Distance Dependent Approach for the Determination of Standard Land Values by Multiple Regression

Dr. Andreas Hendricks

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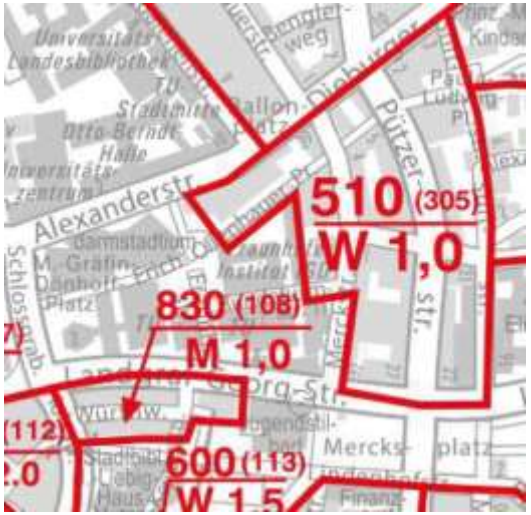
1. Introduction

Committees of valuation experts

- in every bigger town or district
- Important basis for their work: purchasing price data (a copy of every contract of transactions on the real estate market has to be sent to the committee)
- Second step: analysis of these contracts and the derivation of standard land values and further valuation data
- The results have to be published at least every 2 years

1. Introduction

- Standard land values are average land values of defined zones.
- The demarcation of these zones is based on the principle that all plots inside of a zone should have similar characteristics (especially type and degree of building and land use).
- The standard land value is determined by sales comparison approach, if enough comparable plots are available.
- Especially in rural areas is oftentimes a lack of available information. For this reason, it has to be investigated, if there are alternative approaches to obtain an objectification.



2. Research
2.1 Research approach: Multivariate polynomial depending on distance

- $BW = a_1*E_{\Delta ZÖPNV} + a_2*E_{\Delta Z} + a_3*E_{GS} + a_4*E_{GYM} + a_5*E_{LM} + a_6*E_{SM} + a_0$
- a_1 to a_6: influencing factors that have to be estimated
- BW: standard land value of the urban district in investigation
- $E_{\Delta ZÖPNV}$: difference of distance between the urban district and the minimum distance to the city centre (travel time by public transport)
- $E_{\Delta Z}$: difference of distance between the urban district and the minimum distance to the city centre (travel time by car)
- E_{GS}: distance to the next primary school (travel time by car)
- E_{GYM}: distance to the next secondary school (travel time by car)
- E_{LM}: distance to the next grocery (travel time by car)
- E_{SM}: distance to the next supermarket (travel time by car)
- a_0: impact of all other factors (Residuum)

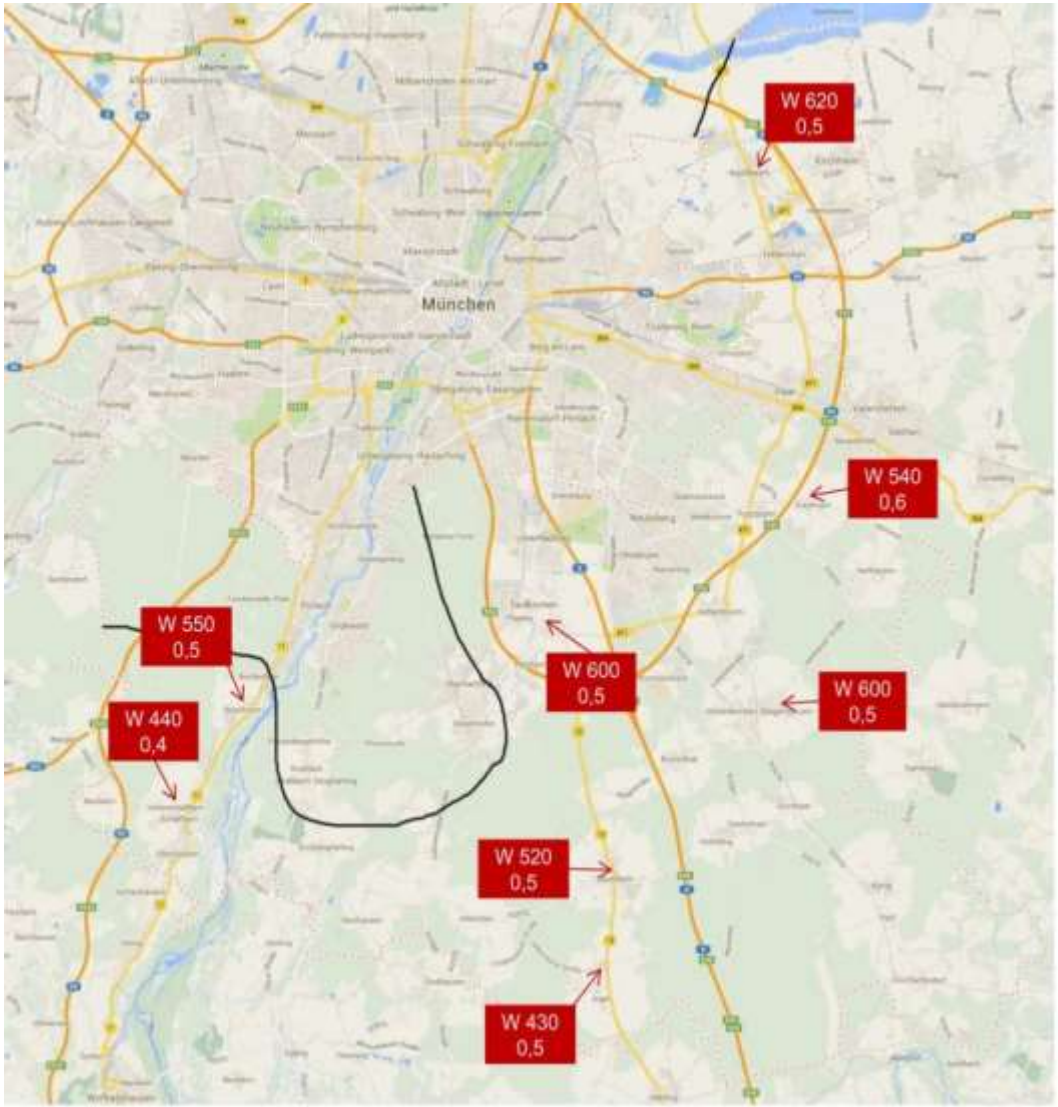
Algorithm

- $BW = a_1 * E_{\Delta ZÖPNV} + a_2 * E_{\Delta Z} + a_3 * E_{GS} + a_4 * E_{GYM} + a_5 * E_{LM} + a_6 * E_{SM} + a_0$
- a_0 may be eliminated by means of averaging → m = 6 unknown regression coefficients
- 21 reference values have been available for the determination of the regression coefficients (reference class 1, at least 5 comparison prices) → n = 21 equations
- The design matrix $\boldsymbol{A}_{n,m}$ may be constructed by means of m distances of n urban districts. The unknown coefficients a_i, form the vector $\boldsymbol{x}_{m,1}$ and the reference standard land values form the vector $\boldsymbol{l}_{n,1}$. The vector of residuals $\boldsymbol{v}_{n,1}$ is calculated by $\boldsymbol{v} = \boldsymbol{Ax} - \boldsymbol{l}$.
- Solution (observations have the same weight):
  - Normal equation: $\boldsymbol{A^T Ax - A^T l = 0}$
  - With $\boldsymbol{A^T A = N}$ and $\boldsymbol{A^T l = n}$ follows: $\boldsymbol{x = N^{-1}\, n}$
- Accuracy measures:
  - Variance: $s_0^2 = \boldsymbol{v^T v}$ / (n-m-1) ; Multiple coefficient of determination: $B = \boldsymbol{x^T n / l^T l}$
  - $\boldsymbol{R'_N}$ Matrix of partial correlation coefficients between the influencing factors
  - $\boldsymbol{R'_M}$ Matrix of partial correlation coefficients between target quantities and influencing factors

2.2 Demarcation of the investigation area

- In the first step has to be checked, if an administrative district or a part of it is suitable for the application of this approach. Therefor has to be considered the **map of standard land values**.
- There must be a **nearly radial structure** of decreasing standard land values for increasing distances of the city centre. There may be certain differences due to the usage of travel time as parameter, but generally this structure should exist.

2.2 Demarcation of the investigation area



Landkreis München (Quelle: www.google.de/maps)

Bereich II:
Homogener Bereich im Südosten

------ = Grenze Landkreis

——— = Abgrenzung Bereich

W 850 0,5 = Beispiel Bodenrichtwert mit Angabe von Art der Nutzung (hier W=Wohnen), Bodenrichtwert (hier 850.- €/m²) und Maß der baulichen Nutzung (hier GFZ 0,5)

The tendency of decreasing standard land values for increasing distances appears clearly in the south-eastern part of the administrative district of Munich

2.3 Problems of data acquisition

- 46 zones of standard land values in the investigation area
- Travel time by car:
  - Determination by means of route planners (e.g. Falk or Google Maps)

2.3 Problems of data acquisition

- Travel time by public transport (problems):
  - Determination by means of the online schedule of the Munich public transport services. Alternative tool: the internet presence of German Railways.
  - Main problems: Adequate registration of different connection qualities (e.g. in comparison of working days and weekend or within and outside of rush-hours) and the modelling of non-existent access to the public transport system in particular urban districts.

2.3 Problems of data acquisition

- Travel time by public transport (solutions):
  - Travel times have been determined on Monday between 7 a.m. and 8 a.m. and between 12 a.m. and 1 p.m. and on Saturday between 2 p.m. and 3 p.m.
  - An alternative calculation from the next connected urban district was realized, if there was no connection available in the mentioned periods. In this case 60 minutes have been added to the travel time to model the non-existing connection.

2.4 Calculation and results

	Regression coefficients [€/(m²×min)]	Residuals [€/m²]	Standard land value (before) [€/m²]	Standard land value (after) [€/m²]	Urban district
a_1	-3,588	-22	620	598	Aschheim
a_2	-6,558	69	630	699	Dornach
a_3	13,952	38	510	548	Aying
a_4	-1,978	-47	550	503	Baierbrunn
a_5	-13,450	-28	549	520	Buchenhain
a_6	-2,769	11	627	638	Feldkirchen
		-4	556	553	Neukeferloh
		6	500	506	Harthausen
		1	628	629	Haar
		-39	620	581	Höhenkirchen
		-1	592	592	Luitpoldsiedlung
		58	540	598	Kirchheim
		27	590	617	Heimstetten
		-49	720	671	Oberhaching
		-3	620	617	Furth
		15	472	486	Oberbiberg
		-76	735	659	Ottobrunn (östl. Ros.)
		-2	570	568	Putzbrunn
		27	520	547	Sauerlach
		19	483	502	Ebenhausen/Zell
		1	683	685	Unterhaching

$v^T v$ [(€/m²)²]	$x^T n$ [(€/m²)²]	B [-]	s_0^2 [(€/m²)²]
24916,9168	80890,6666	0,7645	1779,7798

Complete determination of the polynomial :

- Problem: positive algebraic sign of a_3 (coefficient of the distance to the primary school)
- This result is heavily interpretable. An increasing distance to the city centre, to schools or to shops should have a negative impact on the land value.
- Conclusion: tensions within the model

2.4 Calculation and results

Regression coefficients [€/(m²×min)]	Residuals [€/m²]	Standard land value (before) [€/m²]	Standard land value (after) [€/m²]	Urban district
-1,878	6	620	626	Aschheim
-8,711	29	630	659	Dornach
	-4	510	506	Aying
	5	550	555	Baierbrunn
	-11	549	538	Buchenhain
	32	627	660	Feldkirchen
	35	556	592	Neukeferloh
	-28	500	472	Harthausen
	-13	628	615	Haar
	-40	620	580	Höhenkirchen
	3	592	595	Luitpoldsiedlung
	73	540	613	Kirchheim
	24	590	614	Heimstetten
	-126	720	594	Oberhaching
	16	620	636	Furth
	24	472	495	Oberbiberg
	-108	735	628	Ottobrunn (östl. Ros.)
	27	570	597	Putzbrunn
	55	520	575	Sauerlach
	32	483	514	Ebenhausen/Zell
	-31	683	652	Unterhaching

$v^T v$ [(€/m²)²]	$x^T n$ [(€/m²)²]	B [-]	s_0^2 [(€/m²)²]
45991,3062	59816,2772	0,5653	2555,0726

The bottom-up method starts by means of the distance to the city centre :

- First calculations including the influencing parameters $E_{\Delta ZÖPNV}$ and $E_{\Delta Z}$ resulted in big residuals for Oberhaching and Ottobrunn (v > 100 €).
- The situation has been checked using the map of standard land values.
- Both values have been well-founded eliminated of the calculation.

2.4 Calculation and results

Regressions-koeffizienten [€/(m²×min)]	Verbesse-rungen [€/m²]	BRW GFZ 0,5 (vorher) [€/m²]	BRW GFZ 0,5 (nachher) [€/m²]	Ortsteil
-1,711278	-11,65	620,00	608,35	Aschheim
-8,563751	10,03	630,00	640,03	Dornach
	-8,67	510,00	501,33	Aying
	-1,59	550,00	548,41	Baierbrunn
	-16,46	548,60	532,14	Buchenhain
	16,24	627,21	643,45	Feldkirchen
	18,18	556,48	574,67	Neukeferloh
	-11,79	500,00	488,21	Harthausen
	-31,08	628,29	597,21	Haar
	-53,61	620,00	566,39	Höhenkirchen
	-10,68	592,49	581,81	Luitpoldsiedlung
	56,36	540,00	596,36	Kirchheim
	8,92	590,00	598,92	Heimstetten
	-1,37	620,00	618,63	Furth
	-0,39	471,79	471,40	Oberbiberg
	13,52	570,00	583,52	Putzbrunn
	48,10	520,00	568,10	Sauerlach
	26,26	482,77	509,02	Ebenhausen/Zell
	-50,32	683,49	633,17	Unterhaching

$v^T v$ [(€/m²)²]	$x^T n$ [(€/m²)²]	B [-]	s_0^2 [(€/m²)²]
14248,64996	47451,4022	0,76906584	890,540622

Calculation without Oberhaching and Ottobrunn:

- 4 residuals > 32.- €/m²
- even prices of identical plots may differ up to +/- 10%
- s_0 of around 30 €/m²
- limits of the confidence interval are between 65 and 86 €/m² based on a significance level of 5%
- bigger residuals are consequence of different levels of infrastructure pursuant to the expertise of the committee of valuation experts

2.4 Calculation and results

Question: Improvement by additional parameters?

- The result of this investigation was negative.
- The inclusion of additional parameters did not result in numerical improvements or the results were not interpretable in a reasonable way.

→ The influence of further infrastructure cannot be detected by the chosen polynomial approach. It must be taken into account by professional judgement of the committee of valuation experts.

→ On the other hand, the reduction of effort of data acquisition is an advantage as well as the increasing number of reference values per regression coefficient.

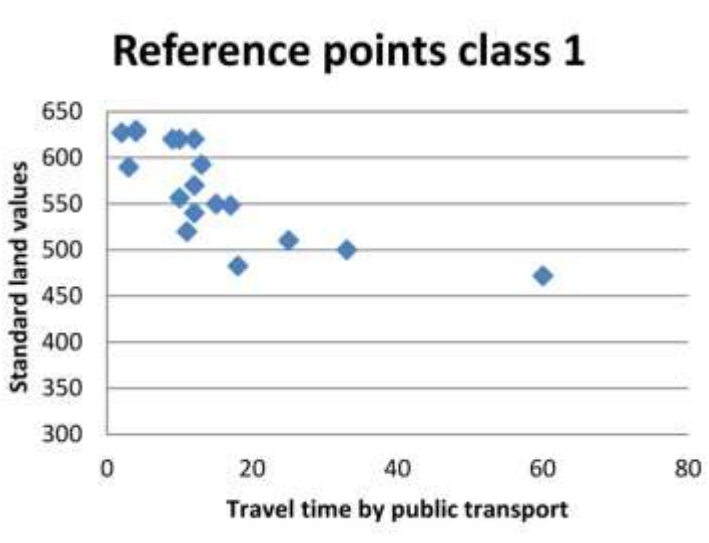
2.4 Calculation and results

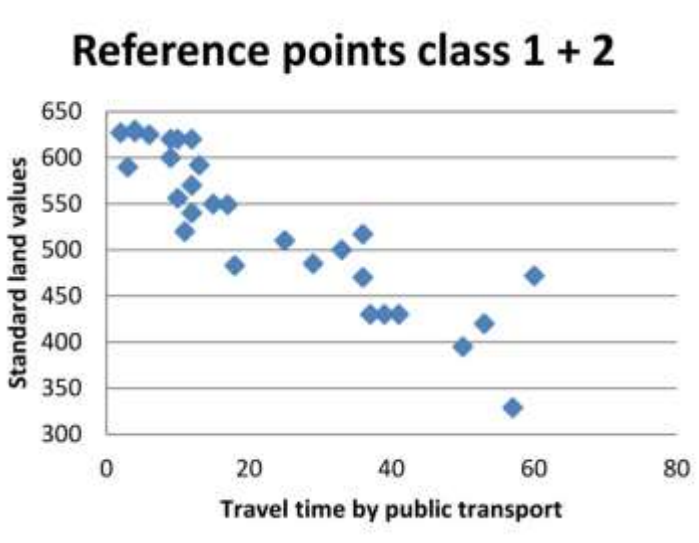
Standard land value (before) [€/m²]	Standard land value (after) [€/m²]	Difference [€/m²]	Urban district	Reference class
420	480	**60**	Gudrunsiedlung	2
470	524	**54**	Otterloh	2
395	523	**128**	Waldbrunn	2
485	516	**32**	Grasbrunn	2
600	603	**3**	Ottendichl	2
625	593	**-32**	Hohenbrunn	2
430	470	**40**	Arget	2
430	469	**39**	Lochofen	2
430	473	**43**	Grafing	2
329	482	**152**	Neufahrn	2
517	443	**-73**	Hailafing	2
395	467	**72**	Großhelfendorf	3
395	512	**117**	Neukirchstockach	3
400	557	**157**	Wächterhofsiedlung	3
446	451	**5**	Grasbrunner Weg	3
470	461	**-9**	Waldsiedlung	3
556	564	**7**	Waldkolonie	3
483	445	**-38**	Großdingharting	3
411	428	**17**	Kleindingharting	3
387	456	**69**	Ebertshausen	3
387	453	**66**	Holzhausen	3
387	421	**34**	Beigarten	3
600	611	**11**	Taufkirchen	3
	Sum:	**953**		

Transformation of the points in reference class 2 and 3:

- Quantity of low standard land values in reference class 2 and 3 is much bigger than in class 1
- Most of the differences are positive (mean value is +41 €/m²)
- Estimations of the committee of valuation experts too pessimistic?
- Does class 1 not reflect adequately the market segment of low standard land values?

2.4 Calculation and results





Validity of the function:

- The validity of the function (class 1) ends obviously after a travel time of about 30 minutes.
- The travel time in class 2 and 3 is oftentimes between 30 and 60 minutes. Due to these extrapolations the function is deemed to be unsuitable.
- In the next step has to be checked, if the results can be improved, if the points of reference class 2 are included in the determination of the regression coefficients.

Regression coefficients [€/(m²×min)]		Residuals [€/m²]	Standard land value (before) [€/m²]	Standard land value (after) [€/m²]	Urban district
a_0	633	-32	620	588	Aschheim
a_1	-3,990	-13	630	617	Dornach
a_2	-2,084	-2	510	508	Aying
		5	550	555	Baierbrunn
		-4	549	544	Buchenhain
		-2	627	625	Feldkirchen
		24	556	581	Neukeferloh
		-22	500	478	Harthausen
		-22	628	606	Haar
		-50	620	570	Höhenkirchen
		-22	592	571	Luitpoldsiedlung
		38	540	578	Kirchheim
		20	590	610	Heimstetten
		-26	620	594	Furth
		-96	472	376	Oberbiberg
		5	570	575	Putzbrunn
		54	520	574	Sauerlach
		52	483	535	Ebenhausen/Zell
		-13	420	407	Gudrunsiedlung
		9	470	479	Otterloh
		33	395	428	Waldbrunn
		17	485	502	Grasbrunn
		-5	600	595	Ottendichl
		-22	625	604	Hohenbrunn
		25	430	455	Arget
		30	430	460	Lochofen
		16	430	446	Grafing
		65	329	394	Neufahrn
		-61	517	456	Hailafing

$v^T v$ [(€/m²)²]	$x^T n$ [(€/m²)²]	B [-]	s_0^2 [(€/m²)²]
35082,5325	8237314,25	0,9958	1403,3013

Results in consideration of class 1 and 2:

- An evident improvement is the elimination of very big differences. This effect is realized by a higher weighting of the travel time by public transport.
- Important: Analysis by scatter diagrams to determine the validity interval of the polynomial.
- Problem: a_2 is statistically not significant

→Even the travel time by public transport seems to provide such a good explication of the standard land values that cannot be improved by the travel time by car

2.5 Conclusion

- The influence of the distance to the city centre is so big that the inclusion of additional parameters does not result in a qualitative improvement of the algorithm.
- The chosen reference values should cover the whole spectrum of standard land values and travel times.
- Overall the algorithm provides convincing results taking into account the accuracy of standard land value determination. Divergences can be oftentimes explained by a very good or very bad infrastructure.
- For this reason, this method can be an interesting tool for the committees of valuation experts to improve the quality of standard land values or for their first definition, if the variance of existing comparison values in a standard land value zone is too big or comparison values do not exist.
- Furthermore, it is an international method that can be used in any country where references values are available for the calculation of the needed coefficients of the polynomial.