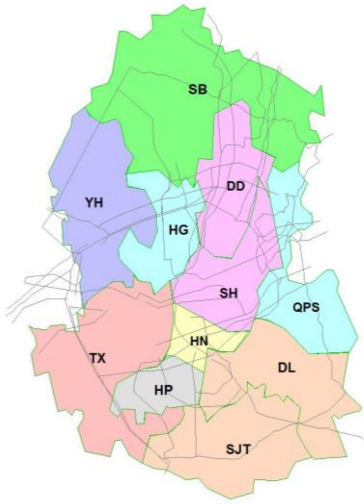

Figure 2.zones and road network of Shenyang

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.

Table 2.Travel time of bicycle (Hour)

	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

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.

$$C_{o,d} = ivtt_{o,d} + parkt_d + VOC\_T \tag{3}$$

Where,

$C_{o,d}$: comprehensive impedance between each pair of OD,
$ivtt_{o,d}$: car's travel time of each pair of OD,
$parkt_d$: 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

3.Taxi

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

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

Where,

$C_{o,d}$: comprehensive impedance between each pair of OD,
$ivtt_{o,d}$: 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 taxi (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	372.86

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.

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

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_n 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.Total cost of bus (Hour)

	TX	YH	SB	SH	DL	SJT	HP	DD	HG	total
TX	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

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.

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

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

α : the weighting parameters.

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

Table 6.General travel cost of OD pairs

	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

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:

$$Acc_o = \sum_{d \in D} \ln\left(\frac{Emp_d}{GC_{o,d}}\right) \tag{7}$$

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.

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

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

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

O \ D	TX	YH	SB	SH	DL	SJT	HP	DD	HG	SUM
TX	∞	4. 61	6. 59	5. 29	7. 35	5. 74	6. 09	5. 72	5. 37	46. 76
YH	5. 70	∞	6. 28	4. 95	7. 18	5. 53	5. 94	5. 11	4. 53	45. 21
SB	6. 73	5. 33	∞	5. 34	7. 45	5. 87	5. 93	5. 71	5. 36	47. 72
SH	6. 27	4. 84	6. 19	∞	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	∞	5. 94	5. 52	5. 23	46. 99
HP	6. 81	5. 57	6. 51	5. 19	7. 45	5. 87	∞	5. 86	5. 70	48. 96
DD	6. 32	4. 61	6. 17	4. 35	7. 03	5. 32	5. 74	∞	4. 15	43. 69
HG	6. 13	4. 20	5. 99	4. 38	6. 94	5. 20	5. 75	4. 31	∞	42. 89

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:

$$A_i = \frac{\sum_{j=1}^{n}(T_{ij} * M_j)}{\sum_{j=1}^{n} M_j} \tag{8}$$

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_j: 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 10 The summary of housing price and accessibility 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
SB01	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

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:

$$P = h(X_1, X_2, \ldots, X_n) \tag{9}$$

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:

$$\ln HP = a + b * Acc_{in} + c * Acc_{out} \tag{10}$$

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:

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

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 models

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

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.

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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