Evolution of Land Values in Cracow during the Transformation of the Polish Economy

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Introduction

The transformation of the Polish economy during the early 1990s offers an unusual opportunity to examine the evolution of a new market for urban land. There has been a great deal of theoretical and empirical research focused on urban land value functions that has derived from the work of Muth (1969) and Mills (1972). Data sets permitting the empirical testing of theoretical structures are few but two sources for the city of Chicago have resulted in numerous studies focusing on this city. These sources are Hoyt (1933) and "Olcott's Land Values Blue Book of Chicago" which together provide actual and estimated values for tracts of land in Chicago at various intervals from 1830 to 1990. These sources are discussed and the data analyzed using non-parametric techniques in McMillen (1996). Most studies have found that a fourth-order polynomial is required to explain land values and that as time as passed, the land value function has become more complex as transportation systems and neighborhoods have evolved and employment nodes and shopping districts have multiplied. For example, McDonald and Bowman (1979) find that explanatory power declines over time and that more complex functional forms do a better job of explaining variation in land price perhaps reflecting increasing complexity of the urban environment and the increasing likelihood that distance from the city center provides an inadequate explanation. In this study, we begin an analysis of land values in Cracow using parametric techniques in order to benchmark our outcomes against the results of prior studies in developed market economies. At this stage, we do not address the issue of selectivity bias or a dynamic approach. In the next section, we summarize political and economics events leading up to, as well as the strategy implemented by the leadership in Poland to privatize land markets. In the third and fourth sections, we discuss the theory and describe the data set which has been accumulated. We follow that with our analysis, results and ideas for future research.

Background

The first historical evidence of Cracow as a center of economic activity dates from 965 A. D. Cracow has evolved into an intellectual, artistic and religious center with the second oldest university in Central Europe, a medieval town square and fortifications among other attributes that have been preserved to the present. Romanesque, gothic, renaissance and baroque architectural styles are found in the more than 50 churches in Old Cracow. From the belltowers of the churches, one can view five rings of fortifications most recently cementing Cracow's role as the northernmost fortress of the Habsburg Austro-Hungarian Empire. In 1978, UNESCO

added the city to its list of 12 major historic sites in the world. After World War II, the socialist government introduced previously non-existent heavy industry by placing a steel mill and related uses now known as Nowa Huta to the east of the historic old town with the objective of remaking an intellectual center known for its anti-Communist sentiment, strong elements of the working proletariat.

The Vistula River winds through the city of Cracow which lies in rollings hills in the southeast of Poland, the center of the region known as Malopolska bordering the Ukraine and Slovakia. The city of 750,000 can be divided into four areas or districts. Srodmiescie (Central Cracow), the central district includes the medieval old city, Kazimierz, the Jewish Quarter and a surrounding area developed during the 1800s and the last forty years. Srodmiescie is largely developed and is home to 156,400 people. To the east side of the city, Nowa Huta (the East Side), a visible legacy of the socialist era houses 221, 200 people and as part of a plan dating from the '50s includes the Sendzimar steel mill and related activities. The residential part of the community is buffered from the mill by a 2500 hectare undeveloped parcel. Podgorze (the South Bank of the Vistula), south of the central area is home to 205,700 residents and includes extensive cooperative housing dating built during the last fifty years along with commerical and industrial corridors. To the northwest lies Krowodrze (the West Side), a largely residential community of 160,700 residents. Housing varies in density but the area has attracted significant single family development. While the city is picturesque it experiences environmental problems including poor air quality attributable to vehicle emissions, local industrial uses including the Sendzimar steel mill and industrial uses in the Silesian region to the west. Water quality is also poor due to inadequate and aging wastewater treatment facilities. What is striking and typical for post-communist cities is that relative to western cities, more land is devoted to industrial uses and less to residential and commerical uses reflecting the low opportunity cost attached to land and the non-existence of market forces to encourage recycling to 'higher and better' uses. [1]

The beginning of the transformation in Poland in 1990, set in process an array of initiatives oriented toward moving the Polish command economy of the previous fifty years toward a market economy. The strategy employed by the Solidarity government involved a radical

[1] A USAID funded study of land use and economic development opportunities in Cracow included briefing materials for an Urban Land Institute Panel. These briefing materials provided a single source for much of the factual information in the background section of this paper. See *An Evaluation of Land Use*

package of reforms dictated in part by the severity of the inherited economic problems and in part by the expectation that the new regime's political capital would be rapidly consumed. The strategy introduced by Deputy Premier and Minister of Finance Leszek Balcerowicz involved macro-economic stabilization to be followed by restructuring and stimulation. Macroeconomic stabilization strategies included the liberalization of prices, the raising of interest rates to a positive real level and the support of internal convertibility of the Polish currency. Critical components of the restructuring included the privatization of some state-owned enterprises and the liquidation of others, the encouragement of start-up firms and the return of the ownership of real estate assets to the private sector. See Rondinelli and Yurkiewicz (1996).

Liberalized market forces rapidly revealed the extent of the misallocation of land uses. As discussed by Bertaud and Renaud (1995), post-communist cities exhibit land use patterns different from market driven cities. The former's spatial structure is highly dispersed with little compactness around urban cores. The overall allocation of land in post-communist cities is characterized by relatively more land allocated to industrial uses than in market driven cities. Moreover, these industrial uses tend to be clustered in central locations while residential density may increase toward the periphery. Commercial uses tend not to be concentrated. This pattern has arisen from decades of non-existent land markets in which the opportunity cost of well located land was not recognized (recycling simply did not occur), infrastructure needs were handled administratively, public transportation was subsidized and growth required new uses to locate further from the city core.

Cracow is no exception to these land-use patterns, although it did have a market economy prior to World War II and its prewar land use structure was consistent with those of cities with land markets. During the communist period the city grew from 200,000 to 750,000 so much of its urban capital was created by central planners. A recent study by Bertaud confirms the spatial character of a post-communist city with about 25% of the built up area devoted to industrial uses and only 35% in residential uses. Bertaud argues that the comparable numbers for a market driven city would be 10% and 50%, respectively. The need for the reallocation of land should be evidenced by increases in residential and commercial land prices relative to industrial land prices along with transaction prices consistent with market theories of land price being paid for vacant

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or developable parcels.

The land price gradient reflects some of the fundamental trade-offs in the land market in a market economy. The allocation of land uses in a command economy is not in response to such forces. Thus as market forces take hold there should be evidence of the conflict or tension between existing uses, a legacy of the communist era, and anticipated uses reflecting the demands of potential users in a market environment.

Protection of private property rights was reestablished through an amendment to the Constitution of Poland and in the Civil Code. The latter established the bundle of rights that could be associated with real estate including forms of tenancy, transfer mechanisms, title and the rights and obligations of ownership. Costs of transfer remain relatively high at about 10% of the price declared in the notorial deed (including brokerage fees). Reprivatization of real property is a work in progress as previous owners and their successors have employed the courts to seek restitution of properties illegally taken by the state (if administrative violations can be demonstrated). Most urban property has been municipalized by transferring ownership of real estate to newly elected local governments (Local Self Government Act of 1990) and regulating their real estate asset management and condemnation practices (1990 amendment to the Land Management and Expropriation Act). Local governments have, to various degrees, been transferring property rights to private sector individuals and firms through auction, sale, exchange and grant. For example, the management and employees of a firm might be granted title to the land that is occupied by their factory. This has allowed public sector property ownership rights to be clarified. However, due to transactions costs and the potential cloudiness of title many private sector possessors of property have chosen not to attempt to formalize title. Still other private sector owners fearful of the costs associated with ownership (particularly of rent-controlled residential units) have not revealed their claims. See Choroszucha.

The real estate brokerage community has rapidly evolved in Poland and Cracow is no exception. While many entrepreneurs have begun careers as brokers, there is relatively little organized public information about listings or transactions. For example, although the data employed in this study is technically public information, its acquisition involves time consuming investigation of individual files maintained in government offices not easily accessed by private citizens. Also, no

multiple listing service exists and individual brokers still believe that access to private information gives them a competitive advantage. Thus sharing of listings and information about sales is not the norm and will not develop unless the exclusive right to sell becomes enforceable and widely used.

Despite the uncertainties associated with ownership, the private sector of the housing market has been the most dynamic sector of the market with new contruction increasing at rapid rates during the 1990s (14.7% growth in 1993). As well there has been a clear preference for single family development. To illustrate, for the three and one half years for which we analyzed sales, the majority of sales involved low density residential lots having residential floor area ratios less than 0.4 and lot sizes between 400 and 1000 square meters.[2] These constraints reflect a density consistent with single family house development though the number of units is not directly regulated. Roughly 27% of the 271,716 housing units (in 30,600 buildings) in Cracow are privately owned. Much of the available housing stock was built between the '50s and '70s and while basic services are available for most existing houses, as we will see, the availability of services for new development has a critical effect on land value. Of the existing housing stock, 93.3% have water, 78.3% have sewer and 94.3% have central heating. Access to utilities including telephone is important.

Most new housing development has involved relatively little financing and builders have performed on a fee for service basis. Fee developers and owners have been reluctant for banks to have much control over their projects and owners have tended to prefer fee developers due to their lack of trust in flegling private developers. Thus new houses have been tended to be built by developers having access to the capital of future buyers who take on a share of the development risk.

Theory

It is well known that the static monocentric model of the urban land market yields a model in which land prices and densities decline with distance from the center of the city. Specifically, land value falls at a constant percentage per increment of distance from the city center if it is

assumed that location or transportation costs increase linearly from the city center, the price elasticity of demand for housing is unitary and that housing production is a Cobb-Douglas function employing capital and land as inputs.

$$P(u) = P_0 \ e^{-\gamma u} \quad (1)$$

$$\ln P(u) = \ln P_0 - \gamma u \quad (2)$$

Equations (1) and (2) are identical where $P(u)$ is the price of land at distance u from the center of the city and γ is the percentage rate of decline per distance measure. Despite the simple form of Equation (1), empiricists have found that since the assumptions of the monocentric model of urban land values are seldom met, analysis of land values or other measures (e.g., population density) require less parsimonous specifications. Typically, second, third and fourth order polynomials are required to adequately explain land values. There is little theoretical justification for these specifications other than that the additional terms proxy for variables left out of Equation (2). Clearly, many factors can complicate this fundamental relationship including transportation systems, heterogeneous neighborhoods and services and shopping districts and employment nodes that compete with the central business district (CBD) or towncenter. Thus, a more complete specification of Equation (2) follows

$$\ln P(u_i) = \ln P_0 - \gamma u_i + \alpha \cdot g(u_i) + b \cdot h(x_i) + e_i \quad (3)$$

where the vector $g(u_i)$ represents the inclusion of second, third and fourth order polynomial terms and $h(x_i)$ is a vector of attributes of land. α and b are vectors of percentage changes in land price arising from changes in the variables that comprise the vectors $g(u_i)$ and $h(x_i)$. Prior results suggest that if land attribute data are available, the polynomial terms often included as proxys can be replaced by variables capturing the true effects on land values of a multitude of factors. Moreover, some studies have chosen to segment the community spatially as a proxy for yet other unmeasured factors.

The above model describes a long run equilibrium in the marketplace assuming continuous redevelopment as market conditions change. In dynamic models, residential density depends on

[2] A floor area ratio or FAR of 0.4 means that one can build 40 square meters of floor area of a building (including floors in multiple stories) for every 100 square meters of land. A minimum lot of 400 square

the history of development and redevelopment may not be costless. In this environment, density functions may not be smooth (Brueckner, 1986). However, if demolition is costless and there are no externalities among alternative densities, previously undeveloped land values should be unaffected by the pattern of historical development as is the case in long run equilibrium.

Selection bias is also raised as an issue in land value function estimation. Specifically, if variables are left out of the model, there is the potential for bias. McMillen et al. (1991) and McMillen et al. (1992) develop and test a models which deal with the potential bias resulting from ignoring the effect of zoning and the quality of agricultural land at the periphery.

In this paper, we employ a long run equilibrium approach to examine the urban land value function in Cracow between 1993 and early 1996. The data set will permit the examination of potential sources of bias in the estimations. However, given the unusual nature of the data having been derived from a newly evolving marketplace, we choose to approach the analysis using Equation (3) and variants thereof in our analysis. This paper is intended to be exploratory leaving the examination of development dynamics or sources of bias in the estimation of pricing models for subsequent work. [3]

The data are derived from a period in the early development of a local land market in an economy experiencing transformation. The Polish economy began to recover in 1993 and continued to grow through 1996. While market transactions occurred prior to early 1993, we do not have the population of transactions prior to 1993 in our data set. Nonetheless, we want to determine whether land value functions in a nascent market economy take on the same form as we observe in developed urban economies. As well, we want to know whether buyers and sellers recognize other factors which may impact land values and, if so, which of those factors seem to be important. Also, we hypothesize that as the market evolves, the land value function should 'tighten'. That is, we would expect less unexplained variation in land prices as the market matures. This would arise from reduced political uncertainty and greater access to market data and information. To provide perspective, we can compare the results of our estimations to those in the literature for developed urban economies. On the other hand, a rapidly growing economy

meters yields a house of 160 square meters sufficient for a small three-bedroom house.

[3] A new zoning plan for Cracow was adopted in 1995

may be producing substantial spreads in prices as the market seeks to reallocate land uses identifying highest and best uses. In addition, a very slow emergence of credit markets for real estate (mortgage lending activity) may yield substantial price differentials between leveraged and cash driven transactions.

Data

This data base on land sales in Cracow was originally developed by the Cracow Real Estate Institute as part of the USAID funded market value based property tax simulation project in Cracow in 1993 and 1994. See Eckert et al. (1996). Since that time, the database, the population of land transactions in the City of Cracow, has grown from about 600 transaction to over 2000 spanning the time from 1992 to mid-1996. [4] Each sale is located spatially in an x-y grid system allowing the computation of distance to the center of the city. The data set used in this analysis is comprised of 2079 sales between 1993 and mid-1996. The 1992 sales are not included as they reflected a sample only of the pre-1993 sales. A significant effort has been made to collect and create through site visits a set of descriptive variables that capture some of the differences in attributes of individual lots which could influence value. Table 1 includes a list of the variables in the data set and their definitions. The linear distance to the central reference point of Cracow, a town square dating from medieval times was computed for each transaction.

Analysis and Results

Our purpose in this paper is to examine the land value function in a new market for land and to explore how that function evolves through time. We undertake an empirical examination of land transactions from January 1993 to June 1996 by estimating equations of the form depicted in Equations (2) and (3). In order to be assured of sufficient transactions per period of analysis, we chose to break up the 42 month period for which complete data were available into seven periods of six months each. The number of records included in the 1996 sample are limited but we are nonetheless able to get a sense for the activity during the first half of 1996.

[4] Sales prices are actually prices declared in notarial deeds which are subsequently reported to tax authorities for imposition of transfer tax. to reduce tax liability, parties tend to understate the true prices although participants are disciplined by the tax authority's right to increase the price for the purpose of determining the tax base if the reported price seems too low. It is generally believed that values are understated by 10 to 15%. This however, adds an additional unexplained and perhaps random factor in th eland value function reducing explanatory power.

Initially, we were simple interested in examining the extent to which land transaction prices reflected the tradeoffs inherent in the traditional land value function. That is, if the tradeoffs implicit in Equation (2) are apparent. Thus we estimated a series of regression models for each half year period beginning with the exponential function followed by the sequential addition of second, third and fourth order terms. Keeping in mind the results of prior studies, we then included land attributes on the right hand side of the model. Table 1 includes all of the available attribute variables. Some are highly correlated as one would expect.

The results of the estimations appear in Table 2a though g. Since one could theorize relationships between land value and virtually any of the attribute variables, our strategy was to search for the combination of attribute variables which provided the highest explanatory power while maintaining significance of each variable. If one could not reject the prospect that the coefficient on the attribute was zero with 90% confidence, the variable was dropped from the regression. In general, substituting attribute variables for the higher order distance measures enhances explanatory power with two exceptions during the first half of 1993 and the second half of 1994. Variables tend to have the expected sign. For example, the coefficient on *area is* negative reflecting the diminishing marginal utility of additional area while coefficients on *sew, tel,* and *tpt* tend to be positive reflecting the purchasers valuation of these attributes.

In some cases, the signs on the coefficients are counter-intuitive. For example one would expect *revzon,* a categorical variable for which higher values represent higher density zoning, to have a positive relationship with price. While this is observed in 1993:1 and 1995:2, the coefficient is negative in 1994:1.

Variables that capture some of the spatial variation in price that is independent of the distance to the center of the city often have explanatory power. Such variables include *revx, revy,* and *dst.* The first two variables are the x and y coordinates of the transaction so when combined with a distance measure, pin down more accurately the location of the transaction. Similarly, the latter variable identifies the district among four in Cracow. The districts are identified and mapped in Figure 1.

The bottom three estimations in each of Tables 2a though 2g are identical except for the measure

of transaction price used as the dependent variable. In order, moving down each table, *lusp,* the per square meter transaction price in US dollars is the dependent variable employed in rows one through five of each table. The estimation appearing in row five is repeated in row six employing the dependent variable *1pm,* the per square meter transaction price Polish currency. Finally, in row seven, the estimation is repeated using the variable *lpr*, the same measure in Polish currency adjusted for the domestic rate of inflation. In general, the results are robust to the choice of currency and the treatment of inflation. The adjusted R^2 varies slightly each period when comparing the results of the three regressions and there appears to be no consistent pattern. One would expect that during periods of high volatility in the value of Polish currency or periods of greater political uncertainty, transactions might tend to have been undertaken in US dollars or US dollar equivalents. This would result in higher R^2s for estimations employing US dollar denominated transaction prices. In three of the seven cases, US dollar denominated prices yield the highest R^2.

To further focus on the spatial variation of land prices in Cracow, we examined land value functions in each of the above four districts. That is, we estimated variations of the models discussed above but where we limited the transactions included in the analysis to those which occurred in each of the four districts. In Figure 1, the center of the city for the purposes of this study is located toward the northern end of *obreb 12* or tract 12 within District 1 (the Central District or Srodmiescie). Thus the distance to the periphery varies dramatically depending on the direction taken and the land value functions within each district should be quite different even when employing the same reference point. Figure 2 includes scatter plots of the log of the price per square meter in US dollars (*lusp*) and the linear distance from the center of the town square (*disctr*) for each district for the first half of 1994. Table 3 summarizes the results of these estimations. Scatter plots and estimations were undertaken for each period and we include the results from early 1994 for illustrative purposes.

Reviewing the plots in Figure 2 in the context of the map of the districts of Cracow in Figure 1 emphasizes the importance of considering the impact of the irregular geography of the city on the land value function as one rotates around the central point of the city. For example, all of the transactions in the Central District take place between 3000 and 5000 meters from the city center while the transactions in the South Side occur between 2000 and 12000 meters from the city

center. The Vistula River creates the irregular boundary at the northern edge of the latter district while a centuries old park created by infilling the moat surrounding the historic city creates the boundary around the core of the Central district. While each of the scatter plots suggest the downward sloping pattern that is expected (and confirmed by the estimations), there is a lot of unexplained variability in transaction prices when comparing observed prices at each distance from the center.

The estimations of the land value functions for each district appear in Table 3. Again, we began with the exponential function and in this case found that the higher order terms did not provide additional explanatory power. This is consistent with prior studies that have shown that segmentation of the data often captures irregularity in the land value function that the higher order terms attempt to explain in the merged data set. The coefficient on the variable *disctr* (distance to the center) reflects the variation in the slope of the function among the districts. The model assumes that there is agricultural land at the urban fringe and with the exception of the East Side and the Central District, transaction prices unadjusted for other factors influencing value (as they appear in Figure 2) decrease from the 12 to 13 range (1 *3*>*lusp*> 12) where *lusp* is the log of the per square meter transaction price in US dollars to values close to 9.

The results of our research suggest that the prices resulting from transactions in the land market in Cracow appear to be consistent with the long run equilibrium land value model. Estimations of data for seven six month periods between January 1993 and June of 1996 show a pattern of prices reflecting the tradeoff between accessibility to the city center (or the costs of transportation) and price. While at this stage of the analysis, we have not examined agricultural land prices, urban land prices fall to roughly the same level at the periphery in each of the districts in the city suggesting a price at which rural to urban land conversion takes place.

Estimation of the relationship between price, distance from the city center and other attribute measures indicate that access to utilities, lot size and allowable density (zoning) have, in most cases, the expected relationship to land value. Also, higher order measures of distance to the city center proxy for other attribute measures when they are not included in the regression model. However, they are not effective proxies as the inclusion of attribute measures invariably enhances the explanatory power of the regression model.

Comparison of the estimation results from the first half of 1993 through to the first of 1996 yields no consistent improvement in the explanatory power. We expected that as the market evolved the explanatory power of the regression models would improve. There is consistent improvement in the R^2 measure between the first half of 1993 through the first half of 1994. However, during the second half of 1994 the R^2 declines and the results from 1995 yield relatively low R^2s.

Our simple OLS results seem to be respectable in comparison to those presented by McMillen (1996) for Chicago. McMillen's negative exponential function estimates (see Table 6, p. 117) for Chicago for 1960 through 1990 have very low R^2s ranging from 0.0051 and 0.10 13. Our estimates range from 0.1724 to 0.4610. McMillen's fully specified OLS regressions for the same periods (see Table 7, p. 118) yield R^2s which range from 0.6280 to 0.8730 while ours range from 0.2246 to 0.6156. These latter results are not directly comparable as McMillen does not drop insignificant variables from the model. Thus, to the extent there may be uncertainty and a scarcity of information in the Cracow market, buyers and sellers seems to be well aware of market prices to the extent that the explanatory power of the land price model captures that awareness.

Future Research

There are a number of avenues for future research. With zoning information available, it should be possible to determine the extent to which there is selection bias not being captured in the simple OLS model. Whether there has been active rezoning activity in Cracow or whether it is anticipated in recent adoption of a new zoning plan should be addressed. In this analysis, we have limited our examination to residential zones. While there are fewer non-residential land transactions, we intend to explore differences between residential and commercial land value functions. We also intend to employ non-parametric approaches to generate three-dimensional mappings of land price functions on an x - y grid system using methodology similar to that employed by McMIllen (1996). Finally, to augment our analysis of land value functions, we

intend to create hedonic price indexes to track price performance and explore relationships between land prices and economic events associated with the transformation.

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Table 2a - 1993: First Half

c	disctr	d2	d3	d4	area	det	revzon	tel	dst	tpt	R^2
12.00230	-0.000157										0.3606
(129.266)	(-11.0579)										
12.39599	-0.000284	8.39E-07									0.3855
(79.5023)	(-6.5933)	(3.1099)									
12.63690	-0.000399	2.33E-06	-5.31E-10								0.3847
(38.4447)	(-2.7513)	(1.2853)	(-0.8327)								
12.57698	-0.000359	1.48E-06	1.76E-10	-1.92E-13							0.3817
(22.5161)	(-1.0759)	(0.2214)	(0.0328)	(-0.1329)							
11.03862	-0.000197	4.90E-07			-8.67E-05	-0.079004	0.153793	0.108054	0.149693	0.091438	0.4679
(32.3920)	(-4.5117)	(1.8138)			(-3.0189)	(-2.2604)	(2.8132)	(1.6676)	(2.9768)	((2.5941)	
11.56817	-0.000193	4.67E-07			-8.51E-05	-0.078202	0.146280	0.104867	0.155968	0.094909	0.4567
(33.4508)	(-4.3571)	(1.7003)			(-2.9208)	(-2.2048)	(2.6368)	(1.5948)	(3.0563)	(2.6533)	
11.67047	-0.000193	4.69E-07			-8.43E-05	-0.074476	0.141295	0.103538	0.160576	0.093570	0.4457
(33.4190)	(-4.2954)	(1.6930)			(-2.8648)	(-2.0794)	(2.5222)	(1.5593)	(3.1161)	(2.5905)	

Table 2b - 1993: Second Half

c	disctr	d2	d3	d4	area	sew	tel	revy	lhd	tpt	R^2
12.14092 (143.475)	-0.000184 (-15.3117)										0.4610
12.3159 (75.2996)	-0.000236 (-5.4483)	3.19E-07 (1.2499)									0.4620
13.04156 (40.6018)	-0.000574 (-4.2125)	4.75E-06 (2.7731)	-1.65E-09 (-2.6152)								0.4734
12.2498 (21.9322)	-8.47E-05 (-0.2696))	-5.04E-06 (-0.8532)	6.04E-09 (1.3458)	-2.04E-12 (-1.7296)							0.4772
11.07392 (54.8372)	-0.000128 (-8.2736)				-3.85E-05 (-3.5627)	0.117288 (3.1494)	0.158425 (2.8921)	1.52E-05 (1.9340)	0.771420 (2.9195)	0.034639 (1.6562)	0.5368
11.79232 (57.7466)	-0.000133 (-8.4615)				-4.04E-05 (-3.6943)	0.124538 (3.3070)	0.153231 (2.76620	1.34E-05 (1.6856)	0.742582 (2.7792)	0.020188 (0.9545)	0.5318
12.07194 (58.1196)	-0.000136 (-8.5423)				-4.20E-05 (-3.7728)	0.129219 (3.3734)	0.150860 (2.6775)	1.28E-05 (1.5821)	0.729549 (2.6844)	0.004739 (0.2203)	0.5249

Table 2c - 1994: First Half

c	disctr	d2	d3	d4	area	sew	revzon	tel	dst	revx	R^2
12.12681	-0.000186										0.4588
(126.659)	(-14.2692)										
11.97571	-0.000144	-2.53-07									0.4587
(65.9352)	(-3.2399)	(-0.9790)									
12.92405	-0.000557	4.79E-06	-1.71E-09								0.4790
(37.3959)	(-4.0907)	(3.0190)	(-3.2025)								
12.82822	-0.000449	3.65E-06	-8.49E-10	-2.17E-13							0.4769
(21.3996)	(-1.5265)	(0.6083)	(-0.1919)	(-0.1958)							
11.36302	-0.000136				-0.000162	0.142891	-0.084731	0.106513	0.157016	3.53E-05	0.6140
(43.4477)	(-10.9790)				(-7.3207)	(3.3485)	(-1.8852)	(2.1050)	(2.5762)	(3.0072)	
12.17483	-0.000164				-0.000162	0.142112	-0.083288	0.103473	0.157319	3.57E-05	0.6149
(46.5526)	(-11.0586)				(-7.3224)	(3.3303)	(-1.8531)	(2.0450)	(2.5812)	(3.0368)	
12.58465	-0.000167				-0.000162	0.140226	-0.080817	0.097018	0.158841	3.64E-05	0.6156
(48.0459)	(-11.2025)				(-7.3073)	(3.2811)	(-1.7954)	(1.9144)	(2.6022)	(3.0945)	

Table 2d - 1994: Second Half

c	disctr	d2	d3	d4	area	sew	acc	ame	ele	hot	R^2
12.18519	-0.000192										0.4417
(144.652)	(-15..9936)										
12.21242	-0.000200	4.70E-07									0.4401
(80.0239)	(-5.1730)	(0.2141)									
12.70935	-0.000429	2.97E-06	-1.03E-09								0.4450
(43.1951)	(-3.5036)	(1.9824)	(-1.9721)								
12.27465	-0.000106	-4.53E-06	5.56E-09	-1.87E-11							0.4456
(25.6619)	(-0.3446)	(-0.6788)	(0.9683)	(-1.1523)							
13.10942	-0.000380	2.87E-06	-9.84E-10		-8.80E-05	0.095755	-0.397799	0.450681	0.295956	-1.705054	0.5385
(20.7697)	(-3.3755)	(2.0614)	(-2.0088)		(-4.0081)	(2.2346)	(-4.5051)	(2.8440)	(3.8013)	(-2.8166)	
13.98660	-0.000374	2.81E-06	-9.70E-10		-8.99E-05	0.096110	-0.396641	0.448764	0.288368	-1.723114	0.5378
(22.0616)	(-3.3141)	(2.0127)	(-1.9727)		(-4.0743)	(2.2330)	(-4.4722)	(2.8194)	(3.6987)	(-2.8339)	
14.51158	-0.000367	2.73E-06	-9.51E-10		-9.25E-05	0.096690	-0.395119	0.445442	0.278931	-1.741009	0.5345
(22.6347)	(-3.2100)	(1.9336)	(-1.9123)		(-4.1456)	(2.2214)	(-4.4054)	(2.7674)	(3.5378)	(-2.8314)	

Table 2e - 1995: First Half

c	disctr	d2	d3	d4	revx	revy	tel	sew	R^2
11.93461	-0.000135								0.1724
(90.1844)	(-6.1365)								
12.13870	-0.000204	5.19E-07							0.1693
(33.0430)	(-1.7183)	(0.5957)							
13.22390	-0.000782	9.87E-06	-4.61E-09						0.1724
(14.3734)	(-1.6826)	(1.3478)	(-1.2861)						
15.65952	-0.002621	5.78E-05	-5.61E-08	1.93E-11					0.1784
(8.4107)	(-2.0035)	(1.7667)	(-1.6286)	(1.5029)					
11.57092	-0.000102				-2.25E-05		-0.160320	0.242276	0.2248
(36.0825)	(-3.9000)				(-1.8984)		(-1.8644)	(3.4769)	
12.43772	-0.000102				-2.28E-05		-0.159135	0.242771	0.2259
(38.7878)	(-3.8998)				(-1.9165)		(1.8508)	(3.4842)	
13.08320	-0.000102				-2.25E-05		-0.163454	0.241410	0.2246
(40.7998)	(-3.9247)				(-1.8949)		(-1.9010)	(3.4646)	

Table 2f - 1995: Second Half

c	disctr	d2	d3	d4	revx	revy	revzon	frt	R^2
12.08510 (90.8635)	-0.000143 (-7.0907)								0.2094
12.56790 (40.8949)	-0.000312 (-3.1531)	1.29E-06 (1.7405)							0.2180
11.59236 (22.9259)	0.000293 (1.0873)	-9.52E-06 (-2.0961)	5.75E-09 (2.4116)						0.2380
11.65691 (16.7929)	0.000220 (0.3656)	-7.13E-06 (-0.3922)	2.76E-09 (0.1254)	1.24E-12 (0.1361)					0.2338
11.53893 (41.2325)	-6.46E-05 (-2.3473)				-2.70E-05 (-2.3963)	2.34E-.05 (2.0197)	0.131531 (2.0000)	-0.006806 (-3.5138)	0.2959
12.41900 (44.2460)	-6.51E-05 (-2.3557)				-2.65E-05 (-2.3504)	2.35E-05 (2.0229)	0.137546 (2.0852)	-0.006751 (-3.4751)	0.2971
13.12625 (46.2301)	-6.46E-05 (-2.3134)				-2.61E-05 (-2.2837)	2.31E-05 (1.9708)	0.146281 (2.1923)	-0.006736 (-3.4278)	0.2938

Table 2g - 1996: First Half

c	disctr	d2	d3	d4	revx	revy	tpt	wat	R^2
12.39648 (39.2757)	-0.000188 (-4.1957)								0.3156
11.90118 (13.4391)	-2.60E-05 (-0.0948)	-1.19E-06 (-0.5994)							0.3029
8.67561 (3.2900)	0.001591 (1.2469)	-2.59E-05 (-1.3523)	1.17E-08 (1.2970)						0.3166
13.11361 (1.9840)	-.001463 (-0.3356)	4.78E-05 (0.4672)	-6.28E-08 (-0.6155)	2.68E-11 (0.7332)					0.3069
12.5504 (22.6312)	-8.29E-05 (-1.8278)				-9.76E-05 (-4.0177)	6.97E-.05 (3.5530)	0.332849 (2.5619)	-0.275177 (-1.7664)	0.5511
13.48856 (24.2270)	-8.02E-05 (-1.7620)				-9.90E-05 (-4.0612)	7.16E-05 (3.6357)	0.348113 (2.6688)	-0.2777191 (-1.7724)	0.5546
14.27540 (25.5430)	-7.64E-05 (-1.6710)				-0.000101 (-4.1268)	7.42E-05 (3.7508)	0.367070 (2.8035)	-0.279229 (-1.7786)	0.5599

Figure 1

Map of the City of Cracow

1 - Central - Srodmiescie

2 - South Side Podgorze

3 - West Side Krowodrza

4 - East Side Nowa Huta

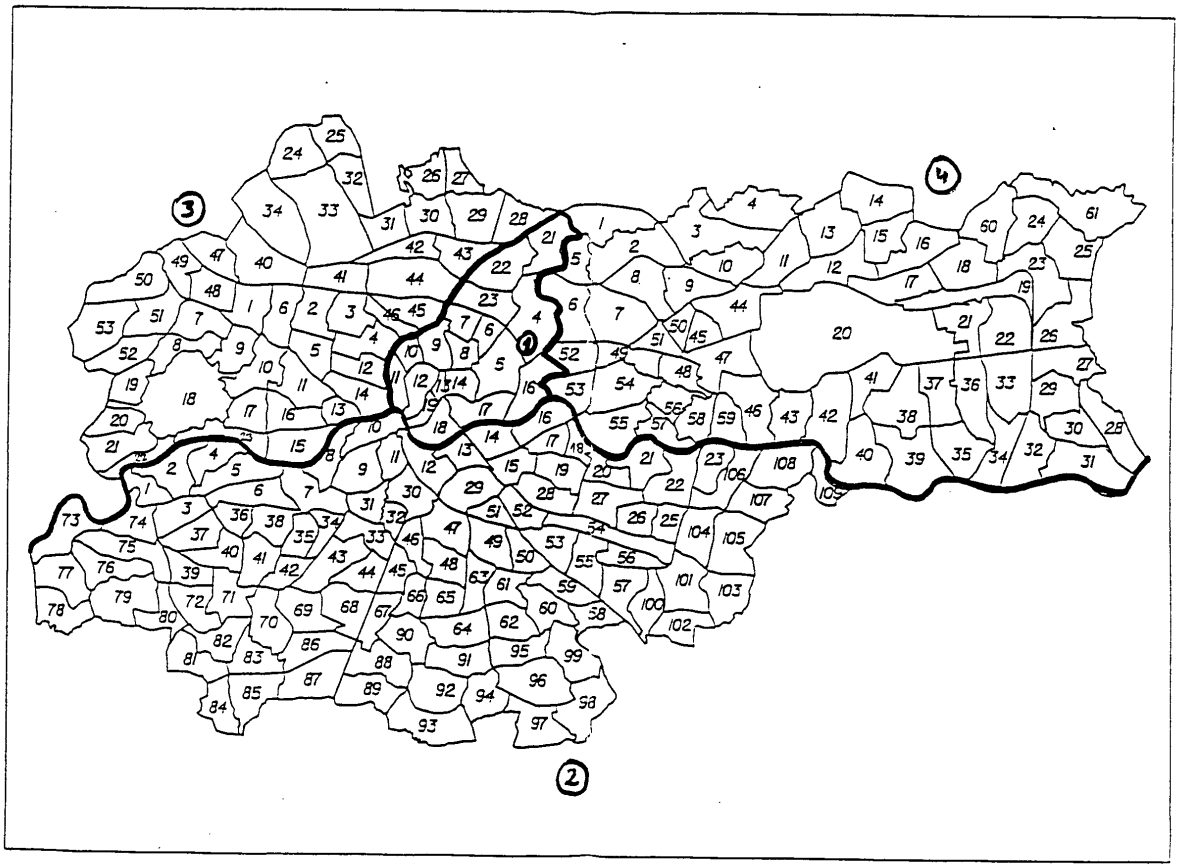

Figure 2 - Scatter Plots - 1994, First Half

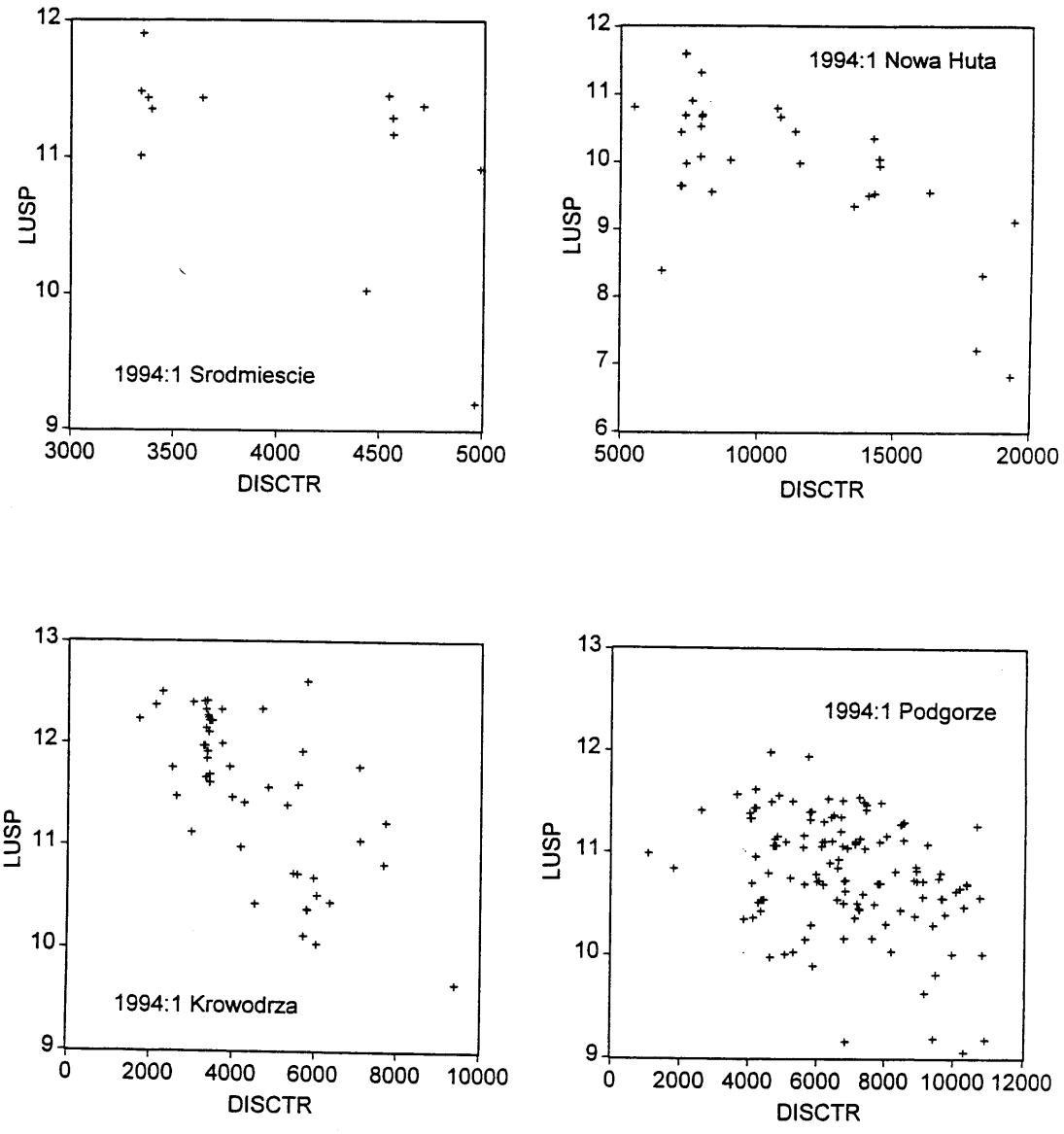

Table 3 - 1994: First Half - by District

	c	disctr	area	sew	obreb	lhd	acc	revzon	wat	det	dpt	R^2
District 1	13.37009 (12.0864)	-0.000559 (-2.0935)										0.2199
District 2	11.47409 (76.4486)	-9.50E-05 (-4.4923)										0.1205
District 2	10.85971 (50.9517)	-9.69E-05 (-2.7868)	-0.000125 (-5.1563)	0.220008 (5.7104)	0.005617 (2.3542)	0.432814 (2.5506)	-0.307953 (-3.5552)					0.4770
District 3	12.97364 (59.1267)	-0.000320 (-6.8136)										0.4663
District 3	11.51776 (22.7659)	-8.87E-05 (-1.8661)			-0.30074 (-5.6735)			0.169010 (2.1288)	0.203167 (1.8849)	-0.125507 (-2.8727)		0.7298
District 4	11.78715 (28.6758)	-0.000167 (-4.7753)										0.4052
District 4	11.77656 (50.7844)	-9.24E-05 (-4.5422)	-0.000103 (-2.8554)			0.796590 (2.3963)					-0.010602 (-4.9946)	0.8334