

# Study on Interacting Relation between Integrated Transportation Hub and Land Development

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**Abstract:** Based on the related theoretical researches and practical experience from the domestic and overseas, this paper encircles the relationship between integrated transportation hub and land development, adopting the theory of differential equation, builds a mathematical model depicting the interacting relationship between traffic volume and land price/ between hub facility utilization and land resource use. Conclusion and proof were given that transportation hub facility and land use is to be interactive feedback relationship, which may provide the theoretic foundation for coordinating hub construction and land development.

**Keywords:** Land development; Interactive feedback; Differential equation; Mode

## 1. INTRODUCTION

Traffic and transportation in modern times produces profound effect to city development and city space evolution, the speed of traffic has become the most important value orientation[1]. The importance of Integrated transport hub is reflected in the use of traffic facilities itself, also reflected in promoting the surrounding areas planning of the transportation hub, the city's economic development and land use planning. Integrated transport hub is two or more than two kinds of transport means and traffic trunk road intersection and cohesion, requiring a variety of transport facilities and ancillary service function of organic synthesis for passengers or goods sending, transit, and arrive, which produces the "ripple effect" to the traffic hub, such as a stone thrown into the water[2]. Transit-oriented development theory guided by the public traffic (TOD) is first presented by Flake[3], who is an American architect. TOD theory thinks: (1) transport hub could eliminate traffic congestion, reduce the total transportation, which may become the industry cluster area and even become a new city center. (2) city development based on the TOD can produce marked positive feedback mechanism of "stream of people-service industry-stream of people", the assemble effect will cause the neighborhood of transportation hub quickly appearing manufacturing, logistics industry, commercial, catering services, exhibition services industry and high density residential community[4].

In classical economics, the land rent theory is main theoretical basis for the evaluation of land use, city planning depends on the rental value, each kind of land use types have the premium zone of corresponding payment ability. The fundamental assumption of land rent theory is to achieve maximum economic benefits  $U_{\max} = U(z, g, s)$ , Where =benefit; = land quality; = distance from land area to downtown. Apparently, can be understood as the degree of regional accessibility, which dependences on the transportation service level, can also be used to represent the convenience when transferring between different traffic modes. If a district accessibility level is high, it indicates that the area may have tended to be higher intensity of land use. Traffic system shows regional superiority and impact monetary value of land. Thus, a high traffic infrastructure level can ensure the land utilization and promote the development of a city[6].

On the other hand, comprehensive transportation terminal facilities construction and operation needs sufficient funds to support. Under the city land reserve system, land is the most effective resources for the hinge region. Reasonable land utilization can acquire the funds of integrated transport hub construction and operation to achieve balance and sustainable development of system. Furthermore, from the perspective of traffic planning, the different land use pattern determines the hub of the traffic structure and the comprehensive transportation hub distribution forms to a certain extent[7]. The unreasonable land use will cause that the traffic capacity cannot meet the traffic demand. In addition, rational land layout and location of facilities, through continuous construction and put into use, also can brings more and more convenient to transportation hub passenger and cargo flow[8]. The circulation and interactive feedback exists between comprehensive transportation hub and its surrounding land development, which interact influence each other, forming a complex system. The income of land development is foundation of comprehensive hub construction and regional sustainable development; while the hub of construction and operation affects the mode of land development.

## 2.INTERACTION MECHANISM BETWEEN

INTEGRATED TRANSPORTATION HUB AND LAND DEVELOPMENT BASED ON DIFFERENTIAL EQUATION

Comprehensive transportation hub and land development can both be represented by different characteristic parameters. The variables to describe the characterization of integrated transport hub are: traffic volume, hub structure, the spatial layout of the facility and so on; land development and situation variables are: land development, land utilization degree, land development intensity. The microcosmic mechanism between volume index reflects the feedback relationship between the comprehensive transportation hub and its surrounding land development from macroscopic angle. Because land reserve and development cost is easy to check, so the indicator of land development income can be instead of the land development prices; the intensity of land development is gradually increased along with the regional development, to some extent, the planning of regional development and the higher rate of development of higher strength, shows more sufficient regional land use[9]. The measure of comprehensive transportation hub and its surrounding land development from microscopic mechanism of interaction are shown in table 1.

Table1: The index of integrated transportation hub system and land development

	Variables	Implication
Integrated transportation hub system	traffic volume	average daily passengers or goods traffic
	hub facility utilization	volume/traffic capacity
	land price	land price of hub area
Land development	land development intensity	developed area/total area

(1) Interaction mechanism between traffic volume and land price

The relationship between traffic volume traffic of hub and land price give expression to interaction between integrated transport hub and land development at the microscopic respective. Macro analysis shows that the construction of comprehensive transportation hub can improve hub traffic accessibility, thereby affecting the surrounding land value; under current land reserve mechanism, land value will influence the hub system benefits and affect the construction and development of comprehensive transport hub system. Thus, this paper uses the differential equation to analyze the relationship between traffic volume of hub and land price from the microscopic respective.

establishing mathematic mode of reflecting the relationship between traffic volume and land price. Hypothesize traffic volume of transportation hub is

$x_1(t)$  at moment , land price of transportation hub is  $x_2(t)$  at moment .

Supposed,

①  $x_1(t)$ 、 $x_2(t)$  is smooth function, and  $x_1(t) > 0$ 、

$x_2(t) > 0$ .

② the biggest traffic volume of its  $X_1$  independent growth after construction of transportation hub is , the highest land price of its independent growth under natural economy conditions in hub area, both of them are finite constant.

③ the growth rate of hub traffic volume is  $r_1$  ,the growth rate of hub land price is  $r_2$  ,  $r_1 > 0$ 、 $r_2 > 0$ .

④ the natural growth rate of hub traffic volume is  $\lambda_1$  , the natural growth rate of hub land price is  $\lambda_2$  .

⑤ influence degree of hub traffic volume to land price is  $\sigma_1$  , influence degree of hub land price to traffic volume is  $\sigma_2$  , both of them are normal number.

Because land is scarce resources, its price growth rate is a normal constant  $\lambda_2$  ( $\lambda_2 > 0$ ) without considering the effect of comprehensive transportation hub, the natural growth rate of land price is corrected

to  $\lambda_2(1 - \frac{x_2}{X_2})$  considering the presence of growth

impedance. In addition, the construction of integrated transportation hub certainly increases the land price, for the simplicity of analysis, supposed this growth of land price is proportional to the traffic volume of hub. Thus, the growth rate of land price is:

$$r_2 = \lambda_2(1 - \frac{x_2}{X_2}) + \sigma_1 x_1$$

Similar discussion can be learned that the growth rate of traffic volume is:

$$r_1 = \lambda_1(1 - \frac{x_1}{X_1}) + \sigma_2 x_2$$

The differential equation between traffic volume and hub land price is:

$$\begin{cases} \frac{dx_1}{dt} = x_1 \left[ \lambda_1(1 - \frac{x_1}{X_1}) + \sigma_2 x_2 \right] \\ \frac{dx_2}{dt} = x_2 \left[ \lambda_2(1 - \frac{x_2}{X_2}) + \sigma_1 x_1 \right] \end{cases}$$

To research if interaction of traffic volume and land price have reached the point of balance and if equilibrium is stable, whether the model is stable is required to be discussed, namely what is the tendency

of  $x_1(t)$  and  $x_2(t)$  when  $t \rightarrow \infty$ . The right ends of two equations in the differential equations (3) are respectively set to 0, then the paper get the following algebraic equations:

$$\begin{cases} x_1 \left[ \lambda \left( 1 - \frac{x_1}{X_1} \right) + \sigma x_2 \right] = 0 \\ x_2 \left[ \mu \left( 1 - \frac{x_2}{X_2} \right) + \delta x_1 \right] = 0 \end{cases} \quad (4)$$

The following conclusion can be drawn through above analysis: a mutual influence and interaction exists between traffic volume of the hub and land price, both of them promote each other, have the potential to reach a stable equilibrium state through feedback cycle. Through the construction of comprehensive transportation hub, the traffic volume expanding leads to improve regional accessibility of hub, the land price rises up, thereby it drives the integrated regional traffic volume increasing, then this interaction enters into the new cycle. The process is a positive feedback cycle, but such a positive feedback process cannot continue without limit, the renovation and expansion to increase its capacity is difficult when traffic facilities develops to a certain extent. The analysis of model is consistent with the real situation, so the differential equation model has certain explanatory for the relationship between traffic facilities and land development[10].

(2) Interaction between hub facility utilization and land development intensity

The relationship of integrated transport hub facility utilization and land development intensity embodies interaction of integrated transport hub and land development at the microscopic level again[11]. As land development intensity increases, the comprehensive regional supporting facilities increasingly becomes mature, which improves the hub facility utilization and further enhances the regional development land value, further promoting land development; if there is no hub facilities construction, the hub land development intensity will be lower than the other plots of the city.  $x_1(t)$  indicates integrated transport hub facility utilization and  $x_2(t)$  indicates land development intensity at time ; the biggest hub facility utilization of its independent variation after construction of

transportation hub is  $X_1$  , the greatest land development intensity of its independent variation under natural economy conditions in hub area.

### 3.SUMMARY

Close feedback interaction exists between the integrated transportation hub and regional land development. The construction of comprehensive transportation hub in the region improves the traffic accessibility and stimulates land value increment; land development of integrated transport hub area promotes regional supporting facilities, so as to increase traffic volume of the integrated traffic hub and improve the utilization rate of facilities. Such views provides basis for coordinating the relationship between hub construction and land development.

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