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Computer-Assisted Mass Appraisal Options for Transition and Developing Countries

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ANDREW YOUNG SCHOOL OF POLICY STUDIES

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Computer-Assisted Mass Appraisal Options for Transition and Developing Countries

Joe Eckert
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Introduction

The Lincoln Institute of Land Policy provided considerable assistance to the development of methods of Computer-Assisted Mass Appraisal (CAMA). Over the last thirty years, CAMA has become a central feature of property tax administration in the United States, Canada and Western Europe. In addition to their use in property tax administration, banking systems in western countries have begun using CAMA methods for single-property appraisals through the use of Automated Valuation Models. The essential concept behind CAMA is to estimate a hedonic price index for a class of real estate, such as residential properties, from a representative sample of sold properties from the entire population. The index relates sale prices to the physical and location features of the sold properties. The weights estimated for marginal changes in the physical and location features are then used to value unsold properties. In property tax administration, the entire universe of unsold properties is valued. In lending applications, only the subject property is valued. In transitional countries, real estate market data to support the operation of a market economy are scarce. In this environment, CAMA methods can make use of scarce price data to value entire classes of properties much more efficiently than traditional appraisal methods. This is because traditional methods of valuation require large amounts of data on sales rents and rates and therefore cannot be used in transition economies.

Systems Weighting Base by Original Cost or Size

Transitional countries in many parts of the world have some kind of tax on land or improvements or both already in place. For instance, in Russia there is both a land tax and a separate tax on residential improvements. The improvements tax is based on a rate multiplied by the book value of the property (original cost). The land tax is based on a rate multiplied by parcel size and adjusted for location by applying an administrative land zone weight. In Poland there is a tax on improvements that is based on a rate multiplied by size and adjusted by use. In Croatia and Serbia there is an urban use tax that is based on a rate multiplied by size and adjusted by use and location (land zone). In countries with existing taxes there is also a cadastre that contains the data that supports the valuation methodology so no additional data collection is needed. Likewise in many countries with existing property tax systems there is also a tax on real estate transfers. While these are just a few examples, they serve to illustrate a point about fairness and good land policy. In none of these examples is the tax base weighted by market value. In a property tax system that is weighted by market price the effective tax rates are uniform by size, use, location, age and amenities of land and improvements to land. This is because market value is just the capitalized value of real estate services that vary by use, location, age, condition and size.

In studies of effective tax rates done by Eckert, Eckert and Kalinina, Eckert and Powers and Eckert and Corson in Poland, Russia, Serbia and Croatia, it was determined that effective tax rates varied considerably when the tax from the administrative model was compared to a tax based on market price with a revenue-neutral rate. In a study of the Polish property tax system it was found that the effective tax rates on residential properties was .00068 but about 3% on commercial properties. In Serbia and Croatia the same phenomenon was observed but the magnitude of the difference was about half the Polish differential. Another aspect of the Polish system was that effective tax rates varied within property classes principally because there was no adjustment of the tax for location differences. Even in countries like Croatia and Serbia, where adjustments were made for land zones differences, the land zone boundaries and multipliers were not determined by an analyses of market activity. These land zone boundaries were based on infrastructure variations that were in place in the late 60s. This resulted in effective tax rate variations within classes. In Russia the land valuation methods lead to similar effective tax rate variations among land zones as compared to a market-based system. A more fundamental problem in the Russian system is that effective tax rates bear little relationship to the relative price of land. Tax burdens based on the relative price of land send signals to the market about land scarcity and provide the private sector the information that lead to land being put to its highest and best use. Land tax systems such as the one operating in Russia send the wrong signals to the market and can lead to a misallocation of land resources.

Market-calibrating Square Meter Systems

CAMA technology can be very useful in addressing the issues of equity and good land policy just described. In countries like Serbia and Croatia, where the base is weighted by square meters, it is possible to recalibrate parts of the existing models so that the outcome reflects the result that would be expected in a system where the base is weighted by market value. In countries with a robust real property cadastre, the data in the cadastre may be used to recalibrate the models, if supplemented with market sales data. Furthermore, if a transfer tax is in place, the transfer tax systems may be augmented with sales data. Information from brokers may be used to estimate the discount in reported prices in systems where the transfer tax is high and there is a fear that reported prices are not accurate. In Poland I was pleased to discover that not only was there a transfer tax but the administration of it incorporated mass appraisal methods to verify the accuracy of reported transfer prices.

With both data from the existing cadastre and current sales data it is possible to update the weights in the existing formulas such that the distribution in the tax closely resembles what it would be if the base were weighted by market value. In several pilot cities in Croatia this was done in the following steps:

1. A hedonic price model was estimated using transfer prices from the transfer tax registry and information on property size use and location found in the use tax registry.

2. The hedonic model was used to estimate market prices for all properties in the use tax file.

3. The total revenue raised by the use tax was divided by the total market value of the use tax role to get the revenue-neutral rate.

4. The value estimated for each property in the use tax role was multiplied by the revenue-neutral rate to derive the amount of tax the taxpayer would have paid if the use tax system were weighted by market value.

5. A second hedonic price index was developed where the dependent variable was the market-based tax amount for each taxpayer and the independent variables were the same size use and location information used to administer the existing use tax.

The result of this process produced an updated table of use and location multipliers and a rate that when used to estimate a tax bill for each property in the inventory file closely replicated the distribution of taxes that would be expected from the system if the base were weighted by market value. To test this we regressed the individual tax amounts based on market value (step 4) on the individual tax amounts estimated based on the new weights estimated in step 5. The R^2 value was .96.

There are further refinements that can be made to square-meter weighted systems that adjust the tax for location using a land zone system. In most of these system the land zones were based on infrastructure that was constructed many years ago. The weights were just guesses at the relative value of the different infrastructure combinations. With the introduction of GIS technology in support of CAMA it has become feasible to update land zone boundaries and multipliers so they reflect current market-based land zones and multipliers. The prerequisite to this is that there is a already in place a source of x,y coordinates for the sales file and all properties in the use tax data base and electronic base maps and shape files available. It is also possible to assemble this data using hand-held GPS devices for the sales file and input from low level satellites such as is available in Google Earth. The method for creating new land zone delineations are as follows:

1. Estimate a hedonic price index where sales prices is the dependent variable and only use and size are the independent variables. No factor for location is included.

2. Using three dimensional graphics, plot the residual from the model estimated in step one where the residual is the z coordinate and the z and y coordinates of the property are on the z and y axis of the graph.

3. Identify high and low points on the three dimensional graph and estimate distance measurements from each point (value influencing centers [VICS]) to all properties in the sales data base.

4. Model the residual using a Tayler series expansion where the residual is the dependent variable and the distance measurements from the VICS are the independent variables. This creates the equation for a three dimensional location response surface .(see Appendix 1).

5. Use the residual model to estimate the value of the residual for each high and low VIC point identified in the three dimensional graph developed in step two.

6. Use cluster analyses to identify properties with similar location residuals.

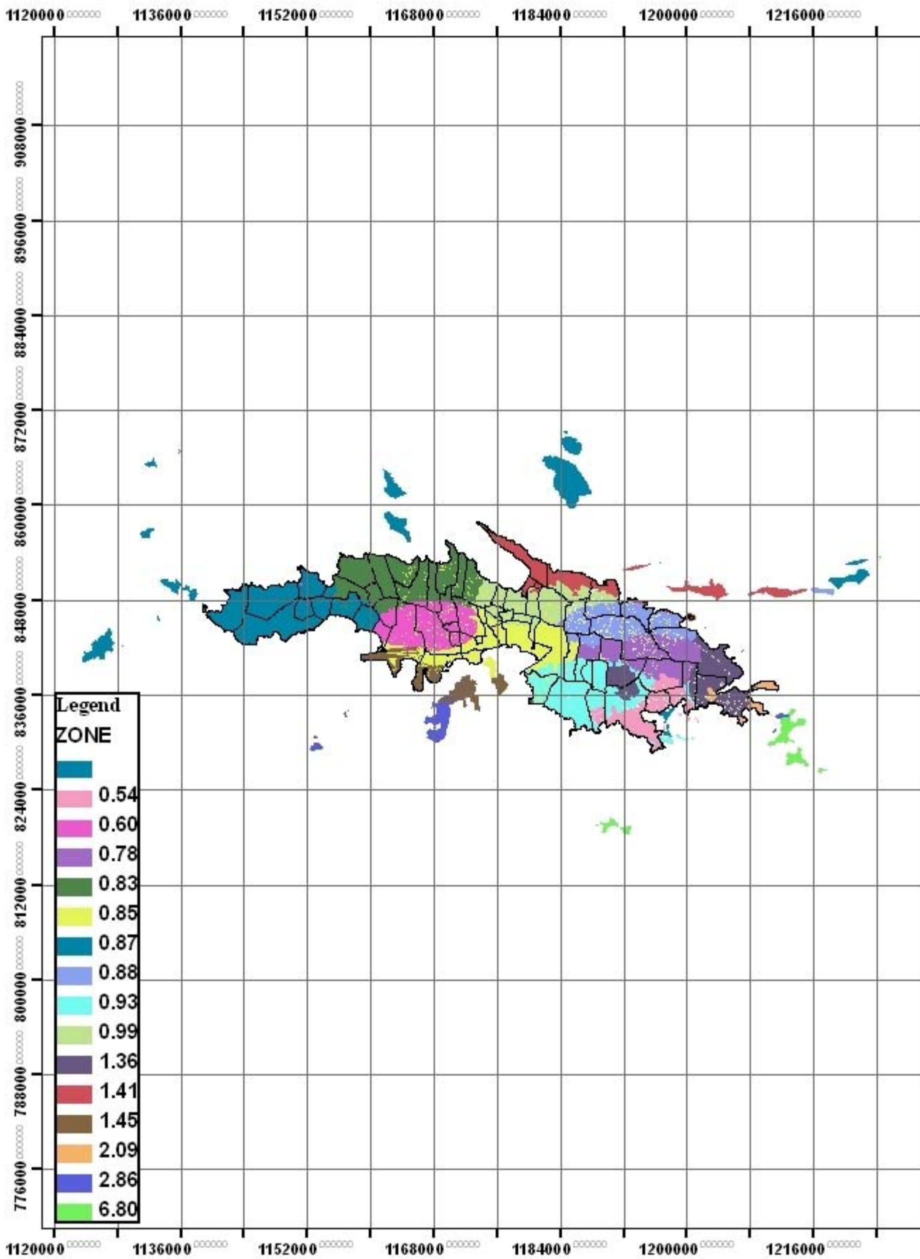
7. Re draw zone maps to reflect these similarities.

8. Use the residual model to estimate the residual value for the midpoint of each new zone.

9. Divide the lowest zone residual into the residuals for the other zones to create the zone multipliers.

10. Use the new zone multipliers in a recalibration of the square meter model as described above.

The following map shows the results of this rezoning process for the island of St Thomas in the United States Virgin Islands. Note that the old administrative land zones are delineated in black and the new zone buy different colors.



It should be noted that while this methodology was developed mainly for countries in the socialist countries of the former Soviet Union, central and Eastern Europe where tax systems adjusted by land zones are common, the method can be used in market-based systems where neighborhood delineation is used to make location adjustments.

One of the major advantages to using CAMA methods in real estate valuation reform is there is no need to change the law. This is because only the tables supporting the administration of the current law need be changed. The results obtained are similar to the results that would be in place if the law were changed to mandate a market-value weighted base. This avoids the political risk of having reform legislation not pass. This point is significant as over 60% of the property tax reform I have worked on or have known about failed because the law did not pass even though the administrative and mass valuation systems were well designed and impact studies showed reasonable tax burden shifts.

Property tax systems in which the weight of the base is changed to market value

CAMA can be useful in cases where the reform in the existing tax system involves a change in the weight of the base. In this case one of the critical steps to take is to support the law that changes the weight of the base by developing an impact study of the effect on taxpayers of this change. The typical change is to propose that the base be weighted by market value rather than cost or size. In order to do the impact study it must be possible to develop a market model using CAMA. In countries where there is a cadastre containing physical and location data supporting the existing system and there is a source of market data, hedonic prices indexes can be estimated and tested using this data. Assuming the models meet international performance standards then the following steps need to be undertaken to complete the impact analyses:

1. Predictions of market value are made for all property using existing cadastre data.
2. The new total tax base is computed from these data.
3. The total revenue from the existing tax is divided by the new base to provide a extimate of the revenue-neutral rate.
4. The revenue neutral rate is multiplied by the estimate of market value for each property to estimate the new tax bill.
5. The old and new tax bill are compared and the change recorded.
6. The properties are stratified and winners and losers are identified.

This type of reform was proposed in Poland a few years ago. The table in appendix 3 chart 1 shows the impact study that was done. The upper part of the table show the existing tax burden by property class. The middle of the table shows the new burden and the botton of the table shows the change in burden. Information from this type of analyses then can be used to design an exemptions system that protect tax payers deemed by the political powers need protecting from the full impact of the reform.

Property tax development in countries with no antecedent property tax system

The most challenging reform occurs in countries where there is no antecedent system. In this situation there is no cadastre that can be used to provide the specific data needed to tax real property. An investigation needs to be made to see if any usable data are anywhere in the system that could support property tax administration. Typically we find many sources of data already in paper and sometime electronic form that are useful to property tax administration. If there are useful data then the data must be put in a common electronic format before they can be used to support assessment administration functions. However, we have found that in most cases where there is no prior tax in place that at least some data must be collected in the field.

The most important aspect of the introduction of a new tax in a country with no prior tax however is the need to design the legal and administrative system. The following design features need to be considered:

1. Tax base – land only, building only, land and building together ,machinery and equipment ,personal property.
2. Weighting of the tax base – by unit, by size, by market value.
3. Tax rate – one rate, split rate by property class, rate cap.
4. Exemptions – personal exemptions, property exemptions, circuit breakers.
5. Tax administration – centralized, decentralized, mixed.

Once these policy decision have been made and included in a draft law then the impact study can be designed and implemented. In this case the impact study is not based on a comparison of the old and new tax burden for different property types at a revenue-neutral rate but is based on a simulation of impacts for different property types by applying the range of rates permitted in the law to the weighted base. An example of this type of impact study was just competed in Brčko District in Bosnia and Herzegovina. The table in Appendix 2 shows the results. The top of the table shows the value of the base for each component of the tax base and the tax yield at three different rates. The middle of the table shows the average burden for each component of the base at three different rates.For instance for apartments the average burden is 198 km,138 km and 67 km at the .005, .0035 and .0017 rates, respectively.

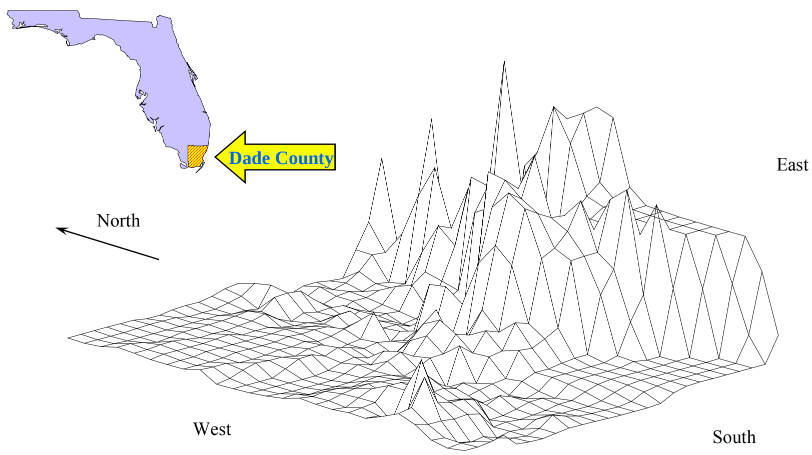
The estimate of the new tax base in this study required the estimation of hedonic price indexes for each component of the base. An apartment model, a commercial model and a detached houses model were estimated and applied to the unsold properties in each base to calculate the total value of the entire base. In order to ensure that the models were accurate a data collection form was designed and data on sold properties for the three property classes were collected in the field. The models that were estimated from this data were not as robust as those used in western countries but were still remarkably good given the relative immaturity of the real estate market in Brčko District. For instance, the house model explained 93% of the variation in prices using typical location, physical and quality characteristics of the houses. The COD was about 24% when this model was tested against sales. The apartment and commercial models had similar results. For the impact study these models were applied to the data for unsold properties where the data was collected for other purposes and may not have been consistently collected. For instance, the data on houses came from the reconciliation committee. When the new tax is implemented the data on unsold properties will be re-collected using low level satellite technology and from exterior inspections in the field.

Conclusion

CAMA is a powerful tool to support the administration of the property tax. In western countries it has revolutionized the way the tax is administered and in fact made possible the achievement, for the first time, the tax policy goal of making the weight of the tax base current market value. In countries in transition where there is an existing property tax, CAMA can be very useful in recalibrating models to achieve a more market-oriented result. In countries with out a tax CAMA in conjunction with low level satellite imagery and some on-ground exterior collection of data can establish a working property tax at reasonable costs in a relatively short time frame. In Kosovo a property tax was established in 30 cities in 18 months. In Cape Town a general revaluation updating a valuing a roll over 20 years old was done in two years using CAMA. Future updates can be done in months, not years, if the roll is kept up to date. While the availability of market data is not robust in transitional economies CAMA is the perfect technology to replicate the rational aspects of the market found in a relatively small sample of sales to the larger population. In fact the use of CAMA in tax administration in countries in transition can accelerate the development of real estate markets.

APPENDIX I

This is a three dimensional response surface representing sale price for Dade County (Miami), Florida.



MAP pdf of St. Croix

MAP pdf St. Thomas

APPENDIX II

DATA TABLE Brcko impact study

Total Assessed Value

			Total Possible Yield		
	Count	**TotalValue**	**0.005**	**0.0035**	**0.0017**
Commercial Buildings	1,421	1,029,382,153	5,146,911	3,602,838	1,749,950
Apartments	3,114	123,095,744	615,479	430,835	209,263
Houses	17,828	1,798,081,039	8,990,405	6,293,284	3,056,738
Total	**22,363**	**2,950,558,936**	**14,752,795**	**10,326,956**	**5,015,950**

Average tax burden .005 tax rate

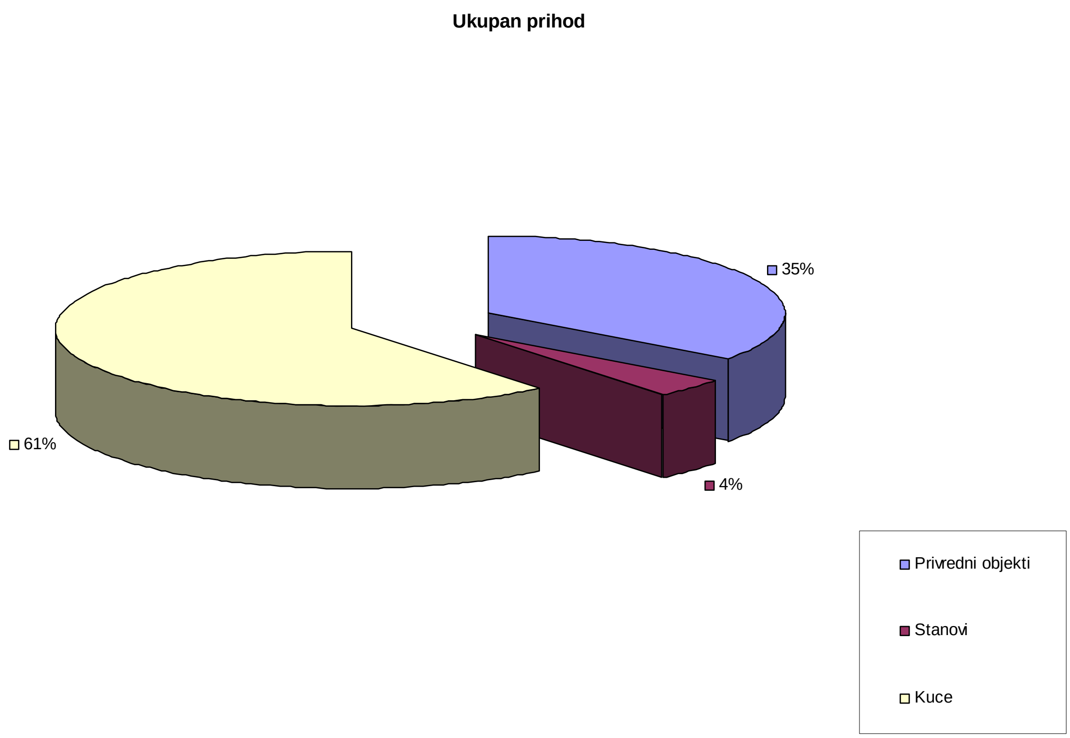
		Tax			
		Mean	**Min**	**Max**	**Yield**
Commercial Buildings	1,421	3,622	79	638,076	5,146,911
Houses	17,828	601	4	2,393	8,990,405
Apartments	3,114	198	48	806	615,479
					14,752,795

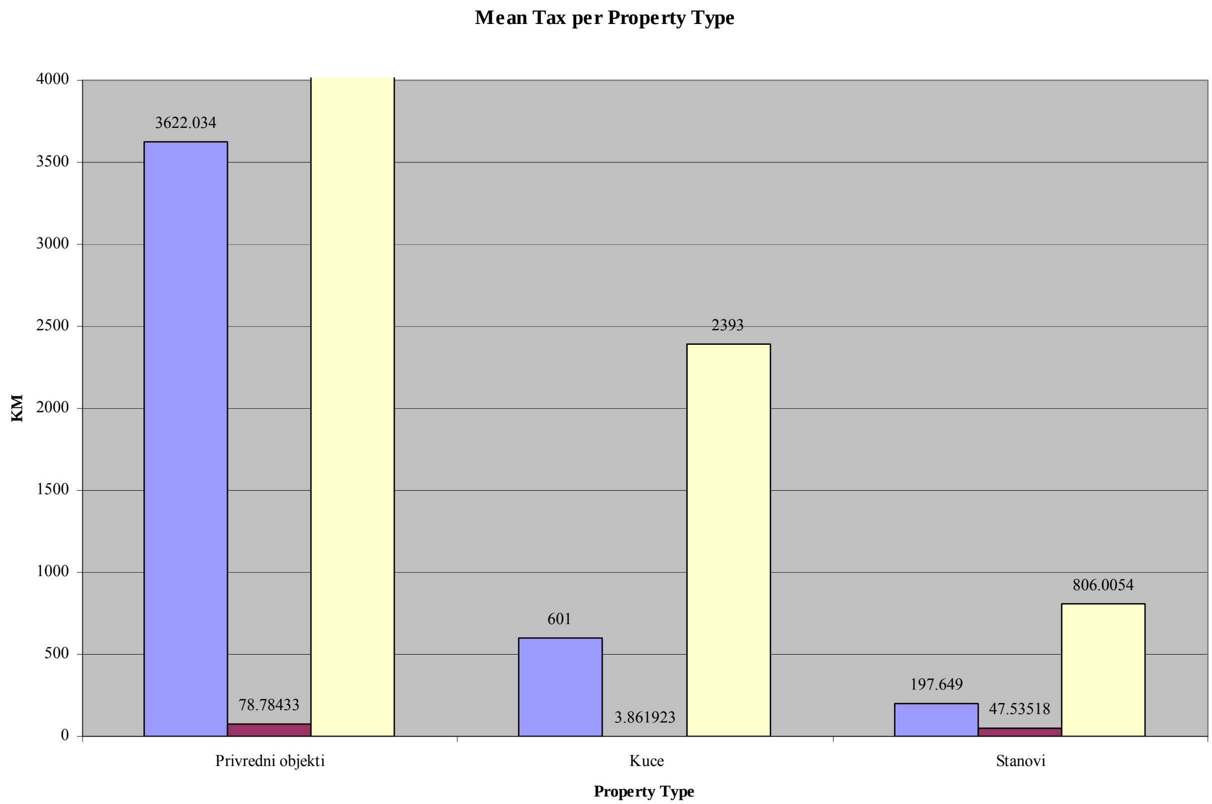
Average tax burden .0035 tax rate

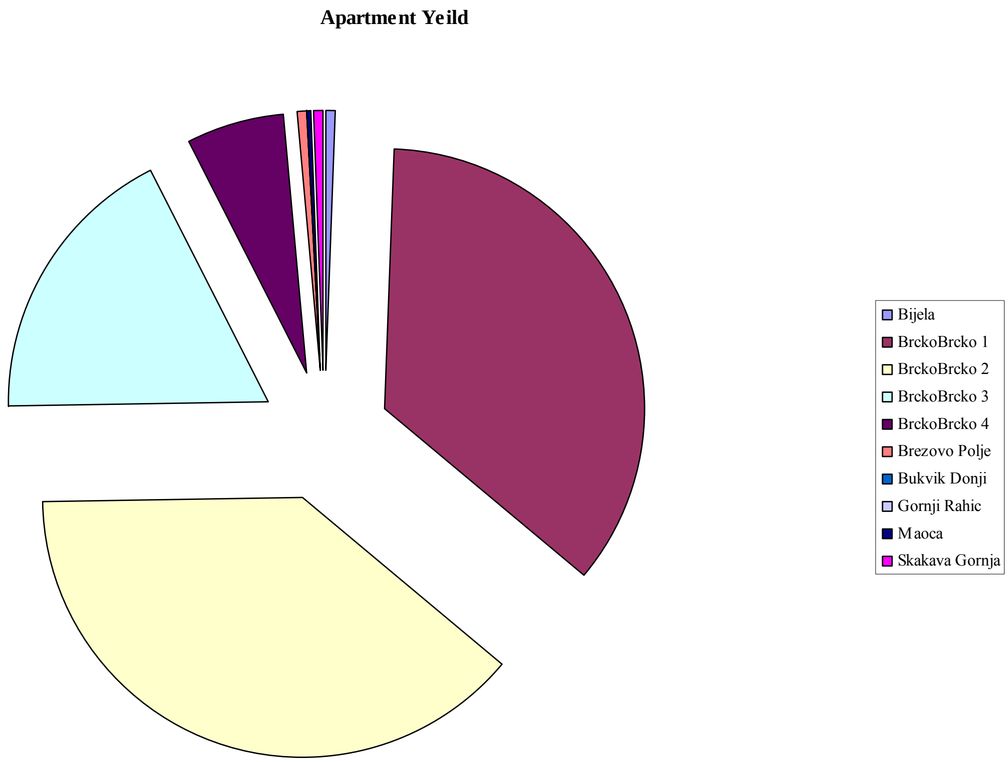
		Tax			
		Mean	**Min**	**Max**	**Yield**
Commercial Buildings	1,421	2,535	55	446,653	3,602,838
Houses	17,828	430	3	1,676	6,293,284
Apartments	3,114	138	33	564	430,835
					10,326,956

Average tax burden .0017 tax rate

		Tax			
		Mean	**Min**	**Max**	**Yield**
Commercial Buildings	1,421	1,231	27	216,946	1,749,950
Houses	17,828	209	1	814	3,056,738
Apartments	3,114	67	16	274	209,263
					5,015,950


Ukupan prihod
35%
61%
4%
Privredni objekti
Stanovi
Kuce


Mean Tax per Property Type
KM
4000
3500
3000
2500
2000
1500
1000
500
0
3622.034
78.78433
601
3.861923
2393
197.649
47.53518
806.0054
Privredni objekti
Kuce
Stanovi
Property Type

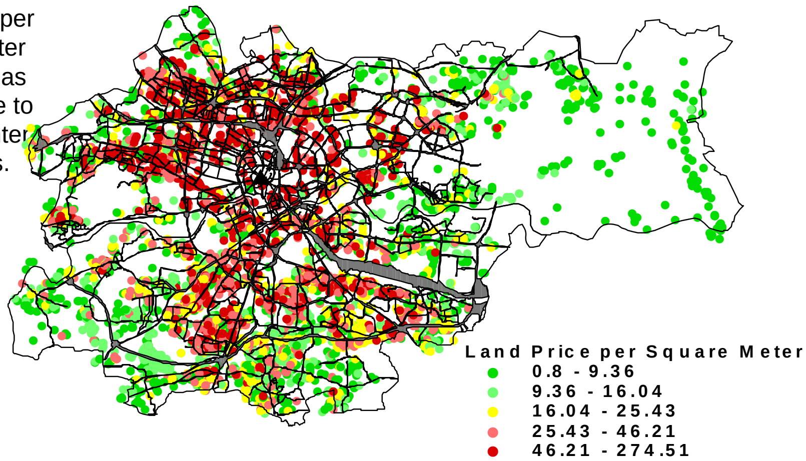

Apartment Yeild
Bijela
BrckoBrcko 1
BrckoBrcko 2
BrckoBrcko 3
BrckoBrcko 4
Brezovo Polje
Bukvik Donji
Gornji Rahic
Maoca
Skakava Gornja

Appendix III
Maps1-4

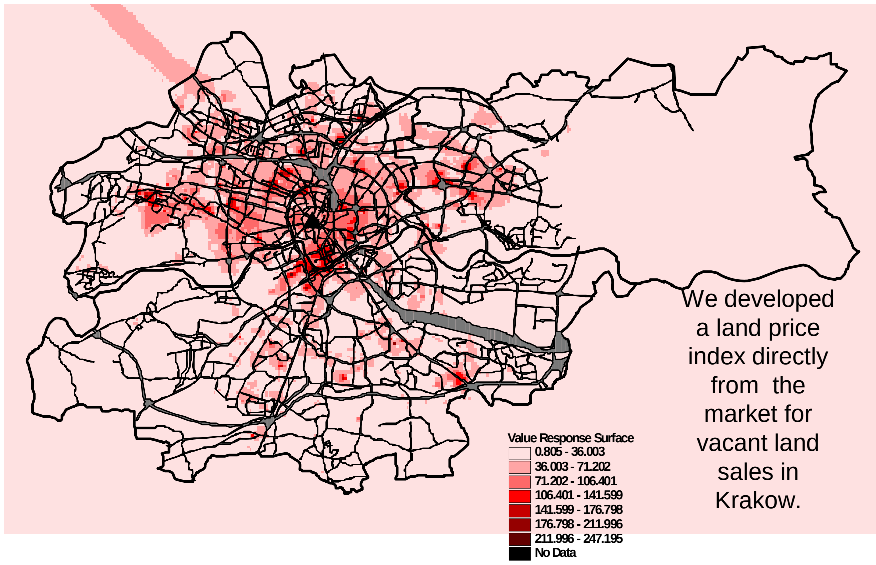
Krakow - Sale Price per Square Meter for Vacant Land Sales

Land value per square meter decreases as the distance to the city center increases.

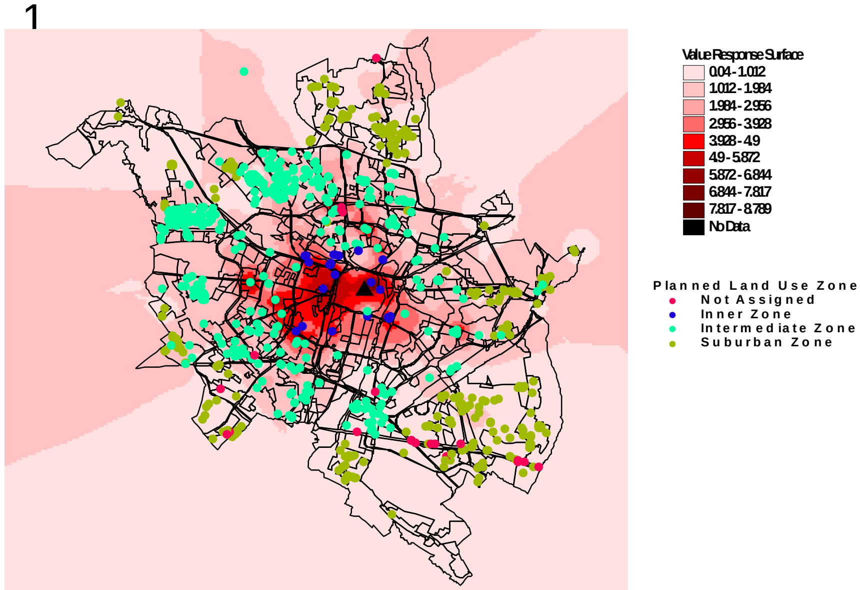
A triangle marks the city center.



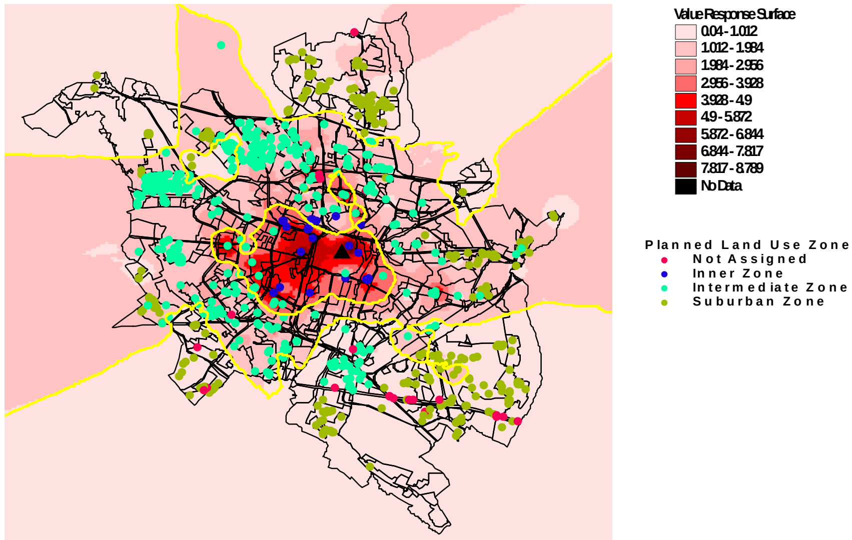
Krakow - Land Price Index

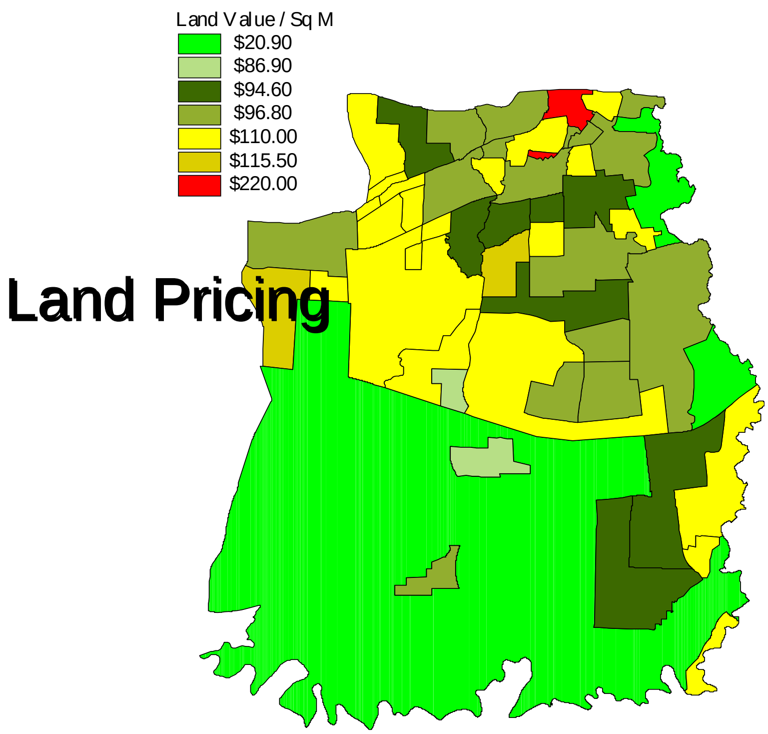


Poznan - Creation of Land Value Zones - 1



Poznan - Creation of Land Value Zones - 2





Average Sale Price

Residential Improved Sales

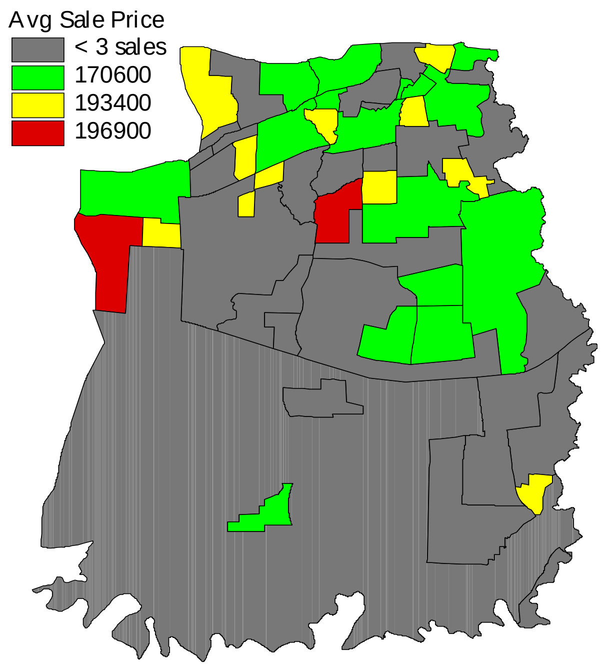


Chart 1

Krakow - Ad Valorem Tax Impact

Krakow Current	**CURTAX**	**CURTAX**	**CURTAX**	**CURTAX**	**CURTAX**	**CURTAX**
Use Type	**Count**	**Mean**	**Median**	**Sum**	**Min**	**Max**
Single Family Land	3387	40.96	29.04	138723.56	0.64	788.92
Multi Family Land	901	69.70	35.56	62795.60	0.60	1200.44
Industrial Land	273	1346.59	719.90	367617.74	10.12	20968.64
Commercial Land	860	947.21	654.12	814598.36	8.74	10978.82
Res - Agric Land	314	101.51	82.06	31875.64	3.88	1013.12
Agricultural Land	596	79.13	38.70	47160.80	0.84	2544.36
Other-Rds,Etc Land	370	655.47	284.97	242524.42	5.52	8632.82
Krakow Estimated	**ESTTAX**	**ESTTAX**	**ESTTAX**	**ESTTAX**	**ESTTAX**	**ESTTAX**
Use Type	**Count**	**Mean**	**Median**	**Sum**	**Min**	**Max**
Single Family Land	3387	40.94	25.88	138674.04	0.73	1333.16
Multi Family Land	901	69.72	35.68	62820.83	0.86	1616.20
Industrial Land	273	1346.59	633.15	367617.83	33.45	17522.57
Commercial Land	860	947.18	647.58	814576.41	15.60	7471.44
Res - Agric Land	314	101.50	61.84	31870.13	5.78	627.14
Agricultural Land	596	79.14	42.07	47165.44	2.45	2291.85
Other-Rds,Etc Land	370	655.49	290.64	242531.83	3.06	6927.58
Krakow Tax Change	**TAXCHG**	**TAXCHG**	**TAXCHG**	**TAXCHG**	**TAXCHG**	**TAXCHG**
Use Type	**Count**	**Mean**	**Median**	**Sum**	**Min**	**Max**
Single Family Land	3387	0.11	-0.06	376.29	-0.92	5.10
Multi Family Land	901	0.20	0.04	183.37	-0.89	4.24
Industrial Land	273	0.30	0.13	83.05	-0.90	3.44
Commercial Land	860	0.24	0.05	202.97	-0.89	4.14
Res - Agric Land	314	0.17	-0.14	53.72	-0.89	6.97
Agricultural Land	596	0.48	0.19	285.46	-0.84	8.05
Other-Rds,Etc Land	370	0.20	0.06	73.57	-0.79	4.53

Krakow - Ad Valorem Tax Impact

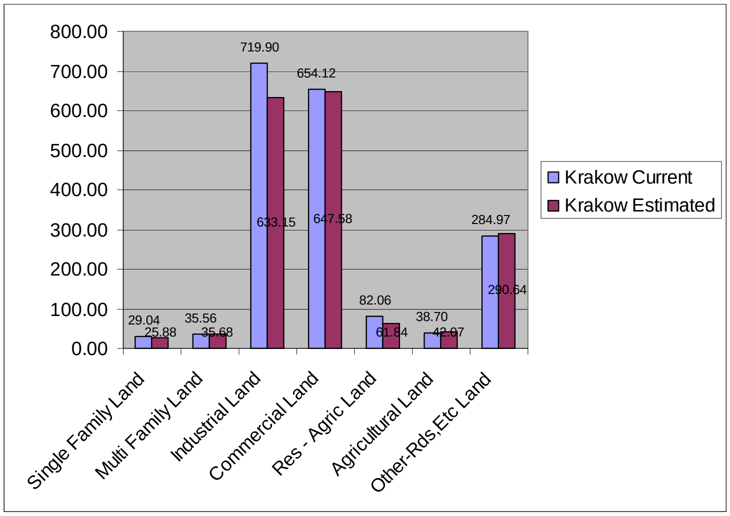


chart 2

The econometric modeling process is an efficient framework for the systematic analysis of factors that influence real estate value

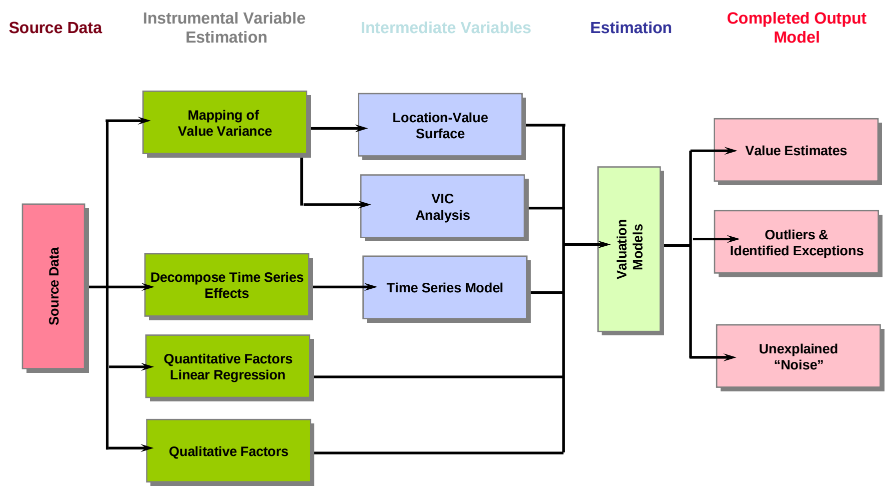


Chart 3

Model Structures

Basic Hybrid (Generic) Model

$$V = GQl * ((LQl * LQn) + (BQl * BQn) + (MQl * MQn))$$

Where:

V = Market value
GQl = General Qualitative Factors
LQl = Land Qualitative Factors
LQn = Land Quantitative Factors
BQl = Building Qualitative Factors
BQn = Building Quantitative Factors
MQl = Miscellaneous Qualitative Factors
MQn = Miscellaneous Quantitative Factors