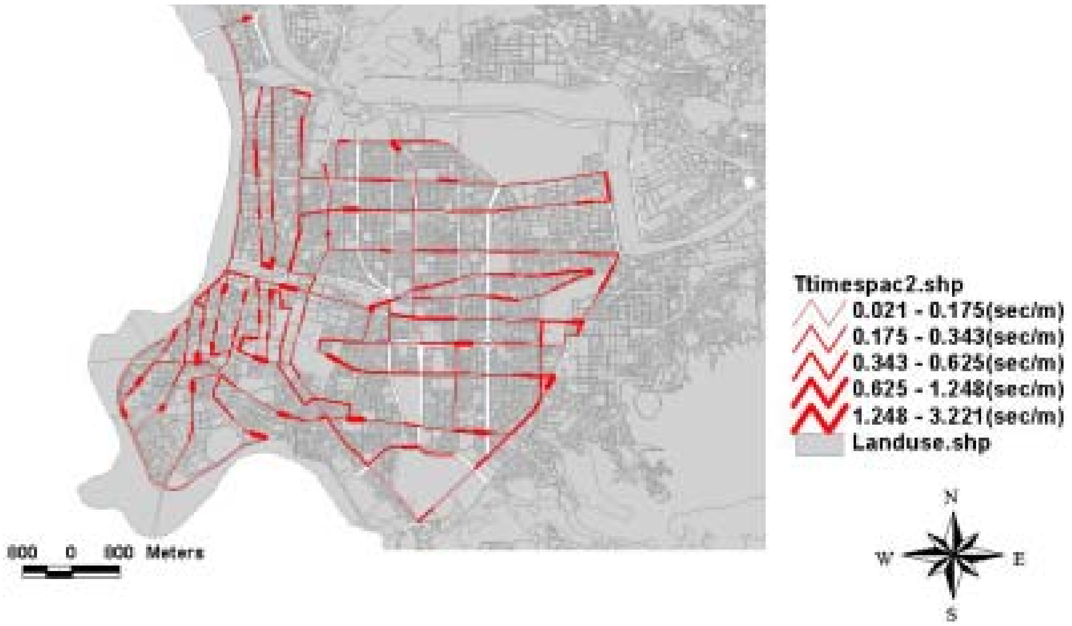

Fig. 1 The equal car velocity diagram of Taipei City

Due to the investigation data based on Taipei's main roads, the minor streets between two main roads may easily be neglected. While the linear data crossing these minor streets, the method of internal difference to calculate is used. Therefore, the problem of accuracy arises. The research here aims at presenting the integral appearance of Taipei city's time and space, temporarily neglecting the problem arising from this part. For further investigation and analysis of actual evidence will be undertaken in the near future.

Out of the conversion of time and distance, the resulted surface data can calculate the equivalent time-distance line between area and time, expressing the original roads in the pattern of linear data. The research defines the tendency of the linear data from the number of the equivalent time-distance lines the surface data crosses. In this way, the research can acquire the area's time-distance map. On this equivalent time-distance map, the scale, which every line contains, equals the cost of time while passing this area.

The presentation of Taipei city roads' equivalent time-distance map can be compared to the actual map. To define Taipei city roads' time equivalent lines, we uses the height of Z axis to express the various cost of time and presents all time equivalent lines in three-dimensional method on the map of Taipei city. The higher place indicates the higher expense of time and also the more difficult to move. The flatter place indicates the moving speed will be much more fast. This indication method can more easily accord with people's perception of movement. The red parts on the map represent the higher places in the three dimensional space which the higher amount of time is consumed. The phenomena of ups and downs on the map can show the city is situated at one time spot as we can see in the Fig 2.

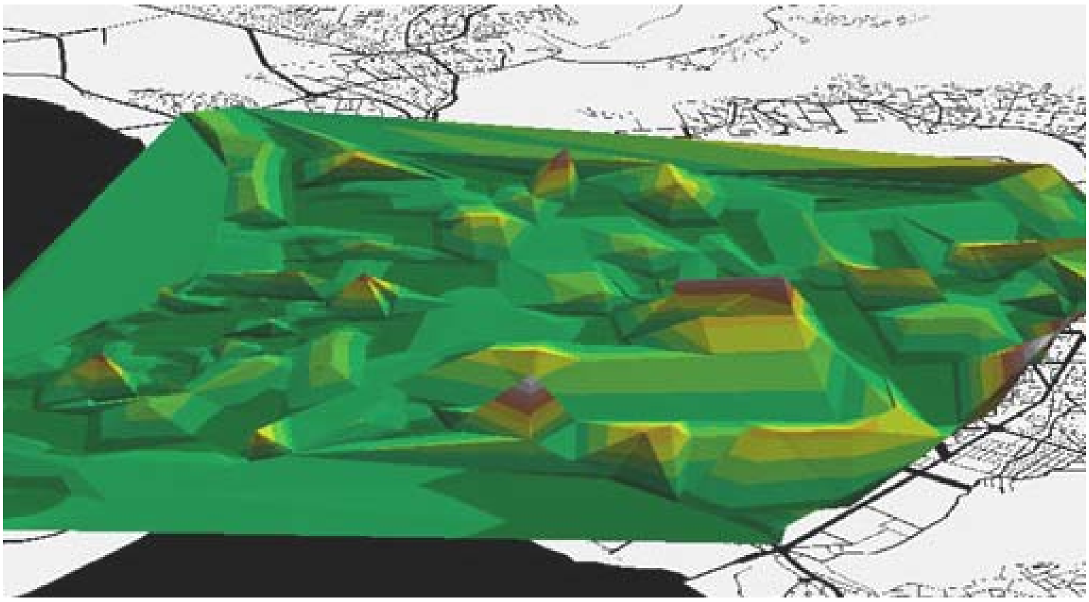

Fig. 2 Taipei City 3 D temporal-spatial map

3.3 Visualize Taipei city's temporal and spatial compression phenomena

If we assume the accessibility of every spot in the city scale is equal, the constructed city or the space construction mode of an area should be a circle or a hexagon. This spatial mode can minimize the cost of distance. However, with the speed of urban development, the frequent human activities tend to affect the relationship between time and distance. Among these relationships, the obvious are the temporal compression and expansion. These two phenomena twist the usage of space. The twisted scale will differentiate itself with the scale of the temporal consumption. In order to simulate the effects of time-space compression and expansion phenomena upon Taipei city, this research calculates the equivalent line of the equal time and distance, visually presenting its condition of distribution. After visualizing the situation, the equivalent time-distance map can show the obvious difference between the scopes of actual distance and time-distance as far as Taipei city is concerned. From the equivalent time-distance map, we can see which place will be struck by traffic congestion and which place will be backward in the quality of traffic service system. These places will be concentrated by the equivalent lines on the map.

3.4 How deduce the way to calculate the Temporal-Spatial Coefficients

(1) The establishment of the temporal map

The temporal map is united by time to measure distance. Hence, the research assumes that the basic principle to draw the temporal map is:

In the temporal map, at the edge of a round circle, the time taken from the center of a circle to the every edge of the circle should be equal as we can see in the Fig 3.

(2) To deduce the way to calculate the coefficients

In the Fig 4, the scope circled by the red lines can be centered by the Taipei

Fig. 3 Concept of the temporal-spatial map

Fig 4. The equal time diagram of Taipei City

Train station and the scope in which cars moves about for 5 minutes. This research temporarily assumes that this investigation data can calculate the average speed rate 7.39m/s, which should be the standard speed for ordinary moving cars. With this average speed rate, we can draw the central point represented by the Taipei Train Station. If we assume under the unrestricted circumstances the scope which cars drive for five minutes to reach and then overlap the average car moving speed with the equivalent time-distance map, we can convert the map shown by the originally equivalent patterns of line to the mode of the temporal map in Fig 3 through the twisting of space.

From Fig3, we can easily sense two phenomena. The first one which occurs in the intestifying space of south to north direction is the so-called Temporal-spatial Compression phenomenon. It means that the actual distance of movement is longer than the estimated distance of movement. The second one occurs in the direction of the west to the east, which is the so-called Temporal-spatial expansion phenomenon.

It means that the actual distance of movement is shorter than the estimated distance of movement. In the Temporal map, the equal length of distance means the equal cost of time. Here the research temporarily assumes the formula to calculate the Temporal-Spatial construction compression coefficients as below:

$$Cts = \frac{Aas}{Ats}$$

To illustrate the symbols

Cts= The Temporal-Spatial Construction Compression Coefficient

Ats=The area of the moving distance on the on the temporal map

Aas=The area of the average moving speed.

Among these, the number K is a corrected right coefficient. If the temporal-spatial construction compression coefficient is more than 100%, it means the actual scope of movement is larger than the movement on the time-space map. It means the

Temporal-spatial compression phenomenon occurs. On the other hand, it means the Temporal-spatial expansion phenomenon occurs.

(3) The calculation of the Temporal-spatial construction compression coefficient

Here we assume the formula to calculate the Temporal-spatial construction compression coefficient to measure the Temporal-spatial construction variance centralized by the Taipei Train station. We can see the Chart 1:

In the scope of five-minute driving, the area of the actually moving scope is 6484689.772m^2. On the Temporal map, the area of moving distance is 15441207.23m^2. Therefore, the temporal-spatial construction compression coefficient is 32.63%, which is the Temporal-Spatial expansion.

The calculation results above mainly aim at exploring the main roads around Taipei Train Station without taking the minor streets into consideration. In addition, the corrected right coefficient isn't mutiplicated. Therefore, some parts of details are neglected. However, the main goal of this calculation only aims at presenting the central area characterized by the Taipei Train Station which will be the basis of the deduction and conclusion for this area's calculating concepts of the temporal-spatial compression or expansion.

Minutes	Aas	Ats	Cts
1	513049.8999	617648.2892	83.07%
2	1670046.071	2470593.157	67.60%
3	2737542.134	5558834.603	49.25%
4	4430970.667	9882372.628	44.84%
5	6484689.772	15441207.23	42.00%
6	9517960.478	22235338.41	42.81%
7	12509594.39	30264766.17	41.33%
8	14363899.08	39529490.51	36.34%
9	16799672.88	50029511.43	33.58%
10	20153086.08	61764828.92	32.63%

Chart. 1 The calculation of urban temporal-spatial structure parameter

4. CONCLUSION

4.1 Deduction

(1) The connection between the temporal-spatial compression and expansion with the subregion of the land use

To compare the calculating result with Taipei's subregion of land usage, this research temporarily assumes that the main factors affecting the urban development are land usage and traffic. The commercial area within the 5-minute moving scope of Taipei Train Station is smaller than the area within 10-minute moving scope. Therefore, if the cost of the traffic time around this area is affected by the number of people moving-in and moving-out simultaneously and whether the land usage of this area is commercialized, we can deduce the more prosperous the area is, the much more traffic time will be consumed around this area. As a result, the effect of Temporal-spatial expansion becomes increasingly intensified. The areas more easily to move on or pass through are the residence area, the agricultural area, the industrial area. People are less likely to gather around areas of these kinds. Therefore, the less prosperous these areas are; the more intensifying the effect of the temporal-spatial compression in these areas will be. This research further verifies the assumption by exploring the intersection between Chung Shia West road and Yet-sun North Road and the intersection between faith road and Fuhsieng south road. The equivalent time-distance maps of these two intersections are focus on and verified. At first, we calculate the subregion of every circular area on this equivalent time-distance map as we can see in Chart 2. Then we calculate the area of one specific subregion and how much the area occupies in this time circle. Afterwards, using related coefficient calculation method to calculate the relationship between how much this subregion weights and how the Temporal-spatial coefficient appears as we can see in Fig 5. From Fig 5, we can see the temporal-spatial compression coefficients of the power company area; the school area, the traffic area, the square area, the institution area, the gas station area, the market area; the commercial area and the industrial area are in the direct ratio. That means the more extensive some subregions occupy, the more intensifying the temporal-spatial compression coefficients appear which allow it easier and faster to pass through these regions. On the other hand, the ancient-remains preservation area, the watery passage area, the dike area, the playground area, the scenic area, the housing area, the agricultural area and the oil-reserved area, the railroad area and the parking area are more likely to undergo the temporal-spatial

Expansion phenomena, which lengthen the cost of time taken while passing through these regions.

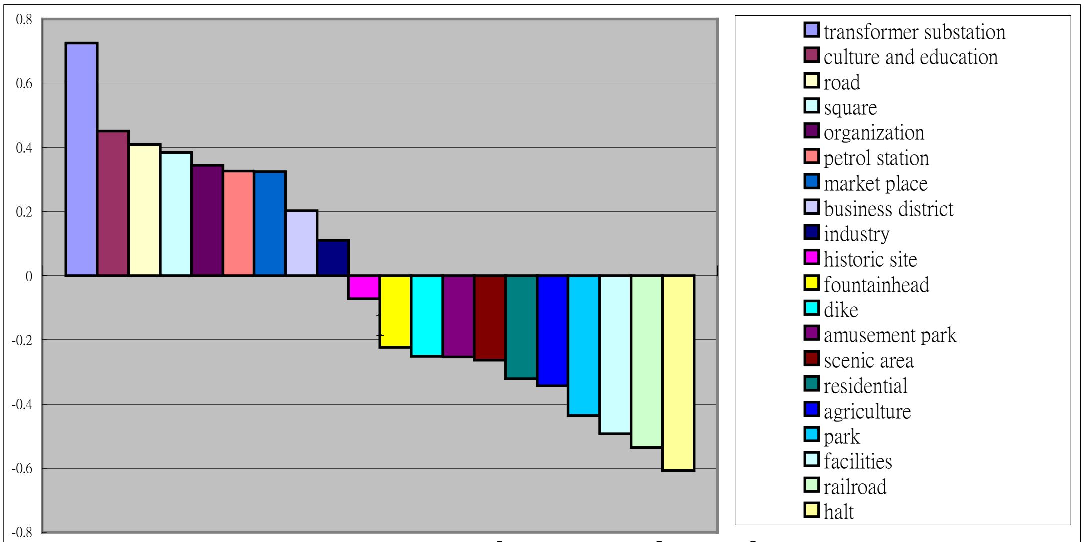

Fig. 5 The relation of land use and urban temporal-spatial structure parameter

Minutes 鐘	Residence 區	Commerce 區	Halt 場	Park
1	8625.3933	15956.2598	0.0000	8674.5047
2	25597.3620	83586.8810	0.0000	28132.9438
3	64475.4215	103487.0004	0.0000	70145.8950
4	108332.4945	141245.4473	957.1250	106322.1004
5	131691.1537	239599.3757	3535.7705	169952.9728
6	139648.9818	343627.0722	4736.7076	263311.2772
7	184764.5383	420317.2787	10034.1017	382191.5623
8	190624.2129	452553.5981	23558.1725	496098.5990
9	198038.1914	475935.7828	33092.0081	713284.4363
10	212584.0000	498548.0000	33092.0000	960762.0000

Chart. 2 The assignation of temporal-spatial structure in various land use

(2) The possible relationship between the housing area, the commercial area, industrial are and the temporal-spatial construction compression coefficient

If you undertake the logarithm analysis by combining how much the housing area, the commercial area and the industrial area weight in the equivalent time circle with the temporal-spatial construction compression coefficient, you can see more intensifying the temporal-spatial expansion phenomena appear as we can see in Fig6, 7. In these pictures, we can see the more intensifying the temporal-spatial expansion phenomenon occurs, the heavier the housing area weights. However, the commercial and the industrial areas aren't so affected by the temporal-spatial expansion phenomenon.

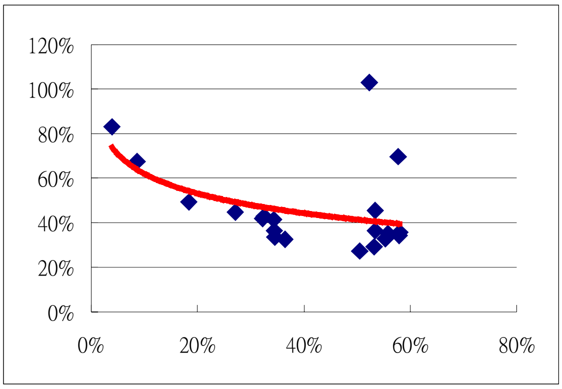

Fig. 6 The business district shares the area percentage of all cents

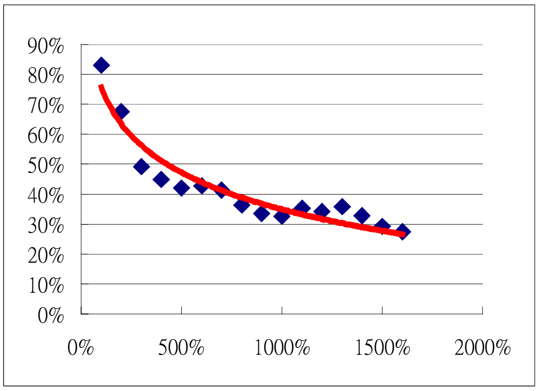

Fig. 7 The industry district shares the area percentage of all cents

(3) Owing to the lack of the sample information, the verified results above only served as proposed references. I hope there should be later and further investigation in the near future.

4.2 Conclusion and further research for future investigation

As far as the research is concerned, the methods of calculation still belong to the stages of concept. Therefore, the primal conclusion of this very research aims at proposing the concept of calculating the temporal-spatial coefficient and also proposing the related methods for further analysis. Out of these calculations and methods, the concepts of the temporal-spatial compression and expansion can possibly be practiced in the classification of city categories and city strata so as to indicate the type and stratum of the urban Temporal-spatial construction. The result of this research is the establishment of the formula for the temporal-spatial compression proposition and the further discussion for Taipei city's temporal-spatial compression and expansion phenomena.

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