# A Study of the Impacts of Inner-city and Inter-city Accessibility on House Price

Na WU<sup>a</sup>, Shengchuan ZHAO<sup>b</sup>, Zhi ZUO<sup>c</sup>

<sup>a,b,c</sup> School of Transportation and Logistics, Dalian University of Technology, Dalian, 116024, China
<sup>a</sup> E-mail: w15184016801@126.com
<sup>b</sup> E-mail: szhao@dlut.edu.cn
<sup>c</sup> E-mail: zuozhi@dlut.edu.cn

**Abstract:** The paper aims to examine the impacts of traffic accessibility on house price. It introduces variables of inner-city accessibility and inter-city accessibility to represent traffic accessibility and calculates the zone's traffic accessibility using spatial interaction model. The paper does curve fitting taking house price as dependent variable in order to reveal the spatial variation characteristics of the house price in the condition of differences of traffic accessibility. The paper chooses the city of Shenyang as an example to study. The paper finds that the impact of inter-city accessibility is greater than inner-city accessibility by curve fitting. Furthermore, the inner-city accessibility may have a negative impact on housing price although the influence is little. Whereas the improvements of the inter-city accessibility will contribute to the rising of the housing price, which is consistent with the common sense.

*Keywords*: Transportation Accessibility, House Price, Hedonic Model, Spatial-interaction Model

## **1.INTRODUCTION**

There are many definitions about accessibility. In the transportation sector, it is the convenience level from a given location to the activity location by a specific transportation system. It was first put forward by Hansen in 1959 to definite the interactive opportunity among transportation network nodes. It can be divided into different accessibilities according to different methods of classification. Kwan classified it into two categories, personal accessibility and place accessibility. The former one is a good indicator of the quality of the personal life; the latter one refers to the ability that the place can be accessed to. However, what Kwan mentioned in place accessibility was just the accessibility the place is accessed to. In fact, in the real estate market, what people concern more is that the ability of this place accessibility upon house price.

There are already many researches about accessibility at home and abroad. Levinson (1998) analyzed the effect of accessibility to jobs and houses at both the home and work ends of trips on commuting duration for respondents to a household travel survey in metropolitan

Washington, DC. Jim énez JL et al (2011) have already done the research about the direct impacts of accessibility upon market competition. They discovered that service stations can establish a dominant position if consumers did not have access to other retailers within a 17-min radius. A study was undertaken by Kangwon Shin, Simon Washington, and Keechoo I et al (2007) to develop a spatial lag hedonic price model in the Seoul, South Korea, metropolitan region, which included a measure of local accessibility as well as systemwide accessibility, in addition to other model covariates. The modeling results suggested that the sales prices for apartment communities are devalued as accessibility deteriorated. Andersson et al (2010) did the research about the influence of high-speed rail accessibility on residential property prices using hedonic price functions. Song (2007) explored how spatial accessibility to retailing is valued by households in a single family housing market. They used Geographic Information Systems (GIS) to develop an Accessibility Index and then incorporated this Index into a hedonic price analysis evaluating the effects of enhanced access to retailing in a single family housing market in the City of Hillsboro, Oregon. Munoz-Raskin (2010) invested the relation of bus rapid transit and residential property values within walking distance to the system. The case study was Bogotá' s Transmilenio (Colombia). This research conducted a city-wide econometric hedonic analysis with 2000 to 2004 Department of Housing Control data across different walking distances, subsystems (trunk, feeder), socio-economic strata and time. The main results showed that, with respect to the value of properties in relation to proximity, the housing market placed value premiums on the properties in the immediate walking proximity of feeder lines. WANG ZB et al (2011) calculated spatial accessibility of all counties (city, urban district) in China with cost weighted distance method. Region divisions of county accessibility were conducted, and relation of traffic accessibility and population aggregation was discussed in that paper. They found that county accessibility in China had mainly low values and there was an obvious correlation between county accessibility and population density in China. With these analyses, inner mechanisms of population migration in different traffic conditions and region types were revealed, and can provide useful proposals to regional planning, traffic planning and smart distribution of people in China.

Yang *et al* (1995) put forward a new set of accessibility indexes including indexes of mobility, reach ability and smooth ability. The impacts of accessibility upon land use have already been studied by Mao *et al* (2005). Many researches about calculation of accessibility have been done. Chen *et at* (2007)summarize the different methods to calculate accessibility such as the topological method, distance method, cumulative Opportunity method, the contour method, gravity model, the balance coefficient method, time and space method, utility method from the point of network topology and compared them. Song *et at* (2000) have studied the algorithm of accessibility from both macro and micro aspects. Lu *et at* (2010) did some researches about the effects of traffic accessibility model according to Lu Huapu, WANG *et at* (2009): spatial separation model, cumulative opportunity model, spatial interaction model of the space, utility model, time and space constraint model. Some advantages and disadvantages also are analyzed by them. In this paper, a derivative model of the spatial interaction model is adopted to calculate accessibility. It is shown as follows.

$$A_i = \sum_j \frac{D_j}{t_{ij}^{\alpha}} \tag{1}$$

Where,

 $\alpha$ : an index parameter reflecting the impacts of distance impedance. Normally it is referred to 2,

 $D_j$ : the opportunities in zone j, and

*t*<sub>*ij*</sub> : travel time.

The model is well defined, the interpretability of which is good. But because travel time  $t_{ij}$  is in denominator, it is difficult to calculate the potential of its own.

However, most of the discussions in this aspect regard focus on the impacts of inner-city accessibility on housing price. There are few people keeping their eyes on the inter-city accessibility. In other words, researches about the impacts of inner-city accessibility and inter-city accessibility upon housing price are little. However, it is a common sense that urban housing price is not only affected by inter-city accessibility, but also by the area position of the city, which is inter-city accessibility. And it can be even more important than inter-city accessibility. For example, housing price in Beijing is much higher than it in Shenyang. What's more, nowadays as the condition of traffic congestion is more serious than before, people pay more attention on traffic accessibility. With the development of urban ciycle, inter-city accessibility has become a very important factor when people want to buy houses. Given the example of a worker living in Tianjin, but he is employed in Beijing. So the accessibility from Tianjin to Beijing dominates the major role when he wants to buy a house. So it is very necessary in this context to study the impacts of inner-city accessibility and inter-city accessibility upon housing price.

Based on the considerations of the above problems, the paper tries to analyze the impacts of traffic accessibility on city's housing prices by collecting housing data in Shenyang before and after the upgrading of Shenyang-Dalian highway. The model proposed in the paper is Hedonic price model. What we research is how big the impacts of housing price are when the accessibilities of inner-city and inter-city are improved. The aim is to supplement the researches about the relationship between city traffic and land price, hoping to play a guiding role in the practice for sustainable development of cities.

The analytical process is shown in Figure 1.

1. The road networks of inner-city and inter-city should be drawn after some attribute data are collected. Here only plain topography is considered. And we don't concern the effects of road type (asphalt, cement).

2. The calculation of traffic accessibility

a. inner-city accessibility

Firstly, the shortest distance between each pair of zones should be obtained by using TransCAD. Then the general cost between each pair of zones is calculated via log-sum model. Finally, the accessibilities of each zone can be computed.

b. inter-city accessibility

The shortest time between Shenyang and any other city in Liaoning province can be obtained via TransCAD software. Then the accessibility between cities can be calculated.

- 3. Construct the Hedonic semi-logarithmic model.
- 4. Analyze the results.



Figure 1. Flowchart of the Research

## 2.CALCULATION OF ACCESSIBILITY

## 2.1 Calculation of Inner-City Accessibility

Place accessibility is an index that can be used to judge the convenient level of transportation system in that location. It is usually decided by integrated traffic conditions and the distribution of main attraction points around the place. The method to calculate the accessibility of inner-city is referred to Zhang et al (2010). Analysis of thought is represented as follows.

1. Draw the inner-city road network of Shenyang. The network is shown in figure 2.

The speeds of different roads are adopted as follows: the speed of Shenhuan highway is

80 km/h (refer to "design specification of urban road engineering"); speed of main road in the city is 30-40 km/h. the speed of railway line in the city is 50 km/h; the speed of national road is 60km/h; the speed of provincial road is 50km/h. Because there was no rail transit in Shenyang in 2005, rail transit lines are not considered.

2. Obtain the shortest distance between each pair of zones on the basis of road network via TransCAD software. The shortest distance is shown in table 1.

3. Split the trip modes into 4 categories. Which are bicycle, car, taxi and public transportation (considering the oneness of public transportation in 2005, we just take bus into account.). And calculate the travel cost between each pair of zones of each trip mode. Where the travel cost is measured in time and any other cost is converted into time using the value of value of time (VOT).

- 4. The general cost of each zone is computed using log-sum model.
- 5. The inner-city accessibility of each zone is computed.

					1				,
	TX	YH	SB	SH	DL	SJT	HP	DD	HG
TX	0.00	26.31	85.12	49.81	82.40	67.63	94.28	52.79	42.70
YH	26.31	0.00	58.80	34.19	67.40	52.94	78.66	26.48	16.38
SB	85.12	58.80	0.00	53.17	93.44	78.98	77.28	51.99	42.42
SH	49.81	34.19	53.17	0.00	48.89	34.13	44.47	17.28	17.80
DL	82.40	67.40	93.44	48.89	0.00	57.72	93.37	56.50	51.02
SJT	67.63	52.94	78.98	34.13	57.72	0.00	78.60	42.05	36.56
HP	94.28	78.66	77.28	44.47	93.37	78.60	0.00	61.75	62.28
DD	52.79	26.48	51.99	17.28	56.50	42.05	61.75	0.00	10.10
HG	42.70	16.38	42.42	17.80	51.02	36.56	62.28	10.10	0.00
Total	501.04	361.16	541.20	299.74	550.74	448.61	590.69	318.94	279.26

Table 1. The shortest distance between each pair of zones in Shenyang (km)



Figure 2.zones and road network of Shenyang

## 2.1.1 Calculate the cost of each trip mode

The methods and results are shown as follows:

1. Bicycle

Bicycle: the cost is represented by the travel time between each pair of OD. The detailed formula is:

$$C_{o,d} = D_{o,d} / v \tag{2}$$

Where,

 $C_{o,d}$ : comprehensive impedance between each pair of OD,  $D_{o,d}$ : the shortest distance of each pair of OD, and

v: is the average speed of bicycle, which is taken as 12 km/h here.

	TX	YH	SB	SH	DL	SJT	HP	DD	HG	TX	
TX	0.00	2.19	7.09	4.15	6.87	5.64	7.86	4.40	3.56	41.75	
YH	2.19	0.00	4.90	2.85	5.62	4.41	6.56	2.21	1.37	30.10	
SB	7.09	4.90	0.00	4.43	7.79	6.58	6.44	4.33	3.54	45.10	
SH	4.15	2.85	4.43	0.00	4.07	2.84	3.71	1.44	1.48	24.98	
DL	6.87	5.62	7.79	4.07	0.00	4.81	7.78	4.71	4.25	45.90	
SJT	5.64	4.41	6.58	2.84	4.81	0.00	6.55	3.50	3.05	37.38	
HP	7.86	6.56	6.44	3.71	7.78	6.55	0.00	5.15	5.19	49.22	
DD	4.40	2.21	4.33	1.44	4.71	3.50	5.15	0.00	0.84	26.58	
HG	3.56	1.37	3.54	1.48	4.25	3.05	5.19	0.84	0.00	23.27	
Total	41.75	30.10	45.10	24.98	45.90	37.38	49.22	26.58	23.27	324.28	

Table 2.Travel time of bicycle (Hour)

## 2. Car

The total cost of car between each pair of OD is composed by three parts, including car's travel time, travel cost and parking time.

$$C_{o,d} = ivtt_{o,d} + parkt_d + VOC_T$$
(3)

Where,

 $C_{o,d}$ : comprehensive impedance between each pair of OD, *ivtt*<sub>o,d</sub>: car's travel time of each pair of OD, *parkt*<sub>d</sub>: parking time, and *VOC\_T*: the value of time.

Here the car refers to private car with displacement of 1.3~1.8 liters, the average speed of which is 40 km/h. Parking time is taken as 10 min. what we take into account about the driving cost between each pair of OD is just the cost of fuel consumption. We take 93 gasoline as an example. The fuel consumption is 8 liters per 100 km. if the cost of every liter is 8 RMB, then the cost per 100 km is 64 RMB. So the average cost per km is 0.64 RMB. Here the value of VOT is taken as 24.58 RMB/h referring to ZHANG (2008).

	Table 3. Total cost of car (Hour)									
	TX	YH	SB	SH	DL	SJT	HP	DD	HG	total
TX	0.00	1.51	4.51	2.71	4.38	3.62	4.98	2.86	2.35	26.93
YH	1.51	0.00	3.17	1.91	3.61	2.87	4.18	1.52	1.01	19.79
SB	4.51	3.17	0.00	2.88	4.94	4.20	4.11	2.82	2.34	28.98
SH	2.71	1.91	2.88	0.00	2.67	1.91	2.44	1.05	1.08	16.66
DL	4.38	3.61	4.94	2.67	0.00	3.12	4.94	3.05	2.77	29.47
SJT	3.62	2.87	4.20	1.91	3.12	0.00	4.18	2.32	2.04	24.26
HP	4.98	4.18	4.11	2.44	4.94	4.18	0.00	3.32	3.35	31.51
DD	2.86	1.52	2.82	1.05	3.05	2.32	3.32	0.00	0.69	17.64
HG	2.35	1.01	2.34	1.08	2.77	2.04	3.35	0.69	0.00	15.61
Total	26.93	19.79	28.98	16.66	29.47	24.26	31.51	17.64	15.61	210.85

Table 3. Total cost of car (Hour)

## 3.Taxi

The total cost of taxi is mainly compounded by taxi's driving time and taxi toll. The detailed formula is:

$$C_{o,d} = ivtt_{o,d} + (Toll + Dist \times Fare) / VOT$$
(4)

#### Where,

 $C_{o,d}$ : comprehensive impedance between each pair of OD,

*ivtt*<sub>o,d</sub>: taxi's travel time of each OD,

*toll* : passage money,

Dist : the driving distance,

Fare : the unit price of taxi, and

*VOT* : means the value of time.

## 1) Toll

Toll: it can be defined 0 because the range of taxi's service is within city.

## 2) Car fare

Fare is defined as follows: It costs 8 RMB within 3 km. if the distance is over 3 km, then add 1RMB every 0.6 km. And the total cost should include 1 RMB is added fuel surcharge. There is no consideration about charging when waiting. There is no air conditioner and the time is not evening.

	Table 4. Total cost of tax1 (Hour)										
_	TX	YH	SB	SH	DL	SJT	HP	DD	HG	total	
TX	0.00	2.60	8.06	4.79	7.81	6.44	8.91	5.06	4.13	47.80	
YH	2.60	0.00	5.62	3.34	6.42	5.08	7.46	2.62	1.68	34.82	
SB	8.06	5.62	0.00	5.10	8.83	7.49	7.33	4.99	4.10	51.53	
SH	4.79	3.34	5.10	0.00	4.70	3.33	4.29	1.77	1.81	29.12	
DL	7.81	6.42	8.83	4.70	0.00	5.52	8.83	5.41	4.90	52.41	
SJT	6.44	5.08	7.49	3.33	5.52	0.00	7.46	4.07	3.56	42.94	
HP	8.91	7.46	7.33	4.29	8.83	7.46	0.00	5.89	5.94	56.12	
DD	5.06	2.62	4.99	1.77	5.41	4.07	5.89	0.00	1.10	30.90	
HG	4.13	1.68	4.10	1.81	4.90	3.56	5.94	1.10	0.00	27.22	
Total	47.80	34.82	51.53	29.12	52.41	42.94	56.12	30.90	27.22	372.8	
10121 47.80	2	1 - 100	_,		,		2.000		6		

**T** 1 1 4 **T** 1 с. • *(*тт

4. Public transportation

Considering the oneness of public transportation in 2005, just bus is taken bus into account. The total cost include parameters of walking time before you take the bus, the waiting time, riding time, transfer times and unit price. It is the most complicated mode among the 4 modes. Detailed formula is as follows.

$$C_{o,d} = a_1 \times T_w + a_2 \times T_a + a_3 \times T_v + m \times T_t + [N \times C + (D - 20) \times F]/VOT$$
(5)

Where,

 $C_{o,d}$ : comprehensive impedance between each h pair of OD,

 $T_w$ : walking time before you take the bus,

 $T_a$ : the waiting time,

 $T_v$ : riding time,

 $T_t$ : the time of transfer penalty: it is 13 minutes in pure conventional public traffic network according to a SP survey in which the log it model was adopted conducted by Wang *et at*. a<sub>n</sub> is a weighted coefficient for parameters; m represents transfer times(where it is taken as 1.42),

C: the unit price of bus (where it is taken as 1 RMB),

N: aboard times (since the times of transfer is 1.42, times of aboard are 2.42),

D: riding distance(provision: the riding price is 1 RMB within 20 km, if the distance is over 20 km, the price will accumulate by 0.11 RMB per km which refers to the guidance of constructional ministry),

F: the fare of per km, and

*VOT* : value of time (where it is taken 24.58 RMB/h, which is the same as car users considering the difficulty to get the value of time for bus. Maybe it is a little higher. But it can be diminished by the weight which is used to calculate the generalized travel cost latter.).

The average speed of bus is 25 km/h. 1) $T_w$ 

It is assumed that the service radius of bus is 300 m. so  $T_w$  is 3.75 minutes if the speed

of walking is 4.8 km/h.

2) $T_{a}$ .

Waiting time  $T_a$ : 10.46 minutes (refer to statistic data).

3) $T_{t}$ .

The time of transfer penalty  $T_t$ : 13 minutes according to Wang H and Wu JR (2011).

4) The calculation of weighted coefficient for parameters

It is determined by the share of each parameters mentioned above, walking time before arriving at the station is 4 minutes, waiting time is 11 minutes, the value of  $T_t$  is taken as 30minutes according to the " code for transport planning on urban road". 5) Totalize

	Table 5.10tal cost of bus (fibul)										
	TX	YH	SB	SH	DL	SJT	HP	DD	HG	total	
ΤХ	0.00	1.18	3.02	1.92	2.93	2.47	3.30	2.01	1.69	18.52	
YH	1.18	0.00	2.20	1.43	2.46	2.01	2.81	1.19	0.89	14.18	
SB	3.02	2.20	0.00	2.02	3.27	2.82	2.77	1.98	1.69	19.77	
SH	1.92	1.43	2.02	0.00	1.89	1.43	1.75	0.92	0.93	12.27	
DL	2.93	2.46	3.27	1.89	0.00	2.16	3.27	2.12	1.95	20.07	
SJT	2.47	2.01	2.82	1.43	2.16	0.00	2.81	1.67	1.50	16.89	
HP	3.30	2.81	2.77	1.75	3.27	2.81	0.00	2.29	2.30	21.31	
DD	2.01	1.19	1.98	0.92	2.12	1.67	2.29	0.00	0.72	12.91	
HG	1.69	0.89	1.69	0.93	1.95	1.50	2.30	0.72	0.00	11.69	
total	18.52	14.18	19.77	12.27	20.07	16.89	21.31	12.91	11.69	147.61	

Table 5. Total cost of bus (Hour)

## 2.1.2 The generalized travel cost

## 1. The definition of the generalized travel cost

The definition of the generalized travel cost is the travel cost of the origin (O) and destination

(D) of the transport model, it synthesizes the travel time and travel cost of each means of transportation, so we named it the definition of the generalized travel cost (GC), We always unite the definition of the generalized travel cost into the travel time, and have transformed relevant the travel time into the travel cost through the value of the time (VOT).

2. The calculate of the generalized travel cost

Based on the results of the total travel cost of all kinds of trip modes above, a currently widely-used log sum method is adopted to calculate the generalized travel cost. The formula is presented as follows.

$$GC_{o,d} = \frac{1}{\alpha} \times \ln(\exp(\alpha \times C_{o,d}^{1}) + \exp(\alpha \times C_{o,d}^{2}) + \dots + \exp(\alpha \times C_{o,d}^{n}))$$
(6)

Where,

 $GC_{o,d}$ : the generalized travel cost between each pair of OD,

 $C_{o,d}^{n}$ : the total travel cost of different kind of trip mode, and

 $\alpha$ : the weighting parameters.

Based on the formula (6) .The generalized travel cost matrix in Shenyang City is calculated.

	TX	YH	SB	SH	DL	SJT	HP	DD	HG		
TX	0.00	196.80	70.27	111.27	72.15	85.14	64.79	105.68	127.66		
YH	196.80	0.00	96.12	155.80	85.39	105.42	74.96	195.68	295.87		
SB	70.27	96.12	0.00	105.01	65.24	74.71	76.07	107.12	128.41		
SH	111.27	155.80	105.01	0.00	113.13	156.04	123.11	283.04	276.13		
DL	72.15	85.39	65.24	113.13	0.00	97.69	65.28	99.54	108.92		
SJT	85.14	105.42	74.71	156.04	97.69	0.00	75.01	129.43	146.71		
HP	64.79	74.96	76.07	123.11	65.28	75.01	0.00	92.10	91.42		
DD	105.68	195.68	107.12	283.04	99.54	129.43	92.10	0.00	433.63		
HG	127.66	295.87	128.41	276.13	108.92	146.71	91.42	433.63	0.00		

Table 6.General travel cost of OD pairs

#### 2.1.3 The model and results of inner-city accessibility

The research of this paper is based on the housing price, which is affected by the traffic conditions around the place and the job opportunities of the neighboring regions. The

accessibility of origin point O is proportional to the job opportunities in the destination point D of the neighboring regions, but inversely proportional to the generalized travel cost from O to D. So the formula of the inner-city accessibility is:

$$Acc_{o} = \sum_{d \in D} \ln(\frac{Emp_{d}}{GC_{o,d}})$$
(7)

Where,

 $Acc_{o}$ : the accessibility of origin point O,

 $GC_{o,d}$ : the generalized travel cost between each pair of OD, and

 $Emp_d$ : jobs in destination point D.

Here the accessibility of each origin point O refers to the total accessibility to all the destination points. The results are shown is table 7 and 8.

) D	TX	YH	SB	SH	DL	SJT	HP	DD	HG	SUM
TX	$\infty$	4.57	6.05	5.13	5.55	5.87	5.77	5.57	5.24	43.75
YH	6.06	00	5.74	4.80	5.38	5.65	5.62	4.95	4.40	42.60
SB	7.09	5.29	x	5.19	5.65	6.00	5.61	5.55	5.23	45.61
SH	6.63	4.80	5.65	$\infty$	5.10	5.26	5.13	4.58	4.47	41.62
DL	7.06	5.41	6.12	5.12	$\infty$	5.73	5.76	5.63	5.40	46.22
SJT	6.89	5.20	5.99	4.80	5.25	$\infty$	5.62	5.37	5.10	44.21
HP	7.17	5.54	5.97	5.03	5.65	5.99	$\infty$	5.71	5.57	46.63
DD	6.68	4.58	5.63	4.20	5.23	5.45	5.42	$\infty$	4.02	41.19
HG	6.49	4.16	5.45	4.23	5.14	5.32	5.42	4.16	$\infty$	40.37

Table 7. The value of inner-city accessibility in 2001

Table 6.111e value of finier-city accessionity in 2005										
0 D	TX	YH	SB	SH	DL	SJT	HP	DD	HG	SUM
TX	$\infty$	4. 61	6. 59	5.29	7.35	5.74	6.09	5.72	5.37	46.76
YH	5.70	$\infty$	6.28	4.95	7.18	5.53	5.94	5.11	4.53	45.21
SB	6.73	5.33	$\infty$	5.34	7.45	5.87	5.93	5.71	5.36	47.72
SH	6.27	4.84	6. 19	$\infty$	6.90	5.13	5.45	4.74	4.60	44.12
DL	6.70	5.44	6.67	5.27	0.00	5.60	6.08	5.78	5.53	47.08
SJT	6.54	5.23	6.53	4.95	7.04	$\infty$	5.94	5.52	5.23	46.99
HP	6.81	5.57	6.51	5.19	7.45	5.87	$\infty$	5.86	5.70	48.96
DD	6.32	4. 61	6.17	4.35	7.03	5.32	5.74	$\infty$	4.15	43.69
HG	6.13	4.20	5.99	4.38	6.94	5.20	5.75	4.31	$\infty$	42.89

Table 8. The value of inner-city accessibility in 2005

#### 2.2 The Calculation of Inter-city Accessibility

The intercity accessibility In the paper is expressed by the shortest time spent between Shenyang to Benxi, Dandong, Jinzhou, Fuxin, Yingkou, Tieling, Anshan, Dalian, Chaoyang, and Huludao.

#### 2.2.1 The model of inter-city accessibility

In this paper method of the beneficial mean travel time (Ma (2008) *et al*) is adopted to calculate the inter-city accessibility of Shenyang. The beneficial mean travel time means the cost or time of a location to other economic centers. The lower the score we get is, the higher the region's accessibility is. And it is more closely linked with the economic centers; and vice versa. The specific formula is:

$$A_{i} = \frac{\sum_{j=1}^{n} (T_{ij} * M_{j})}{\sum_{j=1}^{n} M_{j}}$$
(8)

Where,

 $A_i$ : the accessibility of region node i,

 $T_{ij}$ : the shortest time it takes from node *i* to reach other economic centers through a known transportation network,

 $M_i$ : a certain socio-economic flow of an economic center in the evaluation system,

which can be expressed by GDP (Gross Domestic Product) ,the total population or the total sales of the social commodity and so on. GDP of a city is used in this paper, and

n: the total number of the nodes within the scope of the evaluation system in addition to the node i.

The changes of regional accessibility can be obtained by calculating the differences of travel time before and after the renovation of traffic facilities.

The shortest travel time form Shenyang to any other cities in Liaoning province as is shown as follows (Table 9):

Table 9. The shortest travel time form Shenyang to other cities in Liaoning province in (Hour)

Shortest T	TX	YH	SB	SH	DL	SJT	HP	DD	HG	TX	Total
Shenyang	0.93	2.40	2.29	1.04	5.97	0.52	1.33	3.14	4.44	2.80	24.85

## 2.2.2 The calculation of inter-city accessibility

The inter-city accessibilities of Shenyang in the year of 2001 and 2005 are calculated respectively by formula (8).

The results are shown as follows: 2001: 2.563251 2005: 2.562659

The housing price of each county corresponding to the inter-city accessibility and the inner-city accessibility are summarized as follows (Table 10):

Table	Table 10 The summary of housing price and accessionity in 2001							
ID of traffic district	Average price of city residence	The inner-city accessibility	The intercity accessibility	The conversion of intercity accessibility				
SH01	3057.3	41.62	2.563251	3.901296				
HG01	2762.62	40.37	2.563251	3.901296				
DD01	3020.47	41.19	2.563251	3.901296				
TX01	2836.29	43.75	2.563251	3.901296				
DL01	2615.28	46.22	2.563251	3.901296				
YH01	2504.78	42.60	2.563251	3.901296				
<b>SB</b> 01	1878.58	45.61	2.563251	3.901296				
SJT01	2246.93	44.21	2.563251	3.901296				
SH05	3822.89	44.12	2. 562659	3. 902197				
HG05	3454.42	42.89	2. 562659	3.902197				
DD05	3776.83	43.69	2. 562659	3.902197				
TX05	3546.54	46.76	2. 562659	3. 902197				
DL05	3270.18	47.08	2. 562659	3. 902197				
YH05	3132.01	45.21	2. 562659	3.902197				
SB05	2349.01	47.72	2. 562659	3.902197				
SJT05	2809.6	46.99	2. 562659	3. 902197				

Table 10 The summary of housing price and accessibility in 2001

NOTE:

- 1) The value of inter-city accessibility for a year is just a value correlating with a certain socio-economic flow in that year.
- 2) In the relationship model between the inter-city accessibility and the housing price, the bigger the value of accessibility is, the worse the traffic condition is. However, since the generalized cost is in denominator in inner-city accessibility model, the bigger the value of accessibility is, the better the traffic condition is. In order to make both of them keep consistent with each other in the changing tendency. The data of the intercity accessibility must be processed. So we make some adjustments about the inter-city accessibility.

## **3 .HEDONIC SEMI-LOGARITHMIC NONLINEAR FITTING**

Hedonic model is a model widely used abroad to handle the relationship between the heterogeneous commodity and the commodity prices. The basic thinking clue of Hedonic model is that how much the consumers are willing to pay for a commodity price depends on the enjoyment of the extent to which he can get from the various attributes of the commodity. Hedonic pricing principle is that the price paid by residential buyers should compensate for

the comfort level enjoyed from its various features under the equilibrium conditions in the competitive market.

Assume that the income levels and the preferences of all families are similar with each other, then the market price of all residential houses should be a function of these characteristics, which is:

$$P = h(X_1, X_2, \dots, X_n)$$
(9)

Where,

*P* : commodity price, and  $X_1, X_2, X_3...X_n$ : different characteristics of the commodity.

The Hedonic pricing model is expressed as formula (9).

General Hedonic models can be divided into three main types: linear, logarithmic and semi-logarithmic hedonic model. It has been said by He (2004) that the explaining ability of the semi-logarithmic model is slightly stronger than the linear form in the real estate area.

The conclusion got by Zhang *et al* (2010) in the research of the impacts of accessibility in Beijing upon housing price is: the semi-logarithmic hedonic model is the best among the different kinds of hedonic models. Therefore, in this paper the semi-logarithmic Hedonic model is adopted when doing curve fitting.

The form of the model is expressed as follows:

$$\ln HP = a + b * Acc_{in} + c * Acc_{out}$$
<sup>(10)</sup>

Where,

*HP*: housing price,  $Acc_{in}$ : inner-city accessibility,  $Acc_{out}$ : inter-city accessibility, a: a constant, and b, c: the coefficient of accessibility variables in the formula (10).

In this paper, the curve fitting was conducted by Stata software. Because the data in Heping district is abnormal, it is eliminated when the curve is fitted.

The regression results are summarized as follows:

$$\ln HP = -1526.82 - 0.056 * Acc_{in} + 393.993 * Acc_{out}$$
(11)

R squared=0.6400, Adj R-squared = 0.5847

The statistical significance of the individual variables of the models are as follows.

Table 11 The statistical significance of the individual variables of the induces									
ln HP	Coef.	t	P> t						
Acc in	0556936	-3.25	0.006						
Acc out	393.9932	4.74	0.000						
Cons	-1526.82	-4.71	0.000						

Table 11 The statistical significance of the individual variables of the models

## **4.CONCLUSIONS**

The paper examined the impacts of traffic accessibility on house price by calculating the zone's traffic accessibility using spatial interaction model based on the distance and travel time between zones. The major findings of the paper are tentatively summarized as follows.

1) The inter-city accessibility has a bigger influence on the housing price than the inner city accessibility.

2) The inner-city accessibility may have a negative impact on housing price, but the influence is little. There are two main reasons about that: Firstly, while the accessibility increased quickly as the infrastructure was built extensively in Shenyang at the beginning of 2000, the housing price increased slowly as the real estate market was relatively stable. This objective fact may cause the coefficient of the inner city accessibility variable negative. Secondly, since the improved space of accessibility in the city center is relatively limited contrasting to the outside regions, the housing price of the city center is always the highest, which also can cause the coefficient of inner-city accessibility variable is negative.

3) The improvements of the inter-city accessibility will contribute to the rising of the housing price. Obviously, the regional status of a city determines the level of the housing price in a city, which matches the common sense.

It is a very challenging task to study the urban traffic influence on the structure of the housing pricing. Though some meaningful conclusions are draw in this paper, there are still a lot of research work need to be carried on because of the limited materials, data and time. The following work is summarized as follows:

1) The estimate of the accessibility: there are only four kinds of trip modes considered in this paper. Besides traffic jam and traffic restrictions et al are not considered in the estimate of distance in this paper.

2) The selection of the characteristic variables: only variables of inter-city accessibility and inner-city accessibility are selected when curve is fitted since the limitation of time and energy in this paper. However, the housing price is affected by many factors. If we want to get a more satisfied result in this paper, we should introduce several variables and reject the useless ones one by one.

3) The partition of the traffic zones: Only 9 administrative regions of Shenyang are

taken into account in this case study. And because the time span of the case is also not longer enough, the reliability and general suitability of the research conclusions still need to be proved.

#### REFERENCES

- Andersson, D.E., Shyr, O.F., Fu, J. (2010) Does high-speed rail accessibility influence residential property prices? Hedonic estimates from southern Taiwan. *Journal of Transport Geography*, 18(1), 166-174.
- Chen, J., Lu, F., Cheng, C.X. (2007) Advance in accessibility evaluation approaches and applications. *Progress in Geography*, 26(5), 11.
- Hansen, W.G. (1959) How accessibility shapes land-use. *Journal of the American Institute of Planners*, 25, 73–76.
- He, H. (2004) *Research on the effects of metro line 13 in Beijing on house prices under hedonic model*. Beijing: Tsinghua University.
- Jim énez, J., Perdiguero, J. (2011) Does accessibility affect retail prices and competition? An empirical application. *Networks and Spatial Economics*, 11, 677–699.
- Kwan, M.P., Murray, A.T. (2003) Recent advances in accessibility research: Representation, methodology and applications. *Geographical Systems*, (5), 129–138.
- Levinson, D.M. (1998) Accessibility and the journey to work. *Journal of Transport Geography*, 6(1), 11-21.
- Lu, Q., Lin, T. (2010) Research on the housing price of Shanghai metro suburbs based on the highway accessibility. *Journal of Shanghai Normal University (Natural Sciences)*, 39(4), 6.
- Lu, H.P., W, J.F., Zhang, Y.B. (2009) Models and application of transport accessibility in urban transport planning. *Journal of Tsinghua University (Science and Technology)*, 49(6), 5.
- Ma, A.K., Cao, R.L., Zhang, P.G. (2008) Impacts of the expansion of the railway network on regional accessibility——A case study of the urban agglomeration along with the Jiaoji railway. *Journal of Shandong Normal University (Natural Science)*, (2), 5.
- Mao, J.X., Yan, X.P. (2005) A study to the impacts on urban land use of transport system in highly-densely developed city ——A case study of Guangzhou. *Economic Geography*, 25(2), 4.
- Morris, J.M., Dumble, P.L., Wigan, M.R. (1978) Accessibility indicators for transport planning. *Transportation Research A*, 13, 91-109.
- Munoz-Raskin, R. (2010) Walking accessibility to bus rapid transit: Does it affect property values? The case of Bogotá, Colombia. *Transport Policy*, 17(2), 72-84.
- Shin, K., Washington, S., Choi, K. (2007) Effects of transportation accessibility on residential property values-Application of spatial hedonic price model in Seoul, South Korea, Metropolitan Area. *Transportation Research Record*, 66–73.

- Song, X.D., Niu, X.Y. (2000) The computer-aided evaluation on accessibility. *Urban Planning Review*, (3), 6.
- Song, Y., Sohn, J. (2007) Valuing spatial accessibility to retailing: A case study of the single family housing market in Hillsboro, Oregon. *Journal of Retailing and Consumer Services*, 14(4), 279-288.
- Wang, Z.B., Xu, J.G., Fang, C.L, et al. (2011) The study on county accessibility in china: Characteristics and effects on population agglomeration. Journal of Geographical Sciences, 21(1), 18-34.
- Wang, H., Wu, J.R. (2011) Study on the transfer's penalty of the multi-mode mass transit system. *Transformation and reconstruction 2011 conference proceedings of urban planning in China*.
- Yang, T., Guo, X.C, (1995) New concept of urban travel accessibility and its application. *China Journal Of Highway And Transport*, 8(2), 7.
- Zhang, Y., Zhang, Y.J., Zhang, X.D. (2010) The impacts of zone accessibility on housing price in Beijing. *Planning and Innovation*: 2010 conference proceedings of urban planning in China. Chongqing, China.
- Zhang, Y.X. (2008) *Value of drivers' commuting travel time*. Dalian: Dalian University of Technology.

## Note:

Zone names are represented as follows.

- 1. TX: Tiexi District
- 2. YH: Yuhong District
- 3. SB: Shenbeixin District
- 4. SH: Shenhe District
- 5. DL: Dongling District
- 6. SJT: Sujiatun District
- 7. HP: Heping District
- 8. DD: Dadong District
- 9. HG: Huanggu District
- 10. QPS: Qipanshan District
- 11. HN: Hunnan District