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The Cost of Right-of-Way Acquisition for Transportation Projects: Switching Models for Condemnation versus Negotiated Settlement

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The Cost of Right-of-Way Acquisition for Transportation Projects: Switching Models for Condemnation versus Negotiated Settlement

by

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Dedication

This thesis is dedicated to my parents and husband.

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Preface

This thesis develops an endogenous switching regression model to anticipate whether condemnation is likely and what acquisition costs will be (as paid to property owners). The work reflects the fact that parcels acquired through negotiation and those requiring condemnation involve distinct acquisition procedures (e.g., administrative settlement vs. court trial), with significant cost differences regularly emerging across these two regimes. The two-regime endogenous switching model is later extended to a three-category case, allowing for differential cost estimates across negotiation-deed and administrative settlement stages, along with condemnation cases.

A model of property acquisition times, from initial-offer date to possession date is also developed, and its estimates highlight the effects of condemnation on acquisition duration. Prolonged acquisition proceedings generally entail added costs for acquiring agents and those they serve.

The analysis is based on data exported from the Texas Department of Transportation's Right of Way Information Systems (ROWIS) between fiscal years 2008 and 2011. Much of the content developed here is summarized in a paper co-authored with Dr. Kara Kockelman, and titled "The Cost of Right-of-Way Acquisition: Recognizing the Impact of Condemnation via a Switching Regression Model". This research has been presented at the 2012 Annual Meeting of the Transportation Research Board in Washington, D.C., and will be submitted for archival journal review and publication.

Abstract

The Cost of Right-of-Way Acquisition for Transportation Projects: Switching Models for Condemnation versus Negotiated Settlement

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The costs of acquiring parcels by condemnation are usually significantly higher than those for property acquired by negotiation, suggesting that Right-of-Way (R/W) acquisition costs may best be described by two different regression equations. This paper develops a switching regression model of acquisition cost to simultaneously predict the probability of whether a parcel will go to condemnation rather than be acquired via negotiation and the corresponding acquisition costs under these two regimes. The error terms of the selection equation and the two cost equations follow a trivariate normal distribution to reflect correlations across unobserved factors (such as a land owner's tenacity or a site's view value).

When this model is calibrated using data on properties acquired across the state of Texas for transportation projects between 2008 and 2011, results suggest that R/W appraisers and staff should pay special attention to commercially used parcels in urban areas involving a partial taking with a relatively small remainder. Comparison of cost estimates between the two regimes (condemnation vs. negotiation) suggests that condemned parcels will have, on average, 78% higher acquisition costs across the 1,710 acquired properties and 51% greater price variation. These results suggest that it is much

more costly to acquire a property and more difficult to accurately predict its costs if it cannot be acquired via negotiation. The application of model estimates to an example corridor highlights the value of simulation to capture all modeling uncertainties.

This two-regime model is further extended to a three-category multinomial endogenous switching, allowing for differential cost estimates across negotiation-deed, administrative settlement, and condemnation contexts. A model of acquisition time -- from the agency‘s initial-offer date to its final possession date is also developed, to examine the effects of condemnation on acquisition duration. The results suggest that condemnation proceedings add approximately 7 to 8 months, on average, to parcel acquisitions by the Texas Department of Transportation.

Taken together, such switching models for condemnation versus negotiated settlement highlight the benefits of avoiding condemnation proceedings in R/W acquisition. Estimation results illuminate the relative importance of various parcel and owner attributes, impacting the nature and cost of acquisition, and enhancing opportunities for R/W staff to identify more contentious properties and establish more reliable budget estimates.

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CHAPTER 1: THE COST OF RIGHT-OF-WAY ACQUISITION

INTRODUCTION

Public construction projects often require that government agencies acquire real property (real estate or some interest therein), or Right-of-Way (R/W) acquisition (FHWA, 2011). In the case of travel corridors, R/W acquisition can be divided into five phases: planning, valuation (appraisal), negotiation, property management, and relocation (TxDOT, 2008). Once valuation (appraisal) is approved internally, R/W staff makes an initial offer to the associated property owner and negotiation between the two parties begins. Government agencies can typically acquire a desired property via either negotiation (including administrative settlement and other negotiation options) or condemnation (such as a commissioners hearing or a court trial) [1] (FHWA, 2009). Figure 1 describes the typical acquisition process in Texas (Caldas et al., 2011). As transportation agencies are required to "expedite acquisition, minimize litigation, and promote public confidence in Federal and federally-assisted land acquisition programs" (49 CFR Part 24), condemnation proceedings (brought under the power of eminent domain[2]) will not be initiated unless negotiation fails (FHWA, 2010).

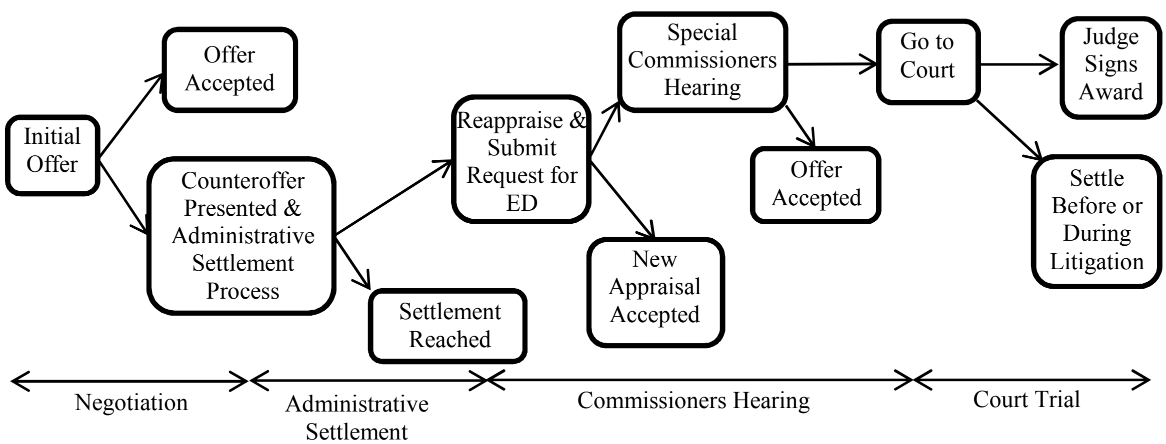

Figure 1: Major Milestones in the R/W Acquisition Process in Texas (Caldas et al., 2011)

[1]It should be noted that as soon as a condemnation action is filed, the possession type is classified as condemnation no matter how the case is later settled (e.g., some cases could have been settled prior to court awards) (FHWA, 2009).

[2] Eminent Domain (ED) is "the right of a government to take private property for public use" (FHWA, 2002, p. 3).

"Just compensation" (based on properties' fair market values) must be paid under federally-funded programs and projects (FHWA, 2002, p. 4). These compensation fees, as well as other costs associated with R/W acquisition (e.g., utility relocation and relocation assistance), can be very expensive. FHWA data for fiscal year 2010 shows that the federal government spent approximately $1.5 billion (or $67,200 per taking) on properties acquired, with an extra $26 million and $45 million on residential and non-residential displacements, respectively (FHWA, 2011a). Approximately 20% of these takings were settled by condemnation, and this percentage is higher in states like Florida (42.9% between 1991 and 1994) where property owners' legal fees are paid by the acquiring agencies (FHWA, 2011b). The condemnation proceeding can add significantly to acquisition and administrative costs (including attorney fees and court costs) and result in significant time delays attributed to the additional stages in the condemnation process. For example, between 2006 and 2010, condemnation awards added an average of 35.3 to 98.7 percent to the Texas Department of Transportation's (TxDOT's) initial approved value for purchasing a parcel (Caldas et al., 2011). Parcels acquired through condemnation in Texas' Austin district also averaged 8-month longer acquisition periods between 2005 and 2009 (Le, 2009). These acquisition delays can result in project cost escalation, due to the effects of inflation (Anderson, 2009). Accurate prediction of a parcel's acquisition type (negotiation vs. condemnation) and attendant costs are useful for project budgeting and completion.

BACKGROUND AND LITERATURE REVIEW

As discussed above, parcels taken by condemnation tend to entail significantly higher acquisition costs than those obtained via negotiation, which can be modeled using an endogenous switching regression. Such model allows for a variety of differences in property cost relationships, while leaving the condemnation outcome naturally endogenous to the model. This section reviews related literature on condemnation rates, R/W cost estimation, and switching regression model applications (in other contexts).

Condemnation Rates

TxDOT acquired from 1,183 to 2,580 parcels a year between fiscal years (FY) 2006 and 2010, with 14.4% of these parcels acquired by condemnation. This condemnation rate is less than the FHWA-reported (2011b) US average of 20% -- presumably under FHWA-sponsored projects. 14.4% is actually rated “high” under Hakimi and Kockelman’s (2005) review of US condemnation rates, though it sits on the edge of “moderate”. Specifically, commercial properties are reported to have higher condemnation rates when compared to properties in other uses (averaging 23.3% for commercial use properties in Texas, vs. 9.6% for other land uses), because they contain expensive improvements and their parking spaces, access points, and internal traffic patterns are often affected by R/W acquisition (Caldas et al., 2011). Access-rights-only parcels, where no physically property is actually acquired, (especially those with access restricted to right-turn-in, right-turn-out) also commonly head to condemnation, along with parcels that involve partial takings, since such acquisitions usually lead to disputes over damages to remainders[3]. FHWA representatives also indicate that property owners' occupation, personal emotions towards the project, and emotional ties to their properties can also play a role in cause for condemnation (Caldas et al., 2011).

Some researchers have examined which factors impact condemnation rates around the U.S. Hakimi and Kockelman (2005) compared state condemnation statutes and found that laws on compensable items, uneconomic remnants, quick and early takings, land consolidation, and land exchange can significantly impact condemnation rates nationwide. Their logistic model of state condemnation rates suggests that more urbanized states with higher education attainment and Republican Party affiliation have higher rates of condemnation, after controlling for other state characteristics – such as the share of federally owned land and total rural highway mileage per capita. Similarly, Kades (2008) found that the presence of water and hills (geography), high density of population, and fee-shifting statutes offer statistically significant explanatory power in condemnation rates nationwide. Caldas et al. (2006) employed descriptive statistics to analyze the probability of condemnation at the parcel level and identified five influential factors: project type (e.g., interchange vs. freeway widening), land use type, taking type (whole or partial), existence of improvements, and parcel location. However, they were unable to obtain sufficient R/W data to estimate parameters for robust regression models.

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[3]A remainder is the portion of a property that is not acquired by the agency, and arises in the case of partial takings (FHWA, 2002).

To date, no published model has analyzed condemnation likelihoods at the level of individual properties/parcels. Such models can help determine which parcels carry higher risk of condemnation, along with ultimate project costs, while allowing for correlation in unobserved components (across the model's two stages).

Cost Estimation

R/W cost estimates are supposed to "capture all costs that affect the expense of acquiring the needed property" (Anderson 2009, Appendix E, p. 2) and typically include the values of taken land (based on highest and best land uses), improvements (e.g., buildings, outdoor signs, and parking lots), damages to properties in partial takings, utility relocations, and occupant relocation assistance (Heiner and Kockelman, 2005). Early estimates often simply use a percent-based procedure (i.e., applying a fixed share of estimated construction costs to anticipate R/W costs or a unit-cost approach (i.e., multiplying land areas by an average R/W unit cost estimate, typically based on historical data) and do not take into account location-specific factors (e.g., improvements, damages, or access issues), which partly explains common cost escalations experienced on projects (Anderson, 2009).

Accurate estimates are usually difficult to obtain due to various uncertainties (especially in appraisal and damages from partial takings) (Anderson, 2009). Formal property appraisals can play an important role in determining final acquisition costs (Heiner and Kockelman, 2005), because inaccurate appraisals can undermine public trust in federal land acquisition practices while increasing the odds of condemnation and incidental costs (e.g., legal costs and staff time). Unfortunately, appraisals can be far from true market valuations due to incomplete data access and collection and/or subjective biases and other limitations on the part of appraisers. Related to this notion, the average percentage increase from initial appraisal value to actual compensation paid to property owners by TxDOT between 2006 and 2010 was 19% for parcels taken by administrative settlement and 67% for parcels taken by condemnation (Caldas et al., 2011). State laws [4] and other distinguishing features (such as environmental, social, and political

[4]For example, since the case of Kelo v. City of New London (2005), some states have enacted laws that provideproperty owners with additional payments in acquisition and/ or relocation beyond the Uniform Act requirements (including "supercompensation" payments that are based on 100% of fair market value plus a certain percentage [e.g., 25% for homestead taking and 50% for heritage taking in Missouri]) (FHWA, 2007).

characteristics), project and parcel complexity, as well as human factors affecting owner-agency interactions also affect overall acquisition costs (Anderson, 2009).

Hedonic price models are widely used in property-value estimation. These typically employ least-squares regression and may decompose property value into individual components (like land and improvements). Variables characterizing property locations are almost always included in such models, since land values can vary tremendously as a function of access. These location characteristics can be categorized into two major types: proximity or cost to reach to certain attractions (such as a central business district [CBD] or high-quality schools and parks), and local neighborhood features (such as population and employment densities) (Gelfand et al., 2004; Brandt, 2010; Iacono and Levinson, 2009; Paiser, 1987; and Sanda, 2010).

Many studies focus on how transportation improvements may impact local property values. For example, Iacono and Levinson (2009) studied the property-sale-price impacts of several updated highways in Minnesota between 1997 and 2007. Their hedonic home-sales model for Hennepin found that home prices were negatively impacted, with price drops varying from 5% (for those within 1/4 mile) to 2% (between 3/4 mile and one mile). Billings (2011) examined the impact of light rail transit (LRT) corridors in Charlotte, North Carolina using sales transaction data from 1994 to 2008. They found positive "capitalization" (value increases) of 4.0% for single-family properties and 11.3% for condominiums within one mile of LRT stations, but, strangely, no capitalization for commercial properties. Related research includes papers by Bina and Kockelman (2009), Carey (2001), Haider and Miller (2000), Srour et al. (2002), TenSiethoff and Kockelman (2002), and Vadali and Sohn (2001).

The type and size of adjacent roadways also impacts property values. Peiser (1987) developed several hedonic models to examine non-residential land values in Dallas, Texas using sales transactions between 1978 and 1982. They estimated that a corner location for industrial land has approximately 46% higher value than a mid-block location for the same general land use. Industrial sites fronting major arterials and expressways enjoyed, on average, 43% and 68% price premia, respectively, relative to such values along a minor street. Ten Siethoff and Kockelman (2002) estimated that commercial properties in Austin, Texas with signalized, corner locations carried approximately $67,000 higher per-acre land values, plus $5.63higher built-space values, per square foot, using data points between 1982 and 1999.

The distance to a region's CBD is regularly a very strong predictor of property values (Haider and Miller, 2000; Kockelman, 1997). McMillen (2003) studied this relationship using single-family houses transactions in the City of Chicago from 1983 to 1998. His hedonic model results suggested that house values declined by approximately 3.8% per added mile of distance from the CBD. Abelson (1997) found that home prices and distance to CBD generally followed a negative exponential relationship in Sydney, Australia (from 1931 to 1989). Peiser (1987) tested for significant differences among regression equations for commercial, industrial and office use land price using sales data from 1978 to 1982 in Dallas, and concluded that distance to CBD had a greater impact on the value of office land than on commercial land, and it did not significantly affect industrial land values.

Importantly, this rich literature on property valuation does not address *public* takings, by public agencies for public uses, which typically involve only parts of parcels. In recent years, 90 to 95 percent of state DOT acquisitions in Texas and Pennsylvania were partial takings (Caldas et al., 2011), usually involving relatively complex contexts – such as split and irregularly-shaped remainders, changes in highest and best property uses, and diminished access. Heiner and Kockelman (2005) developed a model of acquisition costs for properties (and pieces of properties) along Texas corridors. Taken area, remainder area and improved square footage were interacted with variables like year of acquisition, land use type, and parcel location (by county) to reflect unit costs on land and improvements. Their results suggest that retail uses carried the greatest acquisition costs, per acre. Locations, the taking of any improvements, and damages to remainders (especially a change in the parcel's highest and best use, but also a change in shape or reduction of parcel frontage) were very practically (and statistically) significant. However, they did not account for cost differentials that emerge between negotiated and condemned properties.

Buffington et al. (1995) examined the effects of remainders (and their characteristics) on acquisition costs in Texas using least-squares regression. They found variables such as the ratio of the size of taking to the total parcel size, parcel location (especially in suburban areas), reductions in highest and best use, remainder's shape and size, and access point/driveway locations to significantly affect acquisition costs of partial takings. Several cost studies also exist for purchase of property owner's access rights, using either least-squares regression or summary statistics (e.g., Gallego [1996], Kockelman et al. [2003], and Westerfield [1993]). Access costs for TxDOT between 1981 and 1993 averaged $289 and $736 per linear foot, for rural and urban access purchases, respectively, but varied tremendously, with standard deviations as high as $812 per linear foot across all access-right purchases (Kockelman et al., 2003).

Various tools have been developed to assist planning level R/W cost estimation, such as Virginia DOT's Project Cost Estimation System (PCES) (which estimates all project-related costs) (VDOT, 2005) and Georgia DOT's ROW and Utility Estimation Tool (RUCEST) (GDOT, 2007). Kockelman et al. (2006) developed a spreadsheet-based R/W cost estimation tool for TxDOT to assist engineers and planners in project feasibility analysis. In addition to generating least-squares regression estimates of parcel-by-parcel costs, the tool provides average unit costs for comparable parcels (as available in thousands of past-project records). Krugler et al. (2010) designed a program named "TAMSIM" to simulate TxDOT's R/W acquisition process, with cost estimates based on lognormal distributions for Texas metropolitan, urban, and rural areas (which are designations based on regional population levels). The program requires users input an anticipated percentage of condemned parcels to estimate the additional cost of condemnation proceedings, but without controlling for various property features.

Switching Regression Model Applications

Switching models are widely used in contexts with two or more regression equations to describe the behavior of distinct agents or settings (Maddala 1983), such as Lee's (1978) union-nonunion-wage model and Trost's (1977) housing-demand model (for owner-occupied vs. rental housing). Such models have two levels, to decide which regime an observational unit falls into (based on one or more latent state variables), and to describe the behaviors in each regime. Generally, switching regression models can be divided into several types based on the nature of the data: with sample separation known or unknown (i.e., observed or unobserved regimes) and with endogenous or exogenous switching (i.e., with or without correlation across the two model levels) (Maddala, 1986). In the R/W acquisition context, a switching regression with known sample separation and endogenous switching makes the best sense[5]. This functional specification

[5]This is because the R/W cost sample can be segmented into two observed regimes (condemnation and negotiation) and the cost of a certain parcel should correlate with its acquisition type due to several latent attributes.

is provided later in the thesis. Such models have been used in other transportation contexts, but not in R/W acquisition. For example, Abdelwahab and Sargious (1991) estimated freight mode choice (truck vs. rail) and corresponding shipment size. Meurs (1993) modeled household car ownership and trip generation (for 0-vehicle, 1-vehicle and 2-or-more-vehicle households) using panel data. Bhat (1993) modeled wife's employment status and household car ownership (for wife-employed vs. wife-unemployed households).

CHAPTER SUMMARY

This chapter introduced the motivation for this thesis, providing background and a discussion of related research for estimating R/W acquisition costs. Parcels taken by condemnation tend to entail significantly higher acquisition costs than those obtained via negotiation (Caldas et al., 2011), and a two-regime model allows for various differences in property cost relationships, while leaving the condemnation outcome naturally endogenous to the model. Simpler methods, such as least-squares models (Buffington et al., 1995; Heiner and Kockelman, 2005; Kockelman et al., 2006) and binary logistic models (Hakimi and Kockelman, 2005; Kades, 2008), have been used in the past, for estimation of R/W costs and condemnation rates, respectively. The following chapters describe the data used to operationalize this thesis' switching regression models for property acquisition by TxDOT, the models specification, results, conclusions and model extensions – including some results on the duration of individual property acquisitions.

CHAPTER 2: DATA ASSEMBLY

The sample used for the switching model's estimation was exported from TxDOT's Right of Way Information Systems (ROWIS), for all 2,380 acquisitions occurring between September1 of 2008 and January 14 of 2011, covering 81 of Texas' 254 counties. Only data records (parcels) with both "acquisition type" (condemnation or negotiation) and "total amount paid" values were viable for use here. Other possession methods – such as through owner donations, options to purchase, or local public agency acquisition – were not included in the analysis, since these are relatively unique and represent only 5.3% of the total. Access-rights-only parcels (just 1.2 percent of the total) were also dropped because the amount of land affected or "taken" (for access purposes) was not available. Finally, some parcel records were of questionable use, since their settlement type and possession type were recorded inconsistently (e.g., "administrative settlement" showed in the "Settlement type" column but "condemnation" appeared in the "Possession type" column). Dropping all of these cases yielded a final sample of 1,710 parcels for model estimation here.

Table 1 presents the numbers of parcels in this final sample by district and TxDOT-defined region (TxDOT, 2009). Over the 2008 through February 2011 time period, 66 percent of all sample acquisitions were in the northern region (falling primarily in the Dallas district, with 39 percent of sample records). Waco and Houston acquisitions are also very prominent in the data set (with 14 and 8.8 percent of records, respectively). The districts in bold represent the areas with the most takings and for the most part, they coincide with the largest cities in Texas. Figure 1 shows the locations of the Texas regions and data set parcels (the number of parcels acquired at each district in the sample is presented below the abbreviation of each district).

Table 1: Locations of Sample Parcels

Region	District	Number of Parcels by District	Number of Parcels by Region
North	Atlanta	59	1,129
	Brownwood	7	
	Dallas	**669**	
	Fort Worth	**138**	
	Paris	4	
	Tyler	3	
	Waco	**241**	
	Wichita Falls	8	
South	Austin	28	265
	Corpus Christi	49	
	Laredo	43	
	Pharr	41	
	San Antonio	**92**	
	Yoakum	12	
East	Beaumont	37	242
	Bryan	14	
	Houston	**151**	
	Lufkin	40	
West	Abilene	0	74
	Amarillo	14	
	Childress	4	
	El Paso	43	
	Lubbock	1	
	Odessa	11	
	San Angelo	1	

Note: Districts with the most takings showed in bold.

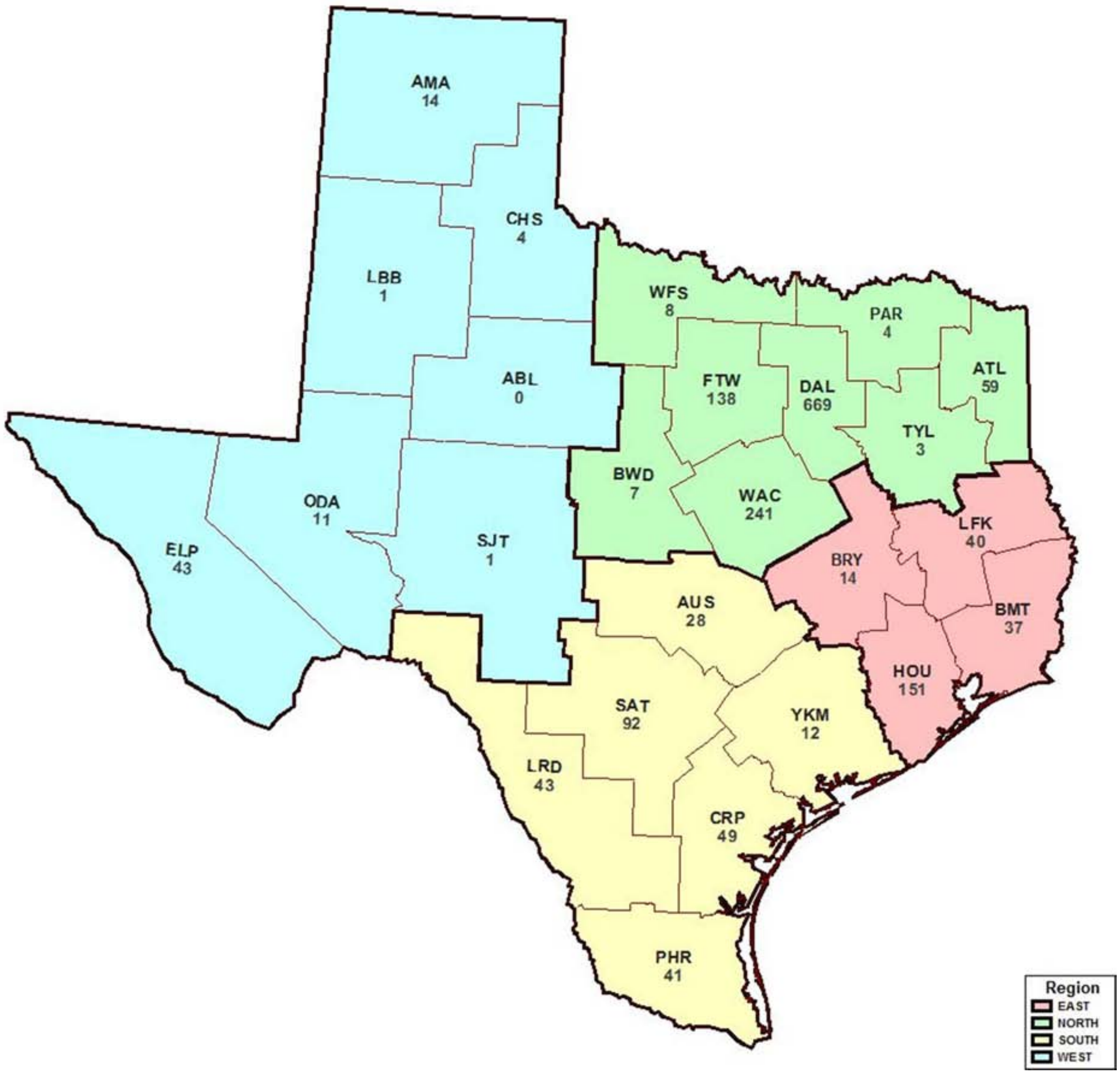

Figure 2: Locations of Texas Regions and Sample Parcels

ROWIS provides information on each taking's "total" acquisition cost (rather than land and improvements separately), acquisition type and parcel characteristics (e.g., size, county, land use type, and ownership type). Details on the nature and size of improvements taken or presence and magnitude of damages caused to remainders are not available in the database, so such attributes are not controlled for here. It should be noted that acquisition costs include only the amount paid to the original property owners for land, improvements (if taken), and damages caused to the reminder (as offered by the DOT and accepted by the property owner or as determined in a court of law); it does not include the value of other costs involved in the acquisition process (e.g., appraisal fees, relocation assistance, attorneys' fees, and project-delay costs, to the extent these exist). Dollar values were adjusted for inflation using the U.S. Consumer Price Index (BLS 2011), to arrive at January 2011 dollars. Table 2 provides descriptions and associated statistics for all variables used.

Table 2: Summary Statistics of ROWIS Data Sample for Parcels Acquired by Negotiation and Condemnation between 2008 and 2011 in Texas (n_{obs} = 1,710)

Variables	Description	Average	Std. Dev
Condemnation	Parcel possession type is condemnation	0.15	0.36
TotalCost	Total acquisition cost ($ 2011 January)	2.36e+05	7.91e+05
LnTotalCost	Natural log of total cost	10.58	1.98
TakenSF	Land area of part acquired (sf)	4.94e+04	1.59e+05
RemainderSF	Land area of remainder parcel (sf)	1.44e+07	4.74e+08
TimeTrend	Trend variable for year of acquisition (1=2008, 2=2009, 3= 2010, & 4=2011)	2.31	0.69
North	Indicator for northern region of Texas	0.66	0.47
South	Indicator for southern region of Texas	0.15	0.36
East	Indicator for eastern region of Texas	0.14	0.35
West	Indicator for western region of Texas	0.04	0.20
PopDensity	Population density (at county level) per square mile (U.S. Census, 2010)	795.73	852.81
Agriculture	Indicator variable for agricultural land use	0.09	0.29
Residential	Indicator variable for residential land use	0.26	0.44
Commercial	Indicator variable for commercial, retail and service land uses	0.35	0.48
OtherUse	Indicator variable for other land use (e.g., ecclesiastical, industry, education, multi-use, and special use)	0.06	0.24
Vacant	Indicator variable for vacant land	0.24	0.42
PartialTaking	Indicator variable for parcel left with a remainder	0.90	0.30
Ratio	Fraction of taken area to total area	0.20	0.31
Individual	Indicator variable for private individual ownership type	0.51	0.50
Corporation	Indicator variable for corporation and partnership ownership types	0.38	0.49
OtherOwnership	Indicator variable for other ownership types (e.g., federal agency, state agency, and municipality)	0.10	0.30

Table 3 presents differences in summary statistics of acquisition costs between the two acquisition types (condemnation vs. negotiation), indicating that condemned parcels average higher purchase costs (per square foot and in total). This feature of the data, along with the fact that such properties involve distinct acquisition procedures (e.g., administrative settlements rather than court awards) suggest that such costs may best be described using separate regression equations.

Table 3: Acquisition Costs by Acquisition Type between 2008 and 2011 in Texas (n_{obs} = 1,710)

Possession Type	Number of Parcels	Acquisition Cost per Square Foot			Total Acquisition Cost		
		Max.	Avg.	Std. Dev.	Max.	Avg.	Std. Dev.
Negotiation	1,457	$75.10	$19.50	$49.90	$16.1M	$203k	$762k
Condemnation	253	$982	$42.80	$94.70	$8.77M	$422k	$917k
All Parcel Acquisitions	1,710	$982	$23.00	$59.30	$16.1M	$236k	$791k

Tables 4 through 6 summarize acquisition cost details across key parcel categories: geographical regions (North, South, East, and West), land use types (Agriculture, Residential, Commercial, Vacant, and Other land use) and ownership types (Individually held, Corporate ownership, and Other ownership types). Table 4 suggests that most parcels were acquired in the Northern Texas and exhibit the highest average acquisition costs (per SF and total). Such parcels also enjoy lower condemnation likelihood, as compared to those in Texas' Eastern region. Commercially-used parcels and those held by corporations more often entailed condemnation and exhibited the highest acquisition costs, on average (per square foot) (Tables 5 and 6). The effects of these parcel characteristics on acquisition type and cost will be examined simultaneously using the switching regression model specified in the next chapter.

Table 4: Acquisition Costs by Region between 2008 and 2011 in Texas (n_{obs} = 1,710)

Region	Number of Parcels	% Condem-nation	Acquisition Cost per Square Foot			Total Acquisition Cost		
			Max	Average	Std. Dev.	Max	Average	Std. Dev.
North	1,129	14.9%	$982	$27.8	$69.7	$13.8M	$260k	$774k
East	242	21.9%	$250	$16.5	$30.0	$16.1M	$229k	$1.21M
South	265	10.9%	$146	$9.80	$17.7	$3.04M	$160k	$340k
West	74	4.0%	$347	$17.4	$42.2	$1.46M	$152k	$235k
All Regions	1,710	14.8%	$982	$23.0	$59.3	$16.1M	$236k	$791k

Table 5: Acquisition Costs by Land Use Type between 2008 and 2011 in Texas (n_{obs} = 1,710)

Land Use Types	Number of Parcels	% Condem-nation	Acquisition Cost per Square Foot			Total Acquisition Cost		
			Max	Average	Std. Dev.	Max	Average	Std. Dev.
Agriculture	161	9.30%	$77.50	$1.80	$7.30	$1.98M	$83.6k	$255k
Residential	440	8.90%	$516	$16.80	$45.20	$2.03M	$62.3k	$125k
Commercial	597	23.30%	$982	$46.30	$87.00	$8.77M	$368k	$808k
Vacant	402	12.20%	$67.90	$6.50	$8.00	$16.1M	$212k	$881k
Other Use	88	8.00%	$85.80	$11.10	$13.60	$13.8M	$610k	$1.89M
All Land Use Types	1,710	14.80%	$982	$23.00	$59.30	$16.1M	$236k	$791k

Note: "Commercial Use" includes Commercial, Retail Store, Service, Strip Shopping Center; "Other Use" includes Ecclesiastical, Industry, School, Multi-Use, Special-Use, etc.

Table 6: Acquisition Costs by Ownership Type between 2008 and 2011 in Texas (n_{obs} = 1,710)

Ownership Type	Number of Parcels	% Condem-nation	Acquisition Cost per Square Foot			Total Acquisition Cost		
			Max	Average	Std.Dev.	Max	Average	Std.Dev.
Individual	878	12.9%	$476	$14.6	$35.9	$5.24M	$121k	$328k
Corporation	657	18.3%	$981	$36.2	$82.7	$16.1M	$341k	$969k
Other Type	175	11.4%	$397	$15.3	$33.4	$13.8M	$419k	$1.38M
All Ownership Types	1,710	14.8%	$982	$23.0	$59.3	$16.1M	$236k	$791k

Note: "Other Type" includes Federal Agency, State Agency, Municipality, Non-profit Organization, Utility Company, Trust, etc.

CHAPTER SUMMARY

This chapter describes how the final sample was extracted from Texas ROWIS records for model estimation (as presented in the following chapter) and describes various property attributes evident in the final sample, based on summary statistics. It also summarizes acquisition cost details across key parcel categories (geographical regions, land use types, and ownership types). The next chapter describes model specifications and estimation results in detail.

CHAPTER 3: MODEL ESTIMATION

This chapter describes the binary endogenous switching regression model specification used to estimate R/W acquisition costs (for negotiated settlements vs. property obtained via condemnation). It then presents (and discusses) all estimation results, along with the two-outcome model's extension to a three-outcome case (allowing for differential cost estimates across negotiation-deed and administrative-settlement acquisitions, within the negotiation regime). In addition, results of a model for each property's acquisition duration are presented, in the process highlighting the additional costs that appear to accompany most cases of condemnation, by delaying R/W acquisition.

Appendices A and B provide MATLAB code for additional analysis of the binary endogenous switching regression results (initially estimated using STATA). Appendix A provides the estimates of elasticities and marginal effects for various attributes, and Appendix B compares acquisition cost estimates for negotiation vs. condemnation regimes. Appendix C presents OxMetrics[6] code for estimating the three-category endogenous switching model. All equations coded in MATLAB and OxMetrics are provided in the body of this thesis.

BINARY ENDOGENOUS SWITCHING MODEL SPECIFICATION

Maddala and Nelson's (1975) endogenous-switching regression model (as described in Maddala [1983]) was used here, to predict the probability of a parcel being acquired via negotiation or condemnation, and the corresponding acquisition costs under these two regimes. Such models allow for correlation in unobserved attributes between acquisition type and acquisition payment (e.g., a sophisticated land owner lobbying for higher payment and more likely to take the case to court, or an oddly shaped parcel fetching a lower appraisal [and DOT offer] but also requiring a more complicated legal process to support the value assessment). The model can be written as follows:

[6]Timberlake Consultants. http://www.oxmetrics.net/.

If $\gamma' Z_i + u_i > 0$, parcel i will go to condemnation, with $Condemn_i = 1$.

If $\gamma' Z_i + u_i \leq 0$, parcel i will go to negotiation, with $Condemn_i = 0$.

If $Condemn_i = 1$, acquisition cost $Y_{1i} = x'_{1i}\beta_1 + \varepsilon_{1i}$.

If $Condemn_i = 0$, acquisition cost $Y_{2i} = x'_{2i}\beta_2 + \varepsilon_{2i}$.

In this model, Z_i is a vector of parcel *i*'s characteristics that affect whether the property will go to condemnation or be acquired via negotiation. These include attributes like parcel location and land use type, parcel size, taking type (partial vs. whole taking) and ownership type (e.g., individual versus corporate owner). Vectors x_{1i} and x_{2i} are parcel characteristics affecting acquisition cost (e.g., a time trend variable for the year of acquisition, population density of the local area, land use type, taking type, and remainder area). Improvement attributes (such as building square footage variables) were not controlled for here since these are not made available in ROWIS. Y_{1i} and Y_{2i} are the dependent variables for acquisition costs (total paid to property owners) under the two regimes (but observed only in one regime for each acquired property). Vectors of parameters to be estimated are γ, β_1 and β_2, along with correlations in the cross-equation covariance matrix (as described below). The error terms (ε) represent unobserved attributes that affect outcomes, which could include any odd shape or severe slope of the parcel, more specific land use types (e.g., gas station or restaurant), and parcel location details (such as mid-block or corner).

Here, the natural-log transformation of acquisition costs (*Y*) and land area variables (*TakenSF* and *RemainderSF*) were used to ensure the non-negativity of cost estimates while dampening rightward skew of the cost data. The model assumes that the three random error terms (u_i, ε_{1i} and ε_{2i}) follow a trivariate normal distribution with a mean vector of zeros and the following covariance matrix:

$$\Omega = \begin{bmatrix} \sigma_u^2 & \sigma_{1u} & \sigma_{2u} \\ \sigma_{1u} & \sigma_1^2 & \text{n/a} \\ \sigma_{2u} & \text{n/a} & \sigma_2^2 \end{bmatrix} \quad (1)$$

The covariance terms between $\varepsilon_{1i}$and $\varepsilon_{2i}$are not defined (n/a) since properties are never acquired both by condemnation and negotiation. The first variance σ_u^2 is normalized to one to ensure statistical identification of parameters. The model can be estimated by the full information maximum likelihood (FIML) procedure, with observation *i*'s likelihood written as follows[7]:

$$\begin{aligned} Lik_i &= \Pr(Cost_i = y_i \& Condemn_i = 0 \text{ or } 1) \\ &= [\Pr(y_i = y_{1i}, Condemn_i = 1)]^{Condemn_i} \cdot \\ &\quad [\Pr(y_i = y_{2i}, Condemn_i = 0)]^{1-Condemn_i} \\ &= [\Pr(y_i = y_{1i}) \cdot \Pr(Condemn_i = 1 \mid y_i = y_{1i})]^{Condemn_i} \cdot \\ &\quad [\Pr(y_i = y_{2i}) \cdot \Pr(Condemn_i = 0 \mid y_i = y_{2i})]^{1-Condemn_i} \end{aligned} \quad (2)$$

Given $u_i \sim \mathrm{N}(0,1)$, $\varepsilon_{ji} \sim \mathrm{N}(0, \sigma_j^2)$ and ε_{ji} and u_i has the bivarate normal distribution, the conditional mean and variance of u_i given $\varepsilon_{ji} = \varepsilon_{j0}$ ($\varepsilon_{j0} \in R$) is:

$$\mu_{u_i|\varepsilon_{ji}=\varepsilon_{j0}} = \mu_{u_i} + \rho_{ju}\sigma_u \frac{(\varepsilon_{ji} - \mu_{\varepsilon_{ji}})}{\sigma_j}, \quad \sigma_{u_i|\varepsilon_{ji}=\varepsilon_{j0}} = \sigma_u\sqrt{1-\rho_{ju}^2}, \quad j = 1, 2 \quad (3)$$

where $\rho_{ju} = \sigma_{ju}/\sigma_u\sigma_j$ is the correlation coefficient between ε_{ji} and u_i.

The conditional probability function of acquisition type given cost can be expressed as follows:

$$\Pr(y_i = y_{ji}) = \Pr(y_i = x_{ji}'\beta_j + \varepsilon_{ji}) = \frac{1}{\sigma_j}\phi\left(\frac{y_i - x_{ji}'\beta_j}{\sigma_j}\right) \quad (4)$$

$$\begin{aligned} \Pr(Condemn_i = 1 \mid y_i = y_{ji}) &= \Pr(u_i | \varepsilon_{ji} = \varepsilon_{j0} > -\gamma' Z_i) \\ &= \Phi\left(\frac{\gamma' Z_i + \rho_{ju}(y_i - x_{ji}'\beta_j)/\sigma_j}{\sqrt{1-\rho_{ju}^2}}\right) \end{aligned} \quad (5)$$

[7]See Lokshin and Sajaia(2004) and Maddala (1983) for more detailed estimation procedures.

$$\Pr\left(Condemn_i = 0 \mid y_i = y_{ji}\right) = \Pr\left(u_i \middle| \varepsilon_{ji} = \varepsilon_{j0} \le -\gamma' Z_i\right)$$

$$= 1 - \Phi\left(\frac{\gamma' Z_i + \rho_{ju}(y_i - x'_{ji}\beta_j)/\sigma_j}{\sqrt{1-\rho_{ju}^2}}\right) \qquad (6)$$

where $\phi(\ )$ and $\Phi(\ )$ represent the standard normal density and cumulative distribution functions, respectively; and j =1, 2 represents condemnation and negotiation regimes, respectively.

MODEL ESTIMATION AND RESULTS

Table 7 shows all model parameters, as estimated using STATA's least-squares command and its “Movestay” module (Lokshin and Sajaia, 2004). Table 7's first column shows ordinary least squares (OLS) regression parameter estimates for the natural log of acquisition cost as the dependent variable, using a single-equation (single regime) to represent all 1,710 parcels at once, without any switching. The second, third, and fourth columns present the parameter estimates for the binary acquisition-type equation (condemnation or not) and the two acquisition cost equations (for parcels that were acquired via condemnation or negotiation), respectively. The OLS parameter estimates are similar to those estimated for acquisition by negotiation, in large part because negotiation is farmore common than condemnation in the data set (1,457 -- or 85 percent -- of the 1,710 acquired properties). Nevertheless, the likelihood-ratio test for joint independence indicates a very statistically significant (at the 0.01 level) correlation between acquisition type and final acquisition costs, underscoring the value of a two-regime model for these data. Moreover, all of the switching regression model’s retained explanatory variables are statistically significant (at the 0.10 level).

Table 7: Estimation Results of Binary Endogenous Switching Model for R/W Acquisition Type and Final Acquisition Cost

Model	(1) OLS	(2)	(3)	(4)
		Endogenous Switching Regression		
			Regime 1 (Condemn. =1)	Regime 2 (Condemn. =0)
Variables	Acquisition Cost	Condemnation Model (1 or 0)	Acquisition Cost for Condemned Parcels	Acquisition Cost for Negotiated Parcels
(Constant)	4.139 (23.24)	-2.426 (-9.07)	4.452 (3.56)	4.099 (20.19)
Taken Area				
ln(TakenSF)	0.385 (19.27)	-	0.363 (6.85)	0.387 (17.36)
ln(TakenSF)×TimeTrend	0.057 (6.86)	-	0.053 (2.42)	0.055 (5.59)
ln(TakenSF)×PopDensity ($\times 10^3$)	0.086 (19.34)	0.033 (6.15)	0.062 (4.58)	0.080 (14.75)
ln(TakenSF)×North	0.057 (3.26)	0.053 (2.65)	-	0.062 (3.06)
ln(TakenSF)×East	-	0.108 (5.12)	-	-
ln(TakenSF)×South	-	0.073 (3.47)	-	-
ln(TakenSF)×Residential	0.079 (6.66)	-	0.077 (2.31)	0.078 (5.73)
ln(TakenSF)×Commercial	0.173 (8.60)	0.038 (3.64)	0.268 (6.73)	0.139 (5.77)
ln(TakenSF)×Vacant	0.101 (9.25)	-	0.108 (3.40)	0.100 (7.99)
ln(TakenSF)×OtherUse	0.136 (8.88)	-	0.111 (2.02)	0.139 (8.12)
Remainder				
PartialTaking	1.611 (8.25)	1.107 (3.95)	1.389 (2.67)	1.474 (5.87)
ln(RemainderSF)	-	-0.085 (-4.19)	-	-
ln(RemainderSF)×TimeTrend	-0.041 (-6.99)	-	-0.045 (-2.60)	-0.036 (-5.05)
ln(RemainderSF)×North	-0.074 (-5.39)	-	-	-0.080 (-5.11)
ln(RemainderSF)×East	-0.051 (-6.27)	-	-	-0.065 (-6.88)
ln(RemainderSF)×Commercial	0.033 (2.44)	-	-	0.044 (2.70)
Ownership Type				
Individual		0.302 (2.02)		
Corporation		0.430 (2.21)		
Sigma			1.138 (14.71)	1.207 (31.99)
Corr. Coef.			0.068(0.15)	-0.570 (-2.76)
Dependent Variable	ln (Cost)			
Number of Obs.	1710 (253 condemnation parcels; 1457 negotiation parcels)			
LRI	0.227			
LR test of Independent Eqns.	11.21> 9.21(χ^2 at 99% confidence level with 2 restrictions)			

Table 8 presents estimates of different explanatory variables' elasticities (for continuous variables) and marginal effects (for indicators) on acquisition costs per square foot, across each of the different land use types (agricultural, residential, commercial, vacant, and all other uses).

Note that in calculating such elasticities and marginal effects, all parcels were changed to the land use of interest for each of the columns in Table 8 for easy comparison across all sample records. This ensured a large sample of values for averaging, resulting in more stable and comparable estimates (though there may be special features about different land uses that will shift these average elasticiteis, in actual applications). Elasticities of continuous variables quantify the percentage change in estimated acquisition cost per square foot (of taken land) associated with a one-percent change in the covariate X_k, while the marginal effects of indicator variables characterize the (estimated) change in expected cost per square foot (of taken land) after changing the binary attribute X_k from 0 to1. The marginal effects of these variables on the probability of condemnation were also calculated, to characterize their practical significance in predicting acquisition type, as shown in Table 9. The elasticities and marginal effects can be written as follows:

$$\text{Elasticity (Cost per sq ft)} = \frac{\partial \log(\text{Cost per sq ft})}{\partial \log(x_k)} \tag{7}$$

$$\text{Marginal Effect (Cost per sq ft)} \\ = [Cost(\text{per sq ft}) \mid x_k = 1, x_*] - [Cost(\text{per sq ft}) \mid x_k = 0, x_*] \tag{8}$$

$$\text{Marginal Effect (Prob)} \\ = \Pr(Condemn. = 1 | x_k = 1, x_*) - \Pr(Condemn. = 1 | x_k = 0, x_*) \tag{9}$$

Elasticities were computed for each parcel's record, and then averaged across sample record values, providing overall/population-wide elasticity averages (rather than simply point estimates of elasticities computed at mean or median values of all covariates). Marginal effects were computed by first estimating individual parcel costs and probabilities (of condemnation) at both x_k=0 and x_k=1, then differencing these values, and finally averaging those differences across the sample, for each case of a binary covariate k.

Table 8: Elasticities and Marginal Effects of Various Attributes on Parcel Acquisition Costs ($/sq ft): Negotiation vs. Condemnation

Elasticity/ Marginal Effects on Cost per Square Foot	Agriculture	Residential	Commercial	Vacant	Other Use	Average
Negotiation Regime (Condemn. = 0)						
PopDensity	0.55%	0.55%	0.55%	0.55%	0.55%	0.55%
TakenSF	-0.38%	-0.30%	-0.24%	-0.28%	-0.24%	-0.29%
RemainderSF	-0.13%	-0.13%	-0.10%	-0.13%	-0.13%	-0.12%
Time Trend	$0.58	$1.30	$2.54	$1.66	$2.44	$1.71
Location (TxDOT-defined region [2009]) ***(Base: North Texas)***						
Non-North	-$6.60	-$9.66	-$18.53	-$11.45	-$15.22	-$12.29
Taking Type ***(Base: Partial Taking)***						
WholeTaking	-$0.56	-$0.72	-$5.84	-$0.73	-$0.72	$1.17
Base Cost[1]						
Cost per sq ft	*$8.66*	*$15.11*	*$28.62*	*$17.94*	*$23.95*	*$18.86*
Condemnation Regime (Condemn. = 1)						
PopDensity	0.42%	0.42%	0.42%	0.42%	0.42%	0.42%
TakenSF	-0.47%	-0.39%	-0.20%	-0.36%	-0.36%	-0.36%
RemainderSF	-0.10%	-0.10%	-0.10%	-0.10%	-0.10%	-0.10%
Time Trend	-$0.35	-$0.39	$0.59	-$0.28	-$0.36	-$0.16
Location (TxDOT-defined region [2009]) ***(Base: North Texas)***						
Non-North	-[2]	-	-	-	-	-
Taking Type ***(Base: Partial Taking)***						
WholeTaking	-$1.58	-$2.46	-$7.29	-$2.81	-$3.37	-$3.50
Base Cost[1]						
Cost per sq ft	*$8.92*	*$16.18*	*$80.75*	*$22.56*	*$26.34*	*$30.95*

Notes: 1) ***Base cost*** values are the average of predicted acquisition costs (in $/sq ft) over all sample records' estimates, after making each record's land use type reflect the associated column label (i.e., agriculture, residential, commercial, vacant, and other uses). 2) "-"denotes variables that were considered but not statistically significant at the 0.25 level and not included in the final regression models. Here it means there is no significant difference in acquisition cost ($/sq ft) among four regions of Texas for condemned parcels, ceteris paribus.

Table 9: Marginal Effects of Indicator Attributes on Probability of Condemnation

Marginal Effects on Prob(Condemn.=1)	Non-Commercial	Commercial	Average
Location (TxDOT-defined region [2009]) ***(Base: North Texas)***			
East	10.9%	14.3%	12.6%
South	3.5%	4.9%	4.2%
West	-5.9%	-9.1%	-7.5%
Taking Type ***(Base: Partial Taking)***			
Whole Taking	-1.6%	-2.0%	-1.8%
Ownership Type ***(Base: Individual-Ownership Type)***			
Corporation	2.7%	3.4%	3.0%
Other Owner	-4.5%	-6.5%	-5.5%
Base Case			
Prob(Condemn.=1)	*39.0%*	*52.6%*	*45.8%*

Notes:
1) Marginal effects on probability of condemnation were calculated by non-commercial and commercial use (rather than all five land use types shown in Table 8) because commercial use is the only ROWIS parcel-use indicator that is statistically significant in predicting the probability of condemnation (Table 7). 2) " - "denotes variables that were considered but not statistically significant at the 0.25 level and not included in the final regression models. Here it means the probability that a non-commercial property (i.e., one that has residential, vacant and other land use) goes to condemnation is not significantly different from that of an agriculturally used parcel, ceteris paribus. 3) Several explanatory variables (including population density, TakenSF, and RemainderSF) were estimated to be practically insignificant for predicting the probability of condemnation, and so are not shown in this table.

Estimates of these elasticities and marginal effects typically rely on simulation of parameter values, rather than simple insertion of mean parameter estimates into equations 7 to 9, which can be misleading. All model parameters were randomly generated 1,000 times assuming a multivariate normal distribution (the maximum-likelihood estimator's asymptotic distribution), and then the probability of condemnation and acquisition costs (for both regimes) were computed for eachparcel with each set of simulated parameter values. Biases due to log-transformation of acquisition costs were essentially removed by using the following log-normal expression:

$$\mathrm{E}(Y) = \mathrm{E}\left(\mathrm{e}^{x'\beta+\varepsilon}\right) = \mathrm{e}^{x'\beta}\mathrm{E}(\mathrm{e}^{\varepsilon}) = \mathrm{e}^{x'\beta}\mathrm{e}^{\sigma^2/2} \quad (10)$$

The next two sections discuss all these estimation results (including the statistical and practical significance of different explanatory variables), along with acquisition cost differences between the two regimes (condemnation and negotiation).

Acquisition Type and Cost Equation Results

As shown in columns 2 through 4 of Table 7, the time trend variable (tracking the year of acquisition) has a positive effect on land values of negotiated acquisitions, suggesting an average increase of $1.71 per square foot per year. The population density variable has a positive effect on both condemnation likelihood and final acquisition costs (a one-percent increase in population density [persons per square mile] is estimatedto trigger a 0.42% to 0.55% increase in costs per square foot [of taken land]); this is as expected, since there are higher property values, generally more educated (and higher income) property owners[8], and presumably better access to legal representation in more densely populated urban counties. As one can see from Table 8, the amount of land taken also has a practically significant impact on acquisition costs. A one-percent increase in taken land is estimated to trigger a 0.29 to 0.36% decrease in cost per square foot (of taken land), presumably thanks to economies-of-scale effects. Specifically, costs per square foot decline most quickly for agricultural land (with an elasticity of -0.38 to -0.47%), and most slowly for commercial land (with an elasticity of-0.20% to -0.24%), among all land uses.

The location indicators for Texas northern, eastern and southern regions are all statistically significant in the OLS (price-paid) and condemnation models, with eastern parcels most often condemned (everything else constant), followed by parcels in southern and then northern locations, all relative to a western location (where land is largely rural in nature and condemnation is least likely, ceteris paribus). An eastern location was estimated to raise the condemnation probabilityby 14% (from 52% to 66%) for properties in non-commercial use, and 11% (from 39% to 50%) for those in commercial use, relative to the state's northern location. These eastern, southern, and northern regions include the state's most populous regions: the Houston, Austin/San Antonio, and Dallas-Ft. Worth metro areas, which contain roughly 6.0, 2.6 and 6.4 million persons, respectively. Interestingly, the results also suggest that eastern Texas

[8]Using Census 2000 data, the correlation between population density and the share of those 25 years and older with a college degree is 0.42 in Texas (254 counties). The correlation is 0.36 between population density and per capita income.

parcels do not enjoy statistically or practically significantly higher acquisition costs (via negotiation or condemnations). Table 8 shows northern locations also tend to result in higher acquisition costs (relative to other locations) if a parcel is acquired by negotiation, with the increased amount varying from $6.60 to $18.53 per square foot for different land uses, everything else constant, reflecting regional differences in land valuation and wealth (in addition to those explained by the model's county-level population density variable). However, such valuation differences are not apparent across the four regions (in any statistically significant way) when such parcels go to condemnation, perhaps because formal, legal proceedings ensure smaller price variation among regions, everything else constant.

As expected, various land uses trigger cost-equation differences. Interestingly, the coefficient estimates are very similar across the two regimes except for cases of commercial use, where the condemnation cost bump is much higher, on average (versus acquisition of commercial porperties via negotiation). Commercial use is also the only ROWIS parcel-use indicator that is statistically significant in predicting the probability of condemnation. Parcels in commercial use averaged a 14% higher condemnation probability than those in non-commercial use (i.e., 53% vs. 39%). Their costs were estimated to be $9.76/sq ft above the average of all land uses if acquired via negotiation and $49.80/sq ft above the average if condemned (see Table 8), everything else constant (including taken area, year of acquisition, county density value, and region indicator). Such jumps can easily mean hundreds of thousands of dollars more for a single property's acquisition. Transportation planners, appraisers, and R/W staff should pay special attention to these properties in the acquisition process (and perhaps during the alignment choice process).

Approximately 90 percent of the sample's parcels involve partial takings, and this indicator has a positive effect on condemnation likelihood and both regimes' acquisition cost estimates, consistent with the expectation that partial takings generally entail damages of some sort (e.g., removal of driveways, parking spaces, buildings, or other improvements). Smaller remainders also increase the chance of condemnation and higher acquisition costs, but without practically significant effects (e.g., a one-percent change in remainder area triggered only a 0.12% change in costs per square foot [see Table 8]).

Partial takings were estimated to increase the condemnation probability by just 2% (i.e., from 44% to 46%), relative to whole takings. Patial takings in commerical use are estimated to increase average acquisition costs by $5.84/sq ft if negotiated and $7.29/sq ft if condemned, everything else constant. The costs of non-commercial properties do not suggest such sizable increases when partial takings occur: they are estimated to average $0.68/sq ft more if acquired via negotiation and $2.56/sq ft more if condemned, relative to whole takings. This is as expected, since commercial properties are generally more improved than those in non-commercial use (e.g., with more parking spaces and buildings on site), and thus tend to experience more damages when acquisitions are partial, rather than whole.

The individual- and corporation-ownership-type variables also appear to increase the condemnation probabilities, by 6% (from 40% to 46%) and 9% (from 40% to 49%), respectively, relative to other ownership types. However, they do not appear to directly affect acquisition costs. It may be that corporations have easier (including in-house) access to legal support in eminent domain cases, but the presence of a legal process levels the playing field, in terms of condemnation awards. Nevertheless, these ownership types can still positively influence acquisition costs (indirectly), since condemnation tends to result in higher model-estimated costs, as discussed in the next section.

The correlation coefficient of error terms between the acquisition-type and negotiation-cost equations is negative and practically (and statistically) significant, yet not statistically significant for the condemnation likelihood-and-cost connection. A priori, one may have expected that unobserved factors leading to condemnation proceedings also lead to higher acquisition costs (e.g., corner parcels with better access may carry a higher risk of condemnation as well as higher value and thus acquisition cost), but that appears to not be the case here. It may simply be that the parcels more likely to be condemned are also less valuable, ceteris paribus, due to unusual features that render the parcels problematic and therefore more contentious (e.g., poor soils, odd shapes and topography, and poor visibility). However, these less-valuable parcels may or may not end up with lower payments if they go to condemnation (e.g., the owners are really attached to their properties and do not want to give them up), since more compensable details can emerge through the process of condemnation (Caldas et al., 2011). The following section further compares differences in acquisition costsbetween the two regimes.

Comparing Acquisition Cost Differences

While the acquisition cost equation for the condemnation regime enjoys a higher constant than the negotiation regime, the estimated coefficients for several explanatory variables and the land-area interacted terms (e.g., time trend, population density, and partial taking indicator) are slightly higher in the negotiation-cost regime, so some negotiated parcels may end with higher acquisition cost estimates. It may be that TxDOT made relatively high initial offers therebyavoiding condemnation proceedings and expediting the R/W acquisition process.

Table 10 compares the estimated costs and their standard deviation across the two acquistion types (condemnation and negotiation). According to the simulation results, 57.9% of sample properties have higher predicted acquisition costs if they were to go to condemnation, with an average increase of $14.7 in acquisition cost per square foot, which is equivalent to an average percentage increase of 77.8% in total cost. This striking estimate suggests *almost a doubling in cost*. The results also show how acquisition costs in the condemnation regime can exhibit substantial variance (averaging of 51.1% greater standard deviation, as compared to values predicted under the negotiation regime). Such findings underscore the notion that condemned parcels may experience higher variation in price (ceteris paribus), so their costs are more difficult to predict accurately.

Table 10: R/W Acquisition Cost Estimates Comparison: Negotiation vs. Condemnation

Acquisition Cost Estimates Comparison (Switching Regression)	Simulation of Betas (n=1000)				Point Estimate
	Average	Std. Dev	Min	Max	
Expected Value[1] of Acquisition Cost					
E(Cost per Square Foot)					
Negotiation	\$20.80	\$1.30	\$17.30	\$26.10	\$20.70
Condemnation	\$35.50	\$28.50	\$3.60	\$209.80	\$26.60
\$ Increase[3] in E(Cost)	\$14.70	\$28.90	-\$18.20	\$187.50	\$5.90
E(Total Cost)					
Negotiation	\$266k	\$23.0k	\$204k	\$351k	\$263k
Condemnation	\$383k	\$243k	\$63.1k	\$2.10M	\$308k
\$ Increase in E(Cost)	\$117k	\$252k	-\$223k	\$1.81M	\$44.9k
% Increase[4] in E(Cost)	77.80%	169.10%	-87.90%	1430.00%	21.40%
% Higher[5] E(Condemn. Cost)	57.90%	35.90%	0.00%	100.00%	59.30%
Standard Deviation[2] of Acquisition Cost					
s.d.(Cost per Square Foot)					
Negotiation	\$37.80	\$2.70	\$30.80	\$49.70	\$37.50
Condemnation	\$56.20	\$42.00	\$7.00	\$324.70	\$43.20
\$ Increase in s.d.(Cost)	\$18.40	\$41.80	-\$33.90	\$288.70	\$5.70
s.d.(Total Cost)					
Negotiation	\$483k	\$40.5k	\$387k	\$643k	\$477k
Condemnation	\$612k	\$359k	\$121k	\$3.34M	\$501k
\$ Increase in s.d.(Cost)	\$129k	\$363k	-\$382k	\$2.84M	\$24.1k
% Increase in s.d.(Cost)	51.10%	131.70%	-86.70%	1326.10%	8.90%
% Higher s.d.(Condemn. Cost)	51.20%	35.00%	0.00%	100.00%	50.50%

Notes:
1, 2) Expected value (E) and standard deviation (s.d.) of acquisition costs were calculated as follows:

$$\mathrm{E}(Y_i) = \mathrm{E}\left(\mathrm{e}^{x'_{ji}\beta_j+\varepsilon_{ji}}\right) = \mathrm{e}^{x'_{ji}\beta_j}\mathrm{E}(\mathrm{e}^{\varepsilon_{ji}}) = \mathrm{e}^{x'_{ji}\beta_j}\mathrm{e}^{\sigma_j^2/2} j = 1,2 .$$

$$\mathrm{s.d.}(Y_i) = \sqrt{\mathrm{Var}(Y_i)} = \sqrt{\mathrm{Var}\left(\mathrm{e}^{x'_{ji}\beta_j+\varepsilon_{ji}}\right)} = \mathrm{e}^{x'_{ji}\beta_j+\sigma_j^2/2}\sqrt{\mathrm{e}^{\sigma_j^2}-1} j = 1,2 .$$

where j=1, 2 represents condemnation and negotiation regime, respectively.
3) "\$ Increase" measures the increase in expected value (or standard deviation) of acquisition cost (per square foot or in total) when a parcel is acquired by condemnation instead of negotiation. 4) "% Increase" measures the percentage increase in expected value (or standard deviation) of acquisition cost (per square foot or in total) when a parcel is acquired by condemnation instead of negotiation. 5) " %Higher" represents the percentage of the parcels which have higher expected value (or standard deviation) of acquisition cost (per square foot or in total) when acquired by condemnation compared with negotiation.

Table 10 also provides point estimates for comparisons (as obtained using mean parameter estimates). These are close to the simulated estimates except for condemnation costs, where fewer data points exist and outcome uncertainties are higher (as discussed earlier). Specifically, while both estimation methods produce similarshares of parcels generating higher condemnation cost (57.9% when simulated and 59.3% when using point estimates), the latter tends to predict a much smaller scale of cost increase (77.8% when simulated and 21.4% when using point estimates) if a parcel cannot be acquired via negotiation. Essentially, the marginal effects of explanatory variables on acquisition costs of condemned parcels involve more uncertainties and are highly variable, which can be a significant source of estimation errors. Such uncertainty is better captured by taking into account the variance and covariance of the parameters (i.e., simulating from their [approximate] distributions). Data analysts should be wary of biases that can arise in interpretating the model results using simple point estimates.

Table 11 shows an applied example of prediction for a 9-parcel corridor in Brazoria County (Houston), highlighting the value of simulation to capture all modeling uncertainties (especially those in the condemnation regime, where simulation generates quite different estimates from use of point estimates). Such predictions could assist R/W staff in identifying potential condemnation settlements and provide possible cost outcomes (recognizing the impact of condmnation), which may help in establishing the basis of cost estimation in R/W acquisition.

Table 11: Application of Switching Regression Model Prediction for 9-parcel Corridor in Brazoria County (Houston)

Property Description	**Parcel #: 1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Total Cost**
Taken Area (sq. ft.)	601	366	349	1,494	2,472	4,648	4,508	11,892	6,591	
Acquisition Year	2009	2009	2008	2009	2009	2009	2008	2009	2008	
Property Use	Vacant Lot	Commercial	Service Station	Commercial	Commercial	Commercial	Retail Store	Commercial	Retail Store	
PartialTaking	1	1	1	1	1	1	1	1	1	
Remainder (sq. ft.)	54,450	277,804	18,382	42,210	52,468	701,926	58,458	854,081	86,075	
Ownership	Individual	Limited Partnership	Limited Partnership	Limited Partnership	Individual	Corporation	Corporation	Limited Partnership	Corporation	
Prob(Condemn. =1)	11.5% *(11.4%)*[1]	15.0% *(14.8%)*	20.7% *(20.5%)*	25.4% *(25.1%)*	23.3% *(23.0%)*	23.4% *(23.1%)*	30.1% *(29.8%)*	27.5% *(27.2%)*	31.0% *(30.7%)*	
Acquisition Type[2]	0	1	0	0	1	1	1	0	1	
E[Cost] [3](Condemn.=0)	$6,312 *($6,278)*	$8,126 *($8,033)*	$10,495 *($10,381)*	$24,242 *($24,072)*	$33,015 *($32,798)*	$39,218 *($38,894)*	$45,411 *($45,049)*	$71,182 *($70,640)*	$55,770 *($55,324)*	
E[Cost] (Condemn.=1)	$17,474 *($10,802)*	$26,232 *($17,818)*	$34,569 *($25,105)*	$82,649 *($60,851)*	$116,632 *($87,108)*	$150,345 *($110,664)*	$183,240 *($142,178)*	$291,416 *($220,270)*	$233,123 *($182,115)*	
Weighted Cost Estimate[4]	$7,601 *($6,796)*	$10,843 *($9,479)*	$15,485 *($13,402)*	$39,053 *($33,306)*	$52,458 *($45,264)*	$65,252 *($55,479)*	$86,909 *($74,011)*	$131,786 *($111,275)*	$110,767 *($94,255)*	$520,154 *($443,268)*
Actual Cost	$5,248	$7,718	$21,083	$22,760	$66,887	$88,110	$107,664	$122,476	$235,836	$677,782
% Difference	44.8% *(29.5%)*	40.5% *(22.8%)*	-26.6% *(-36.4%)*	71.6% *(46.3%)*	-21.6% *(-32.3%)*	-25.9% *(-37.0%)*	-19.3% *(-31.3%)*	7.6% *(-9.1%)*	-53.0% *(-60.0%)*	-23.3% *(-34.6%)*

*Notes:*1) *Point Estimates* are presented as italicized values in parentheses. 2) Acquisition Types 1 and 0 represent condemnation and negotiation, respectively. 3) The Expected value (E) of acquisition costs were calculated as noted for Table 4. 4) The weights for cost estimates of condemnation and negotiation here are their estimated probability of being true, respectively, expressed as: $\text{Weighted Cost} = \Pr(\text{Condemn.} = 1) \cdot E[\text{Cost} \mid \text{Condemn.} = 1] + \Pr(\text{Condemn.} = 0) \cdot E[\text{Cost} \mid \text{Condemn.} = 0]$

EXTENDING THE MODEL: A MULTINOMIAL ENDOGENOUS SWITCHING SPECIFICATION

The binary endogenous switching regression model applied above can be extended to allow for more than two acquisition types. For example, one can classify ROWIS' observations into four regimes: Negotiation-Deed (*j*=0), Negotiation-Admininstrative Settlement (*j*=1), Condemnation-Special Commissioner's Award (*j*=2), and Condemnation-Protracted Process (*j*=3). The selection mechanism could be modelled using a Multinomial Probit Model (MNP), with bivarate normal distributions between the error terms of each selection equation and that regime's corresponding cost equation, as discussed in García-Pérez and Rebollo-Sanz (2005). This extended-switching regression model requires more demanding estimation techniques. García-Pérez and Rebollo-Sanz (2005) discussed a full-information maximum likelihood (FIML) method to estimate such a model across three regimes (to predict wages in three employment contexts). And Preminger et al. (2007) developed an expectation maximization (EM) algorithm to estimate the model with more categories (to forecast exchange rates under different states of the economy). Other approaches are maximum *simulated* likelihood estimation (Train, 2003) and Bayesian techniques. Allowance for more acquisition-type categories in the case of R/W may illuminate other cost differences that emerge, at different stages of the R/W acquisition process.

Considering the limited number of condemned parcels in the sample (253 condemned parcels vs. 1457 negotiated parcels), the model developed here uses multinomial endogenous switching with three outcomes (necessitating just two selection equations and three acquisition cost equations), rather than the four listed above. Observations were thus classified into three regimes: Negotiation-Deed (*j*=0, n_{obs}=1,026), Negotiation-Admininstrative Settlement (*j*=1, n_{obs}=431), and Condemnation (*j*=2, n_{obs}=253). Essentially, the selection process can be written as follows:

$$I_{ji} = \gamma_{ji}{'}Z_i + u_{ji} \qquad (11)$$

$$Y_i = Y_{ki}, \text{ if } I_{ki} = \max\{I_{ji}\}, j = 0, 1, 2. \qquad (12)$$

Here, Equation 10 is the selection equation (or utility expression), where I_{ji} is a latent variable that reflects parcel$i$'s tendency to be acquired under regime-type j. The Z_i represent vectors of parcel i's characteristics affecting the selection process, and u_{ji} are unobserved components of the associated selection equations. Finally,Y_n is the acquisition cost observed under the "winning" regime (i.e., that with the highest I_{ki} value).

Since only utility *differences* are relevant in the selection process, one can take the Negotiation-Deed regime (*j*=0) as a reference, reducing the selection process to two equations:

$$I_{ji}^* = I_{ji} - I_{0i} = \gamma_{ji}^{*\prime} Z_i + u_{ji}^*, \quad j = 1, 2 \tag{13}$$

where $\gamma_{ji}^* = \gamma_{ji} - \gamma_{0i}$ and $u_{ji}^* = u_{ji} - u_{0i}$.

The model assumes the five random random error terms (u_{1i}^*, u_{2i}^*,ε_{0i},$\varepsilon_{1i}$and ε_{2i})[9] follow a multivariate normal distribution with a mean vector of zeros and the following covariance matrix:

$$\Omega = \begin{bmatrix} \sigma_{u_1^*}^2 & \sigma_{u_1^* u_2^*} & \sigma_{\varepsilon_0 u_1^*} & \sigma_{\varepsilon_1 u_1^*} & \sigma_{\varepsilon_2 u_1^*} \\ \sigma_{u_1^* u_2^*} & \sigma_{u_2^*}^2 & \sigma_{\varepsilon_0 u_2^*} & \sigma_{\varepsilon_1 u_2^*} & \sigma_{\varepsilon_2 u_2^*} \\ \sigma_{\varepsilon_0 u_1^*} & \sigma_{\varepsilon_0 u_2^*} & \sigma_{\varepsilon_0}^2 & \mathrm{n/a} & \mathrm{n/a} \\ \sigma_{\varepsilon_1 u_1^*} & \sigma_{\varepsilon_1 u_2^*} & \mathrm{n/a} & \sigma_{\varepsilon_1}^2 & \mathrm{n/a} \\ \sigma_{\varepsilon_2 u_1^*} & \sigma_{\varepsilon_2 u_2^*} & \mathrm{n/a} & \mathrm{n/a} & \sigma_{\varepsilon_2}^2 \end{bmatrix} \tag{14}$$

The covariance terms between ε_{0i}, $\varepsilon_{1i}$and ε_{2i} are not defined (n/a) since the acquisition cost (Y_i) can be observed for only one regime at each property. The first variance $\sigma_{u_1^*}^2$ is normalized to one to ensure statistical identification of parameters.

The likelihood funtion to be estimated has the following form (García-Pérez and Rebollo-Sanz, 2005):

[9] The notations for error terms here are the same as those used in the binary endogenous switching model, where ε_{0i},$\varepsilon_{1i}$and ε_{2i} represent unobserved factors that affect cost outcomes for negotiation-deed, negotiation-administrative settlement, and condemnation parcels, respectively.

$$
\begin{aligned}
Lik_i &= \Pr(Cost_i = y_i \,\&\, j_i = 0, 1, \text{or } 2) \\
&= \prod_{j_i=0} \Pr(y_i = y_{0i}) \cdot \Pr(I_1^* \leq 0, I_2^* \leq 0 | y_i = y_{0i}) \cdot \\
&\quad \prod_{j_i=1} \Pr(y_i = y_{1i}) \cdot \Pr(I_1^* > 0, I_1^* - I_2^* > 0 | y_i = y_{1i}) \cdot \\
&\quad \prod_{j_i=2} \Pr(y_i = y_{2i}) \cdot \Pr(I_1^* > 0, I_1^* - I_2^* \leq 0 | y_i = y_{2i})
\end{aligned} \tag{15}
$$

where $\Pr(y_i = y_{ji})$ describes the cost density function (log-transformation of cost was used for this study), and $\Pr(I_1^* \leq 0, I_2^* \leq 0 | y_i = y_{0i})$, $\Pr(I_1^* > 0, I_1^* - I_2^* > 0 | y_i = y_{1i})$, and $\Pr(I_1^* > 0, I_1^* - I_2^* \leq 0 | y_i = y_{2i})$ are conditional distribution functions for the regime-selection process. The expressions for these terms are as follows:

$$
\Pr(y_i = y_{ji}) = \Pr(y_i = x_{ji}^{'}\beta_j + \varepsilon_{ji}) = \frac{1}{\sigma_j} \phi\left(\frac{y_i - x_{ji}^{'}\beta_j}{\sigma_j}\right), \; j = 0, 1, 2 \tag{16}
$$

$$
\begin{aligned}
&\Pr(I_1^* \leq 0, I_2^* \leq 0 | y_i = y_{0i}) \\
&\quad = \Pr(u_{1i}^* | \varepsilon_{0i} \leq -\gamma_1^{*\prime} Z_i \,, u_{2i}^* | \varepsilon_{0i} \leq -\gamma_2^{*\prime} Z_i) \text{, where}
\end{aligned}
$$

$$
\begin{pmatrix} u_{1i}^* | \varepsilon_{0i} \\ u_{2i}^* | \varepsilon_{0i} \end{pmatrix} \sim N\left(\begin{pmatrix} \rho_{\varepsilon_0 u_1^*} \cdot \sigma_{u_1^*} \cdot \frac{y_i - x_{0i}^{'}\beta_0}{\sigma_0} \\ \rho_{\varepsilon_0 u_2^*} \cdot \sigma_{u_2^*} \cdot \frac{y_i - x_{0i}^{'}\beta_0}{\sigma_0} \end{pmatrix}, \begin{pmatrix} \sigma_{u_1^*}^2 \cdot (1 - \rho_{\varepsilon_0 u_1^*}^2) & \rho_{u_1^* u_2^*} \\ \rho_{u_1^* u_2^*} & \sigma_{u_2^*}^2 \cdot (1 - \rho_{\varepsilon_0 u_2^*}^2) \end{pmatrix} \right) \tag{17}
$$

$$
\begin{aligned}
&\Pr(I_1^* > 0, I_1^* - I_2^* > 0 | y_i = y_{1i}) \\
&\quad = \Pr(-u_{1i}^* | \varepsilon_{1i} \leq \gamma_1^{*\prime} Z_i \,, (u_{2i}^* - u_{1i}^*) | \varepsilon_{1i} \leq (\gamma_1^* - \gamma_2^*)^{\prime} Z_i) \text{, where}
\end{aligned}
$$

$$
\begin{pmatrix} -u_{1i}^* | \varepsilon_{1i} \\ u_{2i}^* - u_{1i}^* | \varepsilon_{1i} \end{pmatrix} \sim N\left(\begin{pmatrix} \rho_{\varepsilon_1(-u_1^*)} \cdot \sigma_{u_1^*} \cdot \frac{y_i - x_{1i}^{'}\beta_1}{\sigma_1} \\ \rho_{\varepsilon_1(u_2^* - u_1^*)} \cdot \sigma_{(u_2^* - u_1^*)} \cdot \frac{y_i - x_{1i}^{'}\beta_1}{\sigma_1} \end{pmatrix}, \right.
$$

$$
\left. \begin{pmatrix} \sigma_{u_1^*}^2 \cdot \left(1 - \rho_{\varepsilon_1(-u_1^*)}^2\right) & \rho_{(-u_1^*)(u_2^* - u_1^*)} \\ \rho_{(-u_1^*)(u_2^* - u_1^*)} & \sigma_{(u_2^* - u_1^*)}^2 \cdot \left(1 - \rho_{\varepsilon_1(u_2^* - u_1^*)}^2\right) \end{pmatrix} \right) \tag{18}
$$

$$\Pr(I_1^* > 0, I_1^* - I_2^* \leq 0 | y_i = y_{2i})$$
$$= \Pr(-u_{1i}^* | \varepsilon_{2i} \leq \gamma_1^{*}{'}Z_i\,, (u_{1i}^* - u_{2i}^*) | \varepsilon_{2i} \leq (\gamma_2^* - \gamma_1^*){'}Z_i), \text{ where}$$

$$\begin{pmatrix} -u_{1i}^* | \varepsilon_{2i} \\ u_{1i}^* - u_{2i}^* | \varepsilon_{2i} \end{pmatrix} \sim N\left(\begin{pmatrix} \rho_{\varepsilon_2(-u_1^*)} \cdot \sigma_{u_1^*} \cdot \frac{y_i - x_{2i}'\beta_2}{\sigma_2} \\ \rho_{\varepsilon_2(u_1^* - u_2^*)} \cdot \sigma_{(u_1^* - u_2^*)} \cdot \frac{y_i - x_{2i}'\beta_2}{\sigma_2} \end{pmatrix}, \right.$$

$$\left. \begin{pmatrix} \sigma_{u_1^*}^2 \cdot \left(1 - \rho_{\varepsilon_2(-u_1^*)}^2\right) & \rho_{(-u_1^*)(u_1^* - u_2^*)} \\ \rho_{(-u_1^*)(u_1^* - u_2^*)} & \sigma_{(u_1^* - u_2^*)}^2 \cdot \left(1 - \rho_{\varepsilon_2(u_1^* - u_2^*)}^2\right) \end{pmatrix} \right) \quad (19)$$

The vector of parameters to be estimated are the coefficients in the cost outcome equation, β_j , and in the acquisition-type (selection) equations γ_j^*; standard deviations of the corresponding error terms,σ_{ε_j} and $\sigma_{u_2^*}$ (where $\sigma_{u_1^*}$ has been normalized to 1 for identification); the correlation coefficient between the selection equations $\rho_{u_1^* u_2^*}$; and all correlation coefficients between the cost and acquisition-type error terms:$\rho_{\varepsilon_0 u_1^*}$, $\rho_{\varepsilon_0 u_2^*}$, $\rho_{\varepsilon_1 u_1^*}$, $\rho_{\varepsilon_1 u_2^*}$, $\rho_{\varepsilon_2 u_1^*}$, and $\rho_{\varepsilon_2 u_2^*}$.

Rather than estimating the variances and correlation coefficients directly, their transformed forms were estimated first, to ensure they lay within valid limits: i.e., logarithms of the standard deviations were used (to ensure non-negativity) and the inverse of the hyperbolic tangent of ρ was used (to ensure that ρ lay between -1 and +1). MNP estimates of the selection equations' parameters and maximum likelihood estimates of the cost outcome equations' parameters (including coefficients and error terms) were used as starting values, before estimating the endogenous switching model's parameters using FIML.

Table 12 presents all parameters of the three-outcome endogenous switching model, as estimated using OxMatrix's maximum likelihood procedure (Doornick, 2011). Table 13 reports the estimated standard deviationsand correlation coefficients. Somewhat unexpectedly, the likelihood-ratio test for joint independence suggests a statistically *in*significant correlation between acqusition type and final acqusition cost. It may be that the parameters were not robustly identified, due to another regime's addition (both negotiated-settlement regimes may be too similar) and the data set being limited to imperfect control variables, as suggested by very low t-statistics for coefficients in the second selection equation I_{2i}^* (as presented under Table 12's condemnation column). Unfortunately, such poorly identified selection equations[10] generally lead to biased parameter estimates in the cost equations (as noted below Table 12).

[10]Various available variables and their interaction terms were tried in the selection equations to reach the final model. For example, rather than using "West" and "OtherOwnership", other region indicators (i.e., north, east, and south) and ownership type indicators (i.e., individuals and corporation) were also tested butseemed to create estimationconvergenceproblems, and so did not enter the final model.

Table 12: Estimation Results of Three-Outcome Endogenous Switching Model for R/W Acquisition Type and Final Acquisition Cost

Model	Variable	Negotiation-Deed		Negotiation-Administrative Settlement		Condemnation	
		Coef.	t-stat.	Coef.	t-stat.	Coef.	t-stat.
Acquisition Cost Outcome Model	Constant	1.778	17.61	2.584	5.43	2.146	4.03
	ln(TakenSF)	0.161	13.87	0.145	7.89	0.153	6.76
	ln(TakenSF)×TimeTrend	0.026	5.71	0.033	3.59	0.023	2.36
	ln(TakenSF)×PopDensity($\times 10^3$)	0.037	15.35	0.049	11.49	0.028	7.45
	ln(TakenSF)×North	-	-	-0.019	-3.33	-	-
	ln(TakenSF)×Residential	0.046	6.73	-	-	0.031	2.14
	ln(TakenSF)×Commercial	0.102	14.29	0.019	1.56	0.109	6.32
	ln(TakenSF)×Vacant	0.059	9.17	-	-	0.045	3.28
	ln(TakenSF)×OtherUse	0.074	8.45	-	-	0.065	3.42
	PartialTaking	0.312	2.73	0.5	1.56	0.605	2.53
	ln(RemainderSF)×TimeTrend	-0.018	-5.47	-0.016	-1.72	-0.02	-2.19
Selection Model	Constant	Base Segment		-1.132	-4.89	-2.954	-0.10
	ln(TakenSF)			0.088	4.78	0.198	0.11
	TimeTrend			-0.131	-2.89	-0.345	-0.10
	West			-0.632	-2.58	-1.166	-0.14
	West×Corporation			0.712	2.38	0.724	0.94
	Commercial			0.183	2.65	0.787	0.08
	Commercial×OtherOwnership[1]			0.172	0.80	0.08	0.05
	Partialtaking			1.207	5.23	2.479	0.12
	ln(RemainderSF)			-0.066	-3.94	-0.174	-0.10
	Partialtaking×OtherOwnership			-0.508	-3.22	-0.733	-0.20
Dependent Variable		ln(Cost)					
Number of Obs.		1710 (1026 = Negotiation-Deed, 431 = Negotiation-Administrative Settlement, and 253 = Condemnation parcels)					
LRI[2]		0.261					
LR test of Independent Eqns. (between cost outcome eqn. & selection eqn.)		6.903<12.592 (chi square at 95% confidence level with 6 restrictions)					

Notes: 1) Although the interaction term of commercial use indicator and other ownership type indicator is not statistically significant in either of the selection equations, it was retained in the final model to ensure convergence. This, however, will result in biased estimates of the parameters (i.e., if the selection equation is not very well identified, then it is likely to result in imprecise estimates in the outcome equation [Sartori, 2003]). 2) LRI was calculated for the switching regression model (ln*L*= -2747.48) versus the constants-only (no-information) model without correlated error terms between cost outcomes and selection equations (lnL_0= -3718.9): LRI=1-(ln*L*/ lnL_0)=0.261.

Table 13: Estimation Results of Error Terms and Correlation Coefficient in Three-Outcome Endogenous Switching Model

Error & Correlation Terms	Parameter	t-stat
Cost Outcome Eqn.		
σ_{ε_0}	0.550	12.10
σ_{ε_1}	0.597	1.85
σ_{ε_2}	0.471	11.74
Cost Outcome & Selection Eqn.		
$\rho_{\varepsilon_0 u_1^*}$	-0.469	-2.74
$\rho_{\varepsilon_0 u_2^*}$	-0.473	-0.45
$\rho_{\varepsilon_1 u_1^*}$	-0.640	-1.56
$\rho_{\varepsilon_1 u_2^*}$	-0.652	-1.51
$\rho_{\varepsilon_2 u_1^*}$	-0.117	-0.11
$\rho_{\varepsilon_2 u_2^*}$	-0.117	-0.17
Selection Eqn.		
$\rho_{u_1^* u_2^*}$	1.000	0.48
$\sigma_{u_2^*}$	2.065	0.09

Somewhat surprisingly, the acquisition cost equation for administrative settlements enjoys the highest constant, followed by those in the condemnation and negotiation-deed equations. Generally, one expects a higher cost estimate if a parcel is condemned, but the other control variables (and their coefficients) can make up for this discrepancy. It may be that although the constants reflect the average cost for each regime to some degree, they also take on other effects related to the range of observed values for the model's exogenous variables. Similar to estimation results from the binary switching model, the time trend variable (tracking the year of acquisition) and population density variable also increase final acqusition costs; moreover, partial takings and commercially used parcels tend to entail a higher probability of condemnation and higher final costs. Parcels located in western Texas and those owned by those other than individuals and corporations are estimated to be the least likely to go to condemnation, followed by administrative settlement, and negotiation-deed.

DURATION MODEL

As noted in Chapter 1, condemnation also tends to delay the acquisition process, resulting in delayed construction and possible project cost escalation (Aleithawe, 2012; Anderson, 2009; and Le., 2009). Identifying important delay factors may help transportation planners and R/W staff speed the acquisition, saving both money and time. For this purpose, a maximum likelihood regression model (rather than a least-squares method, to facilitate simulation of the error term) was developed for acquisition duration (from the DOT's initial-offer date to a parcel's possession date) at the property/parcel level. The estimation results and elasticities/marginal effects of different attributes are presented in Table 14.

Table 14: MLE Estimates for Duration (Days) (Time till Acquisition)

Dependent Variable: ln(Duration) **Number of Obs.:** 964							
Adjusted R-square: 0.349							
Maximum Likelihood Estimates			**Elasticities and Marginal Effects**				
			Simulation Estimate (n=1000)				**Point Estimate**
Variables	**Coef.**	**p-value**	**Average**	**Std. Dev.**	**Min**	**Max**	
(Constant)	4.353	0.000					
TimeTrend	-0.141	0.000	-28d	7d	-48d	-8d	-28d
PopDensity	1.56E-04	0.000	0.119%	0.022%	0.046%	0.189%	0.119%
Parcel Size							
ln(TakenSF)	0.026	0.028	0.026%	0.012%	-0.010%	0.062%	0.026%
ln(RemainderSF)	0.034	0.000	0.033%	0.005%	0.012%	0.050%	0.033%
Land Use Types (Base: Agriculture)							
Residential	-0.087	0.150	-16d	11d	-54d	21d	-16d
Commercial	0.260	0.000	58d	13d	22d	95d	58d
Vacant	-[1]	-					
OtherUse	0.186	0.037	41d	20d	-14d	115d	40d
Location (Base: North Texas)							
West	-0.187	0.133	-34d	22d	-94d	54d	-36d
South	-	-					
East	0.146	0.045	35d	17d	-19d	99d	33d
Ownership Type(Base: All other Types)							
Corporation	0.163	0.001	35d	11d	3d	71d	35d
Individual	-	-					
Possession Type							
Condemnation	1.094	0.000	334d	31d	240d	440d	332d
Base Duration[2]			213d	6d	194d	236d	212d

*Notes:*1) "-"denotes variables that were considered but not statistically significant at the 0.25 level and not included in the final regression models. Here, it means the acquisition durations for vacant and individually owned parcels are not significantly different from those of agriculture use and all other non-corporation ownership type parcels, respectively, ceteris paribus. 2) ***Base duration*** values are the average of predicted duration (in days) over all sample records' estimates.

As suggested in Table 14, condemnation proceedings can significantly lengthen the acquistion process, adding approximately 7 to 8 months for each parcel, on average (as compared to the sample's base case/negotiation-only conditions, which averaged approximately 7 months).

This is as expected, since condemnation proceedings entail commissioners hearings and (oftentimes) court trials. Similar to the cost results obtained above, commericial-use properties, eastern-Texas locations, and corporation-ownership-type indicators are all statistically significant (at the 0.05 level) and practically significant, with the average acquisition time increased by approximately one to one-and-a-half months after changing these binary attributes from 0 to 1. It may be that properties in commerical use are usually improved, with more items likely to lead to price disputes, such as diminished access and parking spaces). Corporate owners often have more legal support (relative to other ownership types) and may tend to disagree more often with the approved appraisal, hoping for higher payments and lengthening the negotiation process.

A switching regression was also performed for acquisition durations under the two regimes (negotiation vs. condemnation), but its parameters were not robustly identified, apparently due to greater variation in acquisition durations and the data set being limited to imperfect control variables. As Gibson et al. (2006) alluded, duration may also be more challenging to predict than acquisition cost due to variations introduced by title curative issues (e.g., deceased owners, multiple ownership, and bankruptcy), legal activities (e.g., coordination of attorneys, witnesses, meeting places, judges, court reporters, and R/W personnel), and other resource- or manpower-related delays.

CHAPTER SUMMARY

This chapter described estimation of binary endogenous switching regression model for acquisition costs using ROWIS FY 2008 to 2011 data. This two-regime model was then extended to a three-category multinomial endogenous switching model, allowing for differential cost estimates across multiple stages of R/W acquisition. Finally, a duration model was estimated to examine the effects of parcel characteristics on acquisition times. The results showed how condemned parcels averaged 78% higher acquisition costs per acquired property and 51% greater price variation than their negotiated counterparts, and how condemnation proceedings can add approximately 7 to 8 months in property acquisition cases, on average (from initial-offer date to possession date). Parcels in commercial use, with corporate ownership, and/or located in more urbanized areas, were estimated to generally entail higher acquisition costs and longer acquisition duration.

CHAPTER 4: CONCLUSIONS AND EXTENSIONS

This thesis offers a series of meaningful insights for those involved in the R/W acquisiton cost process by highlighting the significant cost disparities that emerge between condemnation and negotiaton regimes. The work developed two acquisition-cost equations with endogenous switching, reflecting the reality that R/W staff and apparisers do not know which properties will require condemnation proceedings. This two-regime model was extended to a three-category multinomial endogenous switching, allowing for differential cost estimates across negotiation-deed and administrative settlement outcomes within the larger negotiation regime.

Model results illuminate the effect of key parcel attributes in predicting R/W acquisiton outcomes, and suggest that R/W appraisers and staff should pay special attention to parcels in commercial use involving a partial taking with a relatively small remainder and located in more urbanized areas. Comparison of the cost estimates between the two regimes (condemnation vs. negotiation) suggest that condemned parcels average 78% higher acquisition costs per acquired property and 51% greater price variation than their negotiated counterparts, at least when relying on recent Texas acquisition data.

The ROWIS data set only offers – and thus the model only predicts – costs paid to the property owners. The model does not anticipate other, less tangible costs that can result from condemnation proceedings, such as delays in construction, a less positive public perception of agencies and their ED projects, and more staff effort and time (including attorneys' fees). As suggested in the maximum likelihood regression results for acquisition duration, condemnation proceeding can significantly lengthen the acquistion process, adding approximately 7 to 8 months for each parcel, on average (as compared to the sample's base case conditions). In future work, such delays may be evaluted as additional "costs"of acquisition.

This work can also be enhanced through various data improvements. Adding more attributes of the acquiring parcels and their remainders (e.g., size and type of any improvements taken, presence and magnitude of damages, shape and use of remainders, and site accessibility) into the model would allow for more thorough analysis. Also, data from non-Texas regions with more generic variables may provide additional insight on effects of regional demographics and other attributes. Another extension to this work is to incorporate more categories of R/W acquisition into the model, illuminating key points entailing significant cost changes at different stages of R/W acquisition. Regardless of the methods used, the costs and time involved are real. If projects are to meet budget targets and agencies are to address project delays, more sophistication is needed in this practice area.

APPENDIX A

MATLAB Code for Calculating Elasticities / Marginal Effects
(Binary Endogenous Switching Model)

```
%Elasticities/Marginal effects using simulation
%Average Partial Effects(across sample observations) for switching regression
model
clear all;

load switchingparm_sim.csv; %load simulated parameters from STATA
load finalparcels.csv; %load sample
load area.csv; %load takensf

parm=switchingparm_sim;
parm=parm';  %transpose(dimension: k*nsimulation)
x=finalparcels;

k1=14;          %number of nego parameters
k2=10;          %number of condem parameters
k3=10;          %number of selection parameters
k4=1;           %amount paid (actual price)
k5=1;           %acquisition type
k=[k1 k2 k3];
N=1710;         %number of parcels
simu=1000;      %number of simulations

%Cost esimates & prob estimates
%nego_x=x(1:N,1:k1);
%condem_x=x(1:N,k1+1:k1+k2);
%select_x=x(1:N,k1+k2+1:k1+k2+k3);

%base case:agriculture case
x_agr = x;
x_agr(:,5:8) = zeros(N,4);
x_agr(:,18:21) =zeros(N,4);
%Residential
x_res = x_agr;
x_res(:,5) = x(:,1);
x_res(:,18) = x(:,1);
%Commercial
x_com = x_agr;
x_com(:,6) = x(:,1);
x_com(:,19) = x(:,1);
x_com(:,13) = x(:,31);
x_com(:,29) = x(:,1);
%Vacant
x_vac = x_agr;
x_vac(:,7) = x(:,1);
x_vac(:,20) = x(:,1);
%Other use
x_oth = x_agr;
x_oth(:,8) = x(:,1);
```

```
x_oth(:,21) = x(:,1);

%Elasticities
%popden:
E(price/popden)=alpha(lntakensf*popden)(parm[3,:])*lntakensf*popden(x[:,3])
for i = 1:N;
    parm_popden_nego(i,:) = parm(3,:);
%dimension:nobs*nsimulation
end
for j = 1:simu;
    x_pop(:,j) = x(:,3);
end
elas_pop_negom = parm_popden_nego .* x_pop;
elas_pop_nego = mean(mean(elas_pop_negom))

for i = 1:N;
    parm_popden_condem(i,:) = parm(17,:);
end
elas_pop_condemm = parm_popden_condem .* x_pop;
elas_pop_condem = mean(mean(elas_pop_condemm))

%takenarea
[elas_taken_nego_agr elas_taken_condem_agr] = elas_taken(x_agr, parm, N);
[elas_taken_nego_res elas_taken_condem_res] = elas_taken(x_res, parm, N);
[elas_taken_nego_com elas_taken_condem_com] = elas_taken(x_com, parm, N);
[elas_taken_nego_vac elas_taken_condem_vac] = elas_taken(x_vac, parm, N);
[elas_taken_nego_oth elas_taken_condem_oth] = elas_taken(x_oth, parm, N);

%remainarea
[elas_remain_nego_agr elas_remain_condem_agr] = elas_remain(x_agr, parm, N);
[elas_remain_nego_res elas_remain_condem_res] = elas_remain(x_res, parm, N);
[elas_remain_nego_com elas_remain_condem_com] = elas_remain(x_com, parm, N);
[elas_remain_nego_vac elas_remain_condem_vac] = elas_remain(x_vac, parm, N);
[elas_remain_nego_oth elas_remain_condem_oth] = elas_remain(x_oth, parm, N);

%timetrend
display('agriculture');
[pred_time_agrb diff_time_nego_agr diff_time_condem_agr] = diff_time(x_agr,
parm, k, N, simu, area);
display('residential');
[pred_time_resb diff_time_nego_res diff_time_condem_res] = diff_time(x_res,
parm, k, N, simu, area);
display('commercial');
[pred_time_comb diff_time_nego_com diff_time_condem_com] = diff_time(x_com,
parm, k, N, simu, area);
display('vacant');
[pred_time_vacb diff_time_nego_vac diff_time_condem_vac] = diff_time(x_vac,
parm, k, N, simu, area);
display('otheruse');
[pred_time_othb diff_time_nego_oth diff_time_condem_oth] = diff_time(x_oth,
parm, k, N, simu, area);

pred_timeb = [pred_tot_agrb; pred_tot_resb; pred_tot_comb; pred_tot_vacb;
pred_tot_othb]
```

```
%north-location
[pred_north_agrb diff_north_nego_agr diff_north_condem_agr] =
diff_north(x_agr, parm, k, N, simu, area);
[pred_north_resb diff_north_nego_res diff_north_condem_res] =
diff_north(x_res, parm, k, N, simu, area);
[pred_north_comb diff_north_nego_com diff_north_condem_com] =
diff_north(x_com, parm, k, N, simu, area);
[pred_north_vacb diff_north_nego_vac diff_north_condem_vac] =
diff_north(x_vac, parm, k, N, simu, area);
[pred_north_othb diff_north_nego_oth diff_north_condem_oth] =
diff_north(x_oth, parm, k, N, simu, area);

pred_northb = [pred_north_agrb; pred_north_resb; pred_north_comb;
pred_north_vacb; pred_north_othb]

%whole-taking
[pred_whole_agrb diff_whole_nego_agr diff_whole_condem_agr] =
diff_whole(x_agr, parm, k, N, simu, area);
[pred_whole_resb diff_whole_nego_res diff_whole_condem_res] =
diff_whole(x_res, parm, k, N, simu, area);
[pred_whole_comb diff_whole_nego_com diff_whole_condem_com] =
diff_whole(x_com, parm, k, N, simu, area);
[pred_whole_vacb diff_whole_nego_vac diff_whole_condem_vac] =
diff_whole(x_vac, parm, k, N, simu, area);
[pred_whole_othb diff_whole_nego_oth diff_whole_condem_oth] =
diff_whole(x_oth, parm, k, N, simu, area);

pred_wholeb = [pred_whole_agrb; pred_whole_resb; pred_whole_comb;
pred_whole_vacb; pred_whole_othb]

%marginal effects on prob(condemnation ==1)
%non-commercial
x_noncom = x;
x_noncom(:,29) = zeros(N,1);

%base probability in the sample
[pred_prob_com prob_est_com] = est_prob(x_com,parm,k,N,simu);
[pred_prob_noncom prob_est_noncom] = est_prob(x_noncom,parm,k,N,simu);

%location
[pred_loc_noncomb diff_loc_noncom] = diff_loc(x_noncom, parm, k, N, simu);
[pred_loc_comb diff_loc_com] = diff_loc(x_com, parm, k, N, simu);

%whole taking
[pred_whole_noncomb diff_whole_noncom] = diff_prob_whole(x_noncom, parm, k,
N, simu);
[pred_whole_comb diff_whole_com] = diff_prob_whole(x_com, parm, k, N, simu);

%ownership type
[pred_own_noncomb diff_own_noncom] = diff_prob_own(x_noncom, parm, k, N,
simu);
[pred_own_comb diff_own_com] = diff_prob_own(x_com, parm, k, N, simu);
```

```
%function to calculate elasticity of takenare
function [elas_taken_nego elas_taken_condem] = elas_taken(x, parm, N)

for i = 1:N;
    x_lntaken_nego(i,:) = x(i,1:8)/x(i,1);
end
parm_taken_nego = parm(1:8,:);
elas_taken_nego = mean(mean(x_lntaken_nego * parm_taken_nego));

for i = 1:N;
    x_lntaken_condem(i,:) = x(i,15:21)/x(i,15);
end
parm_taken_condem = parm(15:21,:);
elas_taken_condem = mean(mean(x_lntaken_condem * parm_taken_condem));

%function to calculate elasticity of remainarea
function [elas_remain_nego elas_remain_condem] = elas_remain(x, parm, N)

x_remain_nego = zeros(N,4);
j = 1;
for i = 1:N;
if x(i,31) ~= 0
        x_remain_nego(j,:) = x(i,10:13)/x(i,31);
        j = j + 1;
else
        x_remain_nego(j,:) = [];                    %remove cases with zero
remainders
        j = j + 0;
end
end
parm_remain_nego = parm(10:13,:);
elas_remain_nego = mean(mean(x_remain_nego * parm_remain_nego));

x_remain_condem = zeros(N,1);
j = 1;
for i = 1:N;
if x(i,31) ~= 0
        x_remain_condem(j) = x(i,23)/x(i,31);
        j = j + 1;
else
        x_remain_condem(j) = [];                    %remove cases with zero
remainders
        j = j + 0;
end
end
parm_remain_condem = parm(23,:);
elas_remain_condem = mean(mean(x_remain_condem * parm_remain_condem));

%function to calculate first difference of timetrend
%timetrend +1 on price (nego & condem)
function [pred_tot_b diff_time_nego diff_time_condem] = diff_time(x, parm, k,
N, simu, area)

%base case (timetrend = observed)
```

```
x_b = x;

[pred_tot_b nego_est_b condem_est_b]=est_cost0(x_b,parm,k,N,simu,area);

%increase timetrend by 1 year for all observations
x_1 = x;
x_1(:,2) = x(:,1) .* (x(:,2) ./ x(:,1) + 1);
x_1(:,16) = x_1(:,2);

for i = 1:N;
if x(i,31) ~= 0
        x_1(i,10) = x(i,31) * (x(i,10) / x(i,31) +1);
else
        x_1(i,10) = 0;                    %remove cases with zero remainders
end
end
x_1(:,23) = x_1(:,10);

[pred_tot_1 nego_est_1 condem_est_1]=est_cost0(x_1,parm,k,N,simu,area);

diff_nego_est = nego_est_1 - nego_est_b;
diff_time_nego = mean(mean(diff_nego_est));

diff_condem_est = condem_est_1 - condem_est_b;
diff_time_condem = mean(mean(diff_condem_est));

%function to calculate first difference of north-location
function [pred_tot_b diff_north_nego diff_north_condem] = diff_north(x, parm,
k, N, simu, area)

%base case (non-north location)
x_b = x;
x_b(:,4) = zeros(N,1);
x_b(:,11) = zeros(N,1);

[pred_tot_b nego_est_b condem_est_b]=est_cost0(x_b,parm,k,N,simu,area);

%north-location
x_1 = x;
x_1(:,4) = ones(N,1);
x_1(:,11) = x(:,31);
x_1(:,12) = zeros(N,1);

[pred_tot_1 nego_est_1 condem_est_1]=est_cost0(x_1,parm,k,N,simu,area);

diff_nego_est = nego_est_1 - nego_est_b;
diff_north_nego = mean(mean(diff_nego_est));

diff_condem_est = condem_est_1 - condem_est_b;
diff_north_condem = mean(mean(diff_condem_est));

%function to calculate first difference of whole taking
function [pred_tot_b diff_whole_nego diff_whole_condem] = diff_whole(x, parm,
k, N, simu, area)
```

```
%base case (observed taking)
x_b = x;

[pred_tot_b nego_est_b condem_est_b]=est_cost0(x_b,parm,k,N,simu,area);

%whole-taking
x_1 = x_b;
x_1(:,9:13) = zeros(N,5);
x_1(:,22:23) = zeros(N,2);
x_1(:,30:31) = zeros(N,2);

[pred_tot_1 nego_est_1 condem_est_1]=est_cost0(x_1,parm,k,N,simu,area);

diff_nego_est = nego_est_1 - nego_est_b;
diff_condem_est = condem_est_1 - condem_est_b;

j = 1;
for i = 1:N;
if diff_nego_est(j,:) == zeros(1,simu);
        diff_nego_est(j,:) = [];
        diff_condem_est(j,:) = [];
        j = j + 0;
else
        j = j + 1;
end
end

diff_whole_nego = mean(mean(diff_nego_est));
diff_whole_condem = mean(mean(diff_condem_est));

%report estimates prob(condemn=1)
function [pred_prob prob_est]=est_prob(x,parm,k,N,simu)

k1 = k(1);
k2 = k(2);
k3 = k(3);

parm_select=parm(k1+k2+1:k1+k2+k3,:);
select_x=x(1:N,k1+k2+1:k1+k2+k3);

%log(price)estiamte (latent value)
select_est = select_x * parm_select;

for i=1:N;
for j=1:simu;
        prob_est(i,j)=normcdf(select_est(i,j));
end
end

pred_prob = mean(mean(prob_est(i,:)));                  %predicted
probability to go to condemnation
```

```
%function to calculate first difference of location (east, south,
west,relative to north)on prob(condemnation)
function [pred_loc_b diff_loc] = diff_loc(x, parm, k, N, simu)

%base case (north location)
x_n = x;
x_n(:,26:28) = zeros(N,3);
x_n(:,26) = x(:,1);

%east
x_e = x;
x_e(:,26:28) = zeros(N,3);
x_e(:,27) = x(:,1);

%south
x_s = x;
x_s(:,26:28) = zeros(N,3);
x_s(:,28) = x(:,1);

%west
x_w = x;
x_w(:,26:28) = zeros(N,3);

[pred_probn prob_estn] = est_prob(x_n,parm,k,N,simu);
[pred_probe prob_este] = est_prob(x_e,parm,k,N,simu);
[pred_probs prob_ests] = est_prob(x_s,parm,k,N,simu);
[pred_probw prob_estw] = est_prob(x_w,parm,k,N,simu);

diff_e = mean(mean(prob_este - prob_estn));
diff_s = mean(mean(prob_ests - prob_estn));
diff_w = mean(mean(prob_estw - prob_estn));

pred_loc_b = pred_probn;            %base case probability
diff_loc = [diff_e diff_s diff_w];

%function to calculate first difference of whole taking (relative to partial
taking observed) on prob(condemnation)
function [pred_whole_b diff_whole] = diff_prob_whole(x, parm, k, N, simu)

%base case (observed taking)
x_b = x;

%whole taking
x_1 = x_b;
x_1(:,9:13) = zeros(N,5);
x_1(:,22:23) = zeros(N,2);
x_1(:,30:31) = zeros(N,2);

[pred_probb prob_estb] = est_prob(x_b,parm,k,N,simu);
[pred_prob1 prob_est1] = est_prob(x_1,parm,k,N,simu);

diff_est = prob_est1 - prob_estb;

j = 1;
```

```
for i = 1:N;
if diff_est(j,:) == zeros(1,simu);
        diff_est(j,:) = [];
        j = j + 0;
else
        j = j + 1;
end
end

pred_whole_b = pred_probb;            %base case probability
diff_whole = mean(mean(diff_est));

%function to calculate first difference of ownership type (corporation and
other owner relative to individual) on prob(condemnation)
function [pred_own_b diff_own] = diff_prob_own(x, parm, k, N, simu)

%base case (individual ownership type)
x_ind = x;
x_ind(:,32:33) = zeros(N,2);
x_ind(:,32) =ones(N,1);

%corporation
x_corp = x;
x_corp(:,32:33) = zeros(N,2);
x_corp(:,33) =ones(N,1);

%other owner type
x_otho = x;
x_otho(:,32:33) = zeros(N,2);

[pred_prob_ind prob_est_ind] = est_prob(x_ind,parm,k,N,simu);
[pred_prob_corp prob_est_corp] = est_prob(x_corp,parm,k,N,simu);
[pred_prob_otho prob_est_otho] = est_prob(x_otho,parm,k,N,simu);

diff_corp = mean(mean(prob_est_corp - prob_est_ind));
diff_otho = mean(mean(prob_est_otho - prob_est_ind));

pred_own_b = pred_prob_ind;            %base case probability
diff_own = [diff_corp diff_otho];
```

APPENDIX B

MATLAB Code for Comparing Acquisition Cost Estimates
(Binary Endogenous Switching Model)

```
%Cost differences between nego & condem using simulation
clear all;

load switchingparm_simu.csv; %load simulated parameters from STATA
load finalparcels.csv; %load sample
load area.csv; %load takensf

parm=switchingparm_simu;
parm=parm';  %transpose
x=finalparcels;

k1=14;          %number of nego parameters
k2=10;          %number of condem parameters
k3=10;          %number of selection parameters
k=k1+k2;
N=1710;
simu=1000; %number of simulations

%Cost esimates
[do_incr pctg_incr pctg_higher]=est_cost(x,parm,k1,k2,k3,N,simu);
[std_incr stdpctg_incr stdpctg_higher]=std_cost(x,parm,area,k1,k2,k3,N,simu);

%compare cost estimates (nego vs. condem)across simulations

function [do_incr pctg_incr pctg_higher]=est_cost(x,parm,k1,k2,k3,N,simu);

parm_nego=parm(1:k1,:);
parm_condem=parm(k1+1:k1+k2,:);
lnsigma_nego=parm(k1+k2+k3+1,:);
lnsigma_condem=parm(k1+k2+k3+2,:);
nego_x=x(1:N,1:k1);
condem_x=x(1:N,k1+1:k1+k2);

higher=zeros(simu);                         %indicator when predicted value
if go condem > go nego
lower=zeros(simu);                          %indicator when predicted value
if go condem < go nego

for i=1:N;
    nego_lnest(i,:)=nego_x(i,:)*parm_nego;
    condem_lnest(i,:)=condem_x(i,:)*parm_condem;
end

for i=1:N;
for j=1:simu;
        sigma_nego(j)=exp(lnsigma_nego(j));
        sigma_condem(j)=exp(lnsigma_condem(j));
```

```
        nego_est(i,j)=exp(nego_lnest(i,j))*exp(sigma_nego(j)^2/2);
%negotiation eqn estimates(backtransformation log)
        condem_est(i,j)=exp(condem_lnest(i,j))*exp(sigma_condem(j)^2/2);
%condemnation eqn estimates
        dollar_increase(i,j)=condem_est(i,j)-nego_est(i,j);
        pctg_increase(i,j)=(condem_est(i,j)-nego_est(i,j))/nego_est(i,j);
if dollar_increase(i,j)>0
higher(j)=higher(j)+1;
else
lower(j)=lower(j)+1;
end
end
end

for j=1:simu;
    nego_do(j)=sum(nego_est(:,j))/N;
    condem_do(j)=sum(condem_est(:,j))/N;
    do_incr(j)=sum(dollar_increase(:,j))/N;
    pctg_incr(j)=sum(pctg_increase(:,j))/N;
    pctg_higher(j)=higher(j)/(higher(j)+lower(j));    %percentage of parcels
with higher costs when condem compared to nego
end

avg_nego_do=mean(nego_do)
std_nego_do=std(nego_do)
min_nego_do=min(nego_do)
max_nego_do=max(nego_do)

avg_condem_do=mean(condem_do)
std_condem_do=std(condem_do)
min_condem_do=min(condem_do)
max_condem_do=max(condem_do)

avg_dollar_increase=mean(do_incr)
std_dollar_increase=std(do_incr)            %standard deviation of dollar
increase among the simulations
min_dollar_increase=min(do_incr)
max_dollar_increase=max(do_incr)

avg_pctg_increase=mean(pctg_incr)
std_pctg_increase=std(pctg_incr)
min_pctg_increase=min(pctg_incr)
max_pctg_increase=max(pctg_incr)

avg_pctg_higher=mean(pctg_higher)
std_pctg_higher=std(pctg_higher)
min_pctg_higher=min(pctg_higher)
max_pctg_higher=max(pctg_higher)

function [std_incr stdpctg_incr
stdpctg_higher]=std_cost(x,parm,area,k1,k2,k3,N,simu);  %standard errors of
costs (log-normal distribution)

parm_nego=parm(1:k1,:);
```

```
parm_condem=parm(k1+1:k1+k2,:);
lnsigma_nego=parm(k1+k2+k3+1,:);
lnsigma_condem=parm(k1+k2+k3+2,:);
nego_x=x(1:N,1:k1);
condem_x=x(1:N,k1+1:k1+k2);

higher=zeros(simu);                              %indicator when predicted value
if go condem > go nego
lower=zeros(simu);                               %indicator when predicted value
if go condem < go nego

for i=1:N;
    nego_lnest(i,:)=nego_x(i,:)*parm_nego;
    condem_lnest(i,:)=condem_x(i,:)*parm_condem;
end

for i=1:N;
for j=1:simu;
        sigma_nego(j)=exp(lnsigma_nego(j));
        sigma_condem(j)=exp(lnsigma_condem(j));
        nego_std(i,j)=sqrt((exp(sigma_nego(j)^2)-
1)*exp(2*nego_lnest(i,j)+sigma_nego(j)^2))/area(i);
%negotiation eqn estimates(backtransformation log)
        condem_std(i,j)=sqrt((exp(sigma_condem(j)^2)-
1)*exp(2*condem_lnest(i,j)+sigma_condem(j)^2))/area(i);
%condemnation eqn estimates
        std_increase(i,j)=condem_std(i,j)-nego_std(i,j);
        stdpctg_increase(i,j)=(condem_std(i,j)-nego_std(i,j))/nego_std(i,j);
if std_increase(i,j)>0
higher(j)=higher(j)+1;
else
lower(j)=lower(j)+1;
end
end
end

for j=1:simu;
    nego_stderr(j)=sum(nego_std(:,j))/N;
    condem_stderr(j)=sum(condem_std(:,j))/N;
    std_incr(j)=sum(std_increase(:,j))/N;
    stdpctg_incr(j)=sum(stdpctg_increase(:,j))/N;
    stdpctg_higher(j)=higher(j)/(higher(j)+lower(j));    %percentage of
parcels with higher costs when condem compared to nego
end

avg_nego_stderr=mean(nego_stderr)
std_nego_stderr=std(nego_stderr)
min_nego_stderr=min(nego_stderr)
max_nego_stderr=max(nego_stderr)

avg_condem_stderr=mean(condem_stderr)
std_condem_stderr=std(condem_stderr)
min_condem_stderr=min(condem_stderr)
max_condem_stderr=max(condem_stderr)
```

```
avg_std_increase=mean(std_incr)
std_std_increase=std(std_incr)             %standard deviation of dollar
increase among the simulations
min_std_increase=min(std_incr)
max_std_increase=max(std_incr)

avg_stdpctg_increase=mean(stdpctg_incr)
std_stdpctg_increase=std(stdpctg_incr)
min_stdpctg_increase=min(stdpctg_incr)
max_stdpctg_increase=max(stdpctg_incr)

avg_stdpctg_higher=mean(stdpctg_higher)
std_stdpctg_higher=std(stdpctg_higher)
min_stdpctg_higher=min(stdpctg_higher)
max_stdpctg_higher=max(stdpctg_higher)
```

APPENDIX C

OX Code for Estimating Multinomial Endogenous Switching Model (Two Selection Equations and Three Cost Outcomes)

```
#include <oxstd.h>
#include <oxdraw.h>
#include <oxprob.h>
#import <maximize>

decl g_mY1, g_mY2, g_mY3;                    // global data (indicator
variables for negotiation, administrative settlement, & condemnation)
decl g_mCOST, g_mCOST1, g_mCOST2, g_mCOST3;     // global data (final
log(acquisition cost))
decl g_mX1, g_mX2, g_mX3, g_mX;               // global data (outcome eqn)
decl g_mZ;                                    // global data (selection
eqn)
decl g_numX1, g_numX2, g_numX3, g_numZ;       // number of covariates in
outcome eqn
decl g_num_error;                             // number of estimated
variance-covariance terms in LL
decl g_nobs;                                  // number of observations
declindex;                                    // index for observations

// log likelihood function for three category full information maximum
likelihood estimation
// with correlation between latent selection & cost outcome eqn
fFIML(const theta, const adFunc, const avScore, const amHessian)
{
      //delcare parameters in selection equations and cost outcome equations
      //gamma: parameters in selection utility difference eqn;
      //beta(i): parameters in outcome eqn i;
      decl beta1, beta2, beta3, gamma1_star, gamma2_star, errors;
      beta1 = theta[0 :(g_numX1 - 1)];
      beta2 = theta[g_numX1 : (g_numX1 + g_numX2 - 1)];
      beta3 = theta[(g_numX1 + g_numX2) : (g_numX1 + g_numX2 + g_numX3 - 1)];
      gamma1_star = theta[(g_numX1 + g_numX2 + g_numX3) : (g_numX1 + g_numX2
+ g_numX3 + g_numZ - 1)];
      gamma2_star = theta[(g_numX1 + g_numX2 + g_numX3 + g_numZ) : (g_numX1 +
g_numX2 + g_numX3 + 2 * g_numZ - 1)];
      errors = theta[(g_numX1 + g_numX2 + g_numX3 + 2 * g_numZ) : (g_numX1 +
g_numX2 + g_numX3 + 2 * g_numZ + g_num_error -1)];

      //error terms in likelihood function; order in errors: eps0, eps1,
eps2, roh01, roh02, roh11, roh12, roh21, roh22, roh_err, err2;
      //epsilon: cost eqn;
      //err(u_star error term):variance-cov matrix of selection eqn;(
variance of error term u_star1 is normalized to 1 dist for identification)
      //roh: correlation coef. between cost epsilon & selection u_star;
      decl eps0, eps1, eps2, roh_err, err2, roh01, roh02, roh11, roh12,
roh21, roh22;
```

```
      eps0 = exp(errors[0]);              //ensure non-negativity of sigma
      eps1 = exp(errors[1]);              //ensure non-negativity of sigma
      eps2 = exp(errors[2]);              //ensure non-negativity of sigma
      roh01 = tanh(errors[3]);            //corr coef between eps0 & u_star1;
ensure -1<roh<1
      roh02 = tanh(errors[4]);            //corr coef between eps0 & u_star2;
ensure -1<roh<1
      roh11 = tanh(errors[5]);            //corr coef between eps1 & u_star1;
ensure -1<roh<1
      roh12 = tanh(errors[6]);            //corr coef between eps1 & u_star2;
ensure -1<roh<1
      roh21 = tanh(errors[7]);            //corr coef between eps2 & u_star1;
ensure -1<roh<1
      roh22 = tanh(errors[8]);            //corr coef between eps2 & u_star2;
ensure -1<roh<1
      roh_err = tanh(errors[9]);          //corr coef between u_star1 &
u_star2; ensure -1<roh<1
      err2 = exp(errors[10]);             //ensure non-negativity of sigma

      //declare correlation coeff between bivariate norms
      //roh_bivi: corr coef of two bivarate norms (zi1 & zi2) in selection
prob(outcome i)
      //roh_bivi1: corr coef of first term (zi1) & conditioned epsilon (epsi)
in selection prob(outcome i)
      //roh_bivi2: corr coef of first term (zi2) & conditioned epsilon (epsi)
in selection prob(outcome i)
      decl roh_biv1, roh_biv2, roh_biv3, roh_biv11, roh_biv12, roh_biv21,
roh_biv22, roh_biv31, roh_biv32;
      roh_biv1 = roh_err;
      roh_biv2 = ( - err2 * roh_err + 1) / sqrt(1 + err2^2 - 2 * roh_err *
err2);            //err1 is normalized to 1
      roh_biv3 = - roh_biv2;

      roh_biv11 = roh01;
      roh_biv12 = roh02;
      roh_biv21 = - roh11;
      roh_biv22 = (eps1 * err2 * roh12 - eps1 * roh11) / (eps1 * sqrt(1 +
err2^2 - 2 * roh_err * err2));
      roh_biv31 = - roh21;
      roh_biv32 = - (eps2 * err2 * roh22 - eps2 * roh21) / (eps2 * sqrt(1 +
err2^2 - 2 * roh_err * err2)) ;

      decl z1, z2, z3, z11, z12, z21, z22, z31, z32;
      z1 = (g_mCOST - g_mX1 * beta1) / eps0;
      z2 = (g_mCOST - g_mX2 * beta2) / eps1;
      z3 = (g_mCOST - g_mX3 * beta3) / eps2;

      z11 = (- g_mZ * gamma1_star - roh_biv11 * z1) / sqrt(1 - roh_biv11^2);
      z12 = (- g_mZ * gamma2_star - roh_biv12 * err2 * z1) / (err2 * sqrt(1 -
roh_biv12^2));
      z21 = (g_mZ * gamma1_star - roh_biv21 * z2) / sqrt(1 - roh_biv21^2);
      z22 = (g_mZ * (gamma1_star - gamma2_star) - roh_biv22 * sqrt(1 + err2^2
- 2 * roh_err * err2) * z2) / (sqrt(1 + err2^2 - 2 * roh_err * err2) * sqrt(1
- roh_biv22^2));
```

```
      z31 = (g_mZ * gamma1_star - roh_biv31 * z3) / sqrt(1 - roh_biv31^2);
      z32 = (g_mZ * (gamma2_star - gamma1_star) - roh_biv32 * sqrt(1 + err2^2
- 2 * roh_err * err2) * z3) / (sqrt(1 + err2^2 - 2 * roh_err * err2) * sqrt(1
- roh_biv32^2));

      decl rohv_biv1, rohv_biv2, rohv_biv3;    //vector of corr coef
      rohv_biv1 = roh_biv1 * ones(g_nobs, 1);
      rohv_biv2 = roh_biv2 * ones(g_nobs, 1);
      rohv_biv3 = roh_biv3 * ones(g_nobs, 1);

      decl prob1, prob2, prob3;
      prob1 = (1 / eps0) * densn(z1) .* probbvn(z11, z12, rohv_biv1);   //
joint probability of selection 1 & outcome 1
      prob2 = (1 / eps1) * densn(z2) .* probbvn(z21, z22, rohv_biv2);   //
joint probability of selection 2 & outcome 2
      prob3 = (1 / eps2) * densn(z3) .* probbvn(z31, z32, rohv_biv3);   //
joint probability of selection 3 & outcome 3

      decl ll;                              //log-likelihood
      ll = g_mY1 .* log(prob1) + g_mY2 .* log(prob2) + g_mY3 .* log(prob3);
adFunc[0] = double(meanc(ll));

      return 1;                            // 1 indicates success
}

// restriction of independence equations (for LR test)

fFIML0(const theta, const adFunc, const avScore, const amHessian)
{
      //delcare parameters in selection equations and cost outcome equations
      //gamma: parameters in selection utility difference eqn;
      //beta(i): parameters in outcome eqn i;
      decl beta1, beta2, beta3, gamma1_star, gamma2_star, errors;
      beta1 = theta[0 :(g_numX1 - 1)];
      beta2 = theta[g_numX1 : (g_numX1 + g_numX2 - 1)];
      beta3 = theta[(g_numX1 + g_numX2) : (g_numX1 + g_numX2 + g_numX3 - 1)];
      gamma1_star = theta[(g_numX1 + g_numX2 + g_numX3) : (g_numX1 + g_numX2
+ g_numX3 + g_numZ - 1)];
      gamma2_star = theta[(g_numX1 + g_numX2 + g_numX3 + g_numZ) : (g_numX1 +
g_numX2 + g_numX3 + 2 * g_numZ - 1)];
      errors = fabs(theta[(g_numX1 + g_numX2 + g_numX3 + 2 * g_numZ) :
(g_numX1 + g_numX2 + g_numX3 + 2 * g_numZ + g_num_error -1)]); //ensure non-
negativity of error terms

      //error terms in likelihood function; order in errors: eps0, eps1,
eps2, roh01, roh02, roh11, roh12, roh21, roh22, roh_err, err2;
      //epsilon: cost eqn;
      //err(u_star error term):variance-cov matrix of selection eqn;(
variance of error term u_star1 is normalized to 1 dist for identification)
      //roh: correlation coef. between cost epsilon & selection u_star;
      decl eps0, eps1, eps2, roh_err, err2, roh01, roh02, roh11, roh12,
roh21, roh22;
      eps0 = exp(errors[0]);              //ensure non-negativity of sigma
      eps1 = exp(errors[1]);              //ensure non-negativity of sigma
```

```
      eps2 = exp(errors[2]);              //ensure non-negativity of sigma
      roh01 = 0;                          //corr coef between eps0 & u_star1
      roh02 = 0;                          //corr coef between eps0 & u_star2
      roh11 = 0;                          //corr coef between eps1 & u_star1
      roh12 = 0;                          //corr coef between eps1 & u_star2
      roh21 = 0;                          //corr coef between eps2 & u_star1
      roh22 = 0;                          //corr coef between eps2 & u_star2
      roh_err = tanh(errors[9]);          //corr coef between u_star1 &
u_star2
      err2 = exp(errors[10]);             //ensure non-negativity of sigma

      //declare correlation coeff between bivariate norms
      //roh_bivi: corr coef of two bivarate norms (zi1 & zi2) in selection
prob(outcome i)
      //roh_bivi1: corr coef of first term (zi1) & conditioned epsilon (epsi)
in selection prob(outcome i)
      //roh_bivi2: corr coef of first term (zi2) & conditioned epsilon (epsi)
in selection prob(outcome i)
      decl roh_biv1, roh_biv2, roh_biv3, roh_biv11, roh_biv12, roh_biv21,
roh_biv22, roh_biv31, roh_biv32;
      roh_biv1 = roh_err;
      roh_biv2 = ( - err2 * roh_err + 1) / sqrt(1 + err2^2 - 2 * roh_err *
err2);           //err1 is normalized to 1
      roh_biv3 = - roh_biv2;

      roh_biv11 = roh01;
      roh_biv12 = roh02;
      roh_biv21 = - roh11;
      roh_biv22 = (eps1 * err2 * roh12 - eps1 * roh11) / (eps1 * sqrt(1 +
err2^2 - 2 * roh_err * err2));
      roh_biv31 = - roh21;
      roh_biv32 = - (eps2 * err2 * roh22 - eps2 * roh21) / (eps2 * sqrt(1 +
err2^2 - 2 * roh_err * err2)) ;

      decl z1, z2, z3, z11, z12, z21, z22, z31, z32;
      z1 = (g_mCOST - g_mX1 * beta1) / eps0;
      z2 = (g_mCOST - g_mX2 * beta2) / eps1;
      z3 = (g_mCOST - g_mX3 * beta3) / eps2;

      z11 = (- g_mZ * gamma1_star - roh_biv11 * z1) / sqrt(1 - roh_biv11^2);
      z12 = (- g_mZ * gamma2_star - roh_biv12 * err2 * z1) / (err2 * sqrt(1 -
roh_biv12^2));
      z21 = (g_mZ * gamma1_star - roh_biv21 * z2) / sqrt(1 - roh_biv21^2);
      z22 = (g_mZ * (gamma1_star - gamma2_star) - roh_biv22 * sqrt(1 + err2^2
- 2 * roh_err * err2) * z2) / (sqrt(1 + err2^2 - 2 * roh_err * err2) * sqrt(1
- roh_biv22^2));
      z31 = (g_mZ * gamma1_star - roh_biv31 * z3) / sqrt(1 - roh_biv31^2);
      z32 = (g_mZ * (gamma2_star - gamma1_star) - roh_biv32 * sqrt(1 + err2^2
- 2 * roh_err * err2) * z3) / (sqrt(1 + err2^2 - 2 * roh_err * err2) * sqrt(1
- roh_biv32^2));

      decl rohv_biv1, rohv_biv2, rohv_biv3;    //vector of corr coef
      rohv_biv1 = roh_biv1 * ones(g_nobs, 1);
      rohv_biv2 = roh_biv2 * ones(g_nobs, 1);
```

```
      rohv_biv3 = roh_biv3 * ones(g_nobs, 1);

      decl prob1, prob2, prob3;
      prob1 = (1 / eps0) * densn(z1) .* probbvn(z11, z12, rohv_biv1);   //
joint probability of selection 1 & outcome 1
      prob2 = (1 / eps1) * densn(z2) .* probbvn(z21, z22, rohv_biv2);   //
joint probability of selection 2 & outcome 2
      prob3 = (1 / eps2) * densn(z3) .* probbvn(z31, z32, rohv_biv3);   //
joint probability of selection 3 & outcome 3

      decl ll;                              //log-likelihood
      ll = g_mY1 .* log(prob1) + g_mY2 .* log(prob2) + g_mY3 .* log(prob3);
adFunc[0] = double(meanc(ll));
//    println("\nll = ", meanc(ll));

      return 1;                            // 1 indicates success
}

// log likelihood function for three category full information maximum
likelihood estimation
// relax correlation between latent selection & cost outcome eqn
fMNP(const theta, const adFunc, const avScore, const amHessian)
{
      //delcare parameters in selection equations
      //gamma: parameters in selection utility difference eqn;
      decl gamma1_star, gamma2_star, errors;
      gamma1_star = theta[0 : (g_numZ - 1)];
      gamma2_star = theta[g_numZ : (2 * g_numZ - 1)];
      errors = theta[(2 * g_numZ) : (2 * g_numZ + 2 -1)];

      //err(u_star error term):variance-cov matrix of selection eqn;(
variance of error term u_star1 is normalized to 1 dist for identification)
      decl roh_err, err2;
      roh_err = tanh(errors[0]);            //ensure abs(roh)<1
      err2 = exp(errors[1]);                //ensure non-negativity of sigma2
in selection eqn

      //declare correlation coeff between bivariate norms
      //roh_bivi: corr coef of two bivarate norms (zi1 & zi2) in selection
prob(outcome i)
      decl roh_biv1, roh_biv2, roh_biv3;
      roh_biv1 = roh_err;
      roh_biv2 = ( - err2 * roh_err + 1) / sqrt(1 + err2^2 - 2 * roh_err *
err2);            //err1 is normalized to 1
      roh_biv3 = - roh_biv2;

      decl z11, z12, z21, z22, z31, z32;

      z11 = (- g_mZ * gamma1_star);
      z12 = (- g_mZ * gamma2_star) / err2;
      z21 = (g_mZ * gamma1_star);
      z22 = (g_mZ * (gamma1_star - gamma2_star)) / sqrt(1 + err2^2 - 2 *
roh_err * err2);
      z31 = (g_mZ * gamma1_star);
```

```
      z32 = (g_mZ * (gamma2_star - gamma1_star)) / sqrt(1 + err2^2 - 2 *
roh_err * err2);

      decl rohv_biv1, rohv_biv2, rohv_biv3;    //vector of corr coef
      rohv_biv1 = roh_biv1 * ones(g_nobs, 1);
      rohv_biv2 = roh_biv2 * ones(g_nobs, 1);
      rohv_biv3 = roh_biv3 * ones(g_nobs, 1);

      decl prob1, prob2, prob3;
      prob1 = probbvn(z11, z12, rohv_biv1);   // probability of selection 1
      prob2 = probbvn(z21, z22, rohv_biv2);   // probability of selection 2
      prob3 = probbvn(z31, z32, rohv_biv3);   // probability of selection 3

      decl ll;                             //log-likelihood
      ll = g_mY1 .* log(prob1) + g_mY2 .* log(prob2) + g_mY3 .* log(prob3);
adFunc[0] = double(meanc(ll));

      return 1;                           // 1 indicates success
}

// maximum likelihood function for cost outcome std err estimation
fML(const theta, const adFunc, const avScore, const amHessian)
{
decl beta, sigma;

      beta = theta[0 : (rows(theta)-2)];
      sigma = fabs(theta[rows(theta)-1]);

      decl prob = (1 / sigma) * densn((g_mCOST - g_mX * beta) / sigma);
      adFunc[0] = double(meanc(log(prob)));

      return 1;                           // 1 indicates success
}

main()
{
      decl mx, mx_mnp, COST, nobs1, nobs2, nobs3;


      print("Three categroy discrete-continuous model, run on ", date(),
".\n\n");

mx = loadmat("costdata_dropdif.xls");

    g_mY1 = mx[][0];        // negotiation dummy
      g_mY2 = mx[][1];        // administrative dummy
      g_mY3 = mx[][2];        // negotiation dummy

      COST = mx[][3];                //log(COST);
      g_mCOST1 = selectifr(COST, g_mY1 .== 1);     //select nego cases
      g_mCOST2 = selectifr(COST, g_mY2 .== 1);     //select admin cases
      g_mCOST3 = selectifr(COST, g_mY3 .== 1);     //select condem cases

      g_nobs = rows(g_mY1);   // number of all observations
```

```
	nobs1 = rows(g_mCOST1); // number of nego obs
	nobs2 = rows(g_mCOST2); // number of nego obs
	nobs3 = rows(g_mCOST3); // number of nego obs

	index = mx[][24];	// index of observation

	decl SCALE = 1000;

	//drop outliers

	//declare explanatory variables
	decl timetrend, residential, commercial, vacant, otherland, west,
north, south, east, popdensity, partialtaking, takensf, remaindersf,
individual, corporation, otherown;
	timetrend = mx[][4];
	residential = mx[][6];
	commercial = mx[][7];
	vacant = mx[][8];
	otherland = mx[][9];
	north = mx[][10];
	south = mx[][11];
	east = mx[][12];
	west = mx[][13];
	popdensity = mx[][14] / SCALE;		//re-scale population density
in order to make MLE more stable
	partialtaking = mx[][16];
	takensf = mx[][18];
	remaindersf = mx[][19];
	individual = mx[][20];
	corporation = mx[][21];
	otherown = mx[][22];

    ///generate new variables and interaction terms  (in case of o remainder
or 0 taken(access rights only parcels))
	decl remaindersf2 = remaindersf + 1;
	decl takensf2 = takensf;
	decl lnremain = log(remaindersf2);
	decl lntaken = log(takensf2);
	decl ratio = takensf / (takensf+remaindersf);

	decl lntaken_time = lntaken .* timetrend;
	decl lnremain_time = lnremain .* timetrend;
	decl lntaken_popden = lntaken .* popdensity;
	decl lnremain_popden = lnremain .* popdensity;

	/// Basecase: agriculture
	decl lntaken_res = lntaken .* residential;
	decl lntaken_com = lntaken .* commercial;
	decl lntaken_otherland = lntaken .* otherland;
	decl lntaken_vac = lntaken .* vacant;
	decl lnremain_res = lnremain .* residential;
	decl lnremain_com = lnremain .* commercial;
	decl lnremain_otherland = lnremain .* otherland;
	decl lnremain_vac = lnremain .* vacant;
```

```
    ///Base case: West
    decl lntaken_north = lntaken .* north;
    decl lntaken_south = lntaken .* south;
    decl lntaken_east = lntaken .* east;
    decl lntaken_west = lntaken .* west;
    decl lnremain_north = lnremain .* north;
    decl lnremain_south = lnremain .* south;
    decl lnremain_east = lnremain .* east;
    decl lnremain_west = lnremain .* west;
    decl ns = north + south;

    ///Base case: individual ownership type
    decl lntaken_corp = lntaken .* corporation;
    decl lntaken_indiv = lntaken .* individual;
    decl lntaken_otherown = lntaken .* otherown;
    decl lnremain_corp = lnremain .* corporation;
    decl lnremain_indiv = lnremain .* individual;
    decl lnremain_otherown = lnremain .* otherown;
    decl otherown_com = otherown .* commercial;
    decl otherown_west = otherown .* west;
    decl otherown_part = otherown .* partialtaking;
    decl corp_com = corporation .* commercial;
    decl indiv_com = individual .* commercial;
    decl corp_part = corporation .* partialtaking;
    decl indiv_part = individual .* partialtaking;
    decl corp_east = corporation .* east;
    decl indiv_east = individual .* east;
    decl corp_west = corporation .* west;
    decl indiv_west = individual .* west;

    ///Base case: whole taking
    decl lntaken_part = lntaken .* partialtaking;
    decl part_east = partialtaking .* east;
    decl part_west = partialtaking .* west;
    decl part_com = partialtaking .* commercial;

    decl X1, X2, X3;
    X1 = 1 ~ lntaken ~ lntaken_popden ~ lntaken_time ~ lntaken_res ~
lntaken_com ~ lntaken_otherland ~ lntaken_vac ~ partialtaking ~
lnremain_time;  // regressors: constant and other covariates
    X2 = 1 ~ lntaken ~ lntaken_popden ~ lntaken_time ~ lntaken_north ~
lntaken_com ~ partialtaking ~ lnremain_time;
    X3 = 1 ~ lntaken ~ lntaken_popden ~ lntaken_time ~ lntaken_res ~
lntaken_com ~ lntaken_otherland ~ lntaken_vac ~ partialtaking ~
lnremain_time;
    g_mX1 = selectifr(X1, g_mY1 .== 1);     //select nego cases
    g_mX2 = selectifr(X2, g_mY2 .== 1);     //select admin cases
    g_mX3 = selectifr(X3, g_mY3 .== 1);     //select condemnation cases

    g_mZ = 1  ~ lntaken ~ timetrend ~ west ~ commercial ~ lnremain ~
corp_com ~ indiv_com ~ corp_part ~indiv_part ~ corp_west;

    g_numX1 = columns(g_mX1);
```

```
      g_numX2 = columns(g_mX2);
      g_numX3 = columns(g_mX3);
      g_numZ = columns(g_mZ);
      g_num_error = 11 ;                     //(3 epsilons) + (u_star2 + corr
coef. u_star1&2) + (6 corr coef. between selection eqn & cost outcome eqn).

MaxControl(-1, 1, 1);          // print each iteration

//*****************************************************************
//** estimate three-outcome MNP model to get starting values for FIML **

//*****************************************************************
      decl  theta_mnp, dfunc_mnp, ir_mnp,  mhess_mnp;

      theta_mnp = zeros(2 * g_numZ + 2,1);   //starting value at zeros for
MNP model

      decl gamma1_star, gamma2_star;

      gamma1_star = <-1;0;0;0;0;0;0;0>;
      gamma2_star = <-4;0;0;0;0;0;0;0>;
      theta_mnp[0 : (g_numZ - 1)] = gamma1_star;
      theta_mnp[g_numZ : (2 * g_numZ - 1)] = gamma2_star;
      theta_mnp[2 * g_numZ] = 0;                  //staring value of roh_err
at 0.1
      theta_mnp[2 * g_numZ + 1] = -1;             //starting value of err2 at
1

      ir_mnp = MaxBFGS(fMNP, &theta_mnp, &dfunc_mnp, 0, TRUE);    //
numerical derivatives

println("\nLog-likelihood_mnp = ", dfunc_mnp * g_nobs);
      println("MNP parameters: ", theta_mnp);

if (Num2Derivative(fMNP, theta_mnp, &mhess_mnp))
    {
      mhess_mnp = -invert(mhess_mnp) / g_nobs;
            print("hess_MNP:", diagonal(mhess_mnp));
    }

      print("%r",{"variables(mnp)"},                   // row titles
            "%c",{"Coeff","s.e.","z-stat","p-val"},               // column
headers
              "%#10.4f", theta_mnp ~
sqrt(diagonal(mhess_mnp)')~(theta_mnp./sqrt(diagonal(mhess_mnp)'))~2*tailn(fa
bs(theta_mnp./sqrt(diagonal(mhess_mnp)'))));    // format to have three
significant digits

//*********************************************************************
*
//** estimate outcome (log(COST)) ML model to get starting values for FIML
**
//*********************************************************************
*
```

```
      decl theta_ml1, theta_ml2, theta_ml3, ir_ml1, ir_ml2, ir_ml3,
dfunc_ml1, dfunc_ml2, dfunc_ml3, mhess_ml1, mhess_ml2, mhess_ml3;
      decl beta_ols1, beta_ols2, beta_ols3, epshat1, epshat2, epshat3;

      //negotiation cost
      g_mX = g_mX1;
      g_mCOST = g_mCOST1;

      beta_ols1 = invert(g_mX'g_mX)*g_mX'g_mCOST;
      epshat1 = g_mCOST - g_mX * beta_ols1;

      theta_ml1 = beta_ols1 | sqrt(epshat1'epshat1 / (nobs1 - g_numX1));
//including sigma in cost eqn; use OLS estimates as starting values

      ir_ml1 =MaxBFGS(fML, &theta_ml1, &dfunc_ml1, 0, TRUE);      //
numerical derivatives

println("\nLog-likelihood_ml1 = ", dfunc_ml1 * g_nobs);
      println("ML1 (log(COST)) parameters: ", theta_ml1);

if (Num2Derivative(fML, theta_ml1, &mhess_ml1))
    {
      mhess_ml1 = -invert(mhess_ml1) / g_nobs;
    }

      print("%r",{"variables(cost1)"},                // row titles
            "%c",{"Coeff","s.e.","z-stat","p-val"},               // column
headers
              "%#10.4f", theta_ml1 ~
sqrt(diagonal(mhess_ml1)')~(theta_ml1./sqrt(diagonal(mhess_ml1)'))~2*tailn(fa
bs(theta_ml1./sqrt(diagonal(mhess_ml1)'))));    // format to have three
significant digits

      //Administrative cost
      g_mX = g_mX2;
      g_mCOST = g_mCOST2;

      beta_ols2 = invert(g_mX'g_mX)*g_mX'g_mCOST;
      epshat2 = g_mCOST - g_mX * beta_ols2;

      theta_ml2 = beta_ols2 | sqrt(epshat2'epshat2 / (nobs2 - g_numX2));
//including sigma in cost eqn; use OLS estimates as starting values

      ir_ml2 =MaxBFGS(fML, &theta_ml2, &dfunc_ml2, 0, TRUE);      //
numerical derivatives

println("\nLog-likelihood_ml2 = ", dfunc_ml2 * g_nobs);
      println("ML2 (log(COST)) parameters: ", theta_ml2);

if (Num2Derivative(fML, theta_ml2, &mhess_ml2))
    {
      mhess_ml2 = -invert(mhess_ml2) / g_nobs;
    }
```

```
      print("%r",{"variables(cost2)"},                // row titles
            "%c",{"Coeff","s.e.","z-stat","p-val"},              // column
headers
              "%#10.4f", theta_ml2 ~
sqrt(diagonal(mhess_ml2)')~(theta_ml2./sqrt(diagonal(mhess_ml2)'))~2*tailn(fa
bs(theta_ml2./sqrt(diagonal(mhess_ml2)'))));    // format to have three
significant digits

      //condemnation cost
      g_mX = g_mX3;
      g_mCOST = g_mCOST3;

      beta_ols3 = invert(g_mX'g_mX)*g_mX'g_mCOST;
      epshat3 = g_mCOST - g_mX * beta_ols3;

      theta_ml3 = beta_ols3 | sqrt(epshat3'epshat3 / (nobs3 - g_numX3));
//including sigma in cost eqn; use OLS estimates as starting values
      ir_ml3 =MaxBFGS(fML, &theta_ml3, &dfunc_ml3, 0, TRUE);      //
numerical derivatives

println("\nLog-likelihood_ml3 = ", dfunc_ml3 * g_nobs);
      println("ML3 (log(COST)) parameters: ", theta_ml3);

if (Num2Derivative(fML, theta_ml3, &mhess_ml3))
    {
      mhess_ml3 = -invert(mhess_ml3) / g_nobs;
    }

      print("%r",{"variables(cost3)"},                // row titles
            "%c",{"Coeff","s.e.","z-stat","p-val"},              // column
headers
              "%#10.4f", theta_ml3 ~
sqrt(diagonal(mhess_ml3)')~(theta_ml3./sqrt(diagonal(mhess_ml3)'))~2*tailn(fa
bs(theta_ml3./sqrt(diagonal(mhess_ml3)'))));    // format to have three
significant digits

      decl eps_ml = theta_ml1[g_numX1] | theta_ml2[g_numX2] |
theta_ml3[g_numX3];

//*************************************************************
//** estimate three-outcome discrete-continuous model using FIML **
//*************************************************************
      decl theta_FIML, dfunc, ir, mhess, cov_FIML;

      g_mCOST = COST;          //restore to all observations
      g_mX1 = X1;                    //restore to all observations
      g_mX2 = X2;                    //restore to all observations
      g_mX3 = X3;                    //restore to all observations

      theta_FIML = ones((g_numX1 + g_numX2 + g_numX3 + 2 * g_numZ +
g_num_error), 1);
      theta_FIML[0 :(g_numX1 - 1)] = theta_ml1[0 : (g_numX1-1)];       //use
ML estimates as beta1 starting value
```

```
      theta_FIML[g_numX1 : (g_numX1 + g_numX2 - 1)] = theta_ml2[0 : (g_numX2-
1)];
      theta_FIML[(g_numX1 + g_numX2) : (g_numX1 + g_numX2 + g_numX3 - 1)] =
theta_ml3[0 : (g_numX3-1)];
      theta_FIML[(g_numX1 + g_numX2 + g_numX3) : (g_numX1 + g_numX2 + g_numX3
+ 2 * g_numZ - 1)] = theta_mnp[0 : (2 * g_numZ - 1)];       //use MNP
estimates as gamma_star starting value
      theta_FIML[(g_numX1 + g_numX2 + g_numX3 + 2 * g_numZ) : (g_numX1 +
g_numX2 + g_numX3 + 2 * g_numZ + 2)] = eps_ml;    //use ML estimates as
epsilon in cost eqn
      theta_FIML[(g_numX1 + g_numX2 + g_numX3 + 2 * g_numZ + 3) : (g_numX1 +
g_numX2 + g_numX3 + 2 * g_numZ + 8)] = <0;0;0;0;0;0>;
      theta_FIML[(g_numX1 + g_numX2 + g_numX3 + 2 * g_numZ + 9) : (g_numX1 +
g_numX2 + g_numX3 + 2 * g_numZ + 10)] = theta_mnp[(2 * g_numZ) : (2 * g_numZ
+ 1)];        //use MNP estimates as error term starting value

      println("\nstarting theta = ", theta_FIML);

      ir = MaxBFGS(fFIML, &theta_FIML, &dfunc, 0, TRUE);    // numerical
derivatives

      println("\nLog-likelihood_FIML(Unrestricted Model) = ", dfunc *
g_nobs);

if (Num2Derivative(fFIML, theta_FIML, &mhess))
    {
      cov_FIML = -invert(mhess) / g_nobs;
    }

//****************************************
//** LR test of independent equations **
//****************************************
      //three restrictions : sig01=0 & sig11=0 & sig12=0
      decl theta0, dfunc0, ir0, mhess0, LR_Indep;

      theta0 = theta_FIML;                      //starting value as final
estimates with dependence assumption (UR model)

      ir0 = MaxBFGS(fFIML0, &theta0, &dfunc0, 0, TRUE);     // numerical
derivatives

      println("\nLog-likelihood_FIML0 (Restricted Model) = ", dfunc0 *
g_nobs);
      LR_Indep = -2 * (dfunc0 - dfunc) * g_nobs;


//*********************************************
//** Calculation of Likelihood Ratio Index **
//*********************************************
      decl LRI ;

      theta0 = 0.1 * ones(13,1);
```

```
      theta0[5:12] = theta_FIML[(g_numX1 + g_numX2 + g_numX3 + 2 * g_numZ) :
(g_numX1 + g_numX2 + g_numX3 + 2 * g_numZ + 7)];   //starting value of error
terms at final UR model estimates
      g_mX1 = 1;                //constant only model
      g_mX2 = 1;                //constant only model
      g_mX3 = 1;                //constant only model
      g_mZ = 1;                 //constant only model
      g_numX1 = 1;
      g_numX2 = 1;
      g_numX3 = 1;
      g_numZ =1;

      ir0 = MaxBFGS(fFIML, &theta0, &dfunc0, 0, TRUE);      // numerical
derivatives

      println("\nLog-likelihood_FIML_constant only (constant only Model) = ",
dfunc0 * g_nobs);
      LRI = 1 - dfunc / dfunc0;

//*******************************************
//** commands to do nicer tabular output **
//*******************************************
      print("\nFIML output\n");
      print("%r",{"cons1","lntaken","lntaken_popden","lntaken_time","lntaken_
res","lntaken_com","lntaken_otherland","lntaken_vac","partialtaking","lnremai
n_time","cons2","lntaken","lntaken_popden","lntaken_time","lntaken_north","ln
taken_com","partialtaking","lnremain_time","cons3","lntaken","lntaken_popden"
,"lntaken_time","lntaken_res","lntaken_com","lntaken_otherland","lntaken_vac"
,"partialtaking","lnremain_time","cons1*","timetrend","west","commercial","pa
rtialtaking","lnremain","otherown","cons2*","timetrend","west","commercial","
partialtaking","lnremain","otherown","eps0","eps1","eps2","sig01","sig11","si
g22","err12","err2"},              // row titles
            "%c",{"Coeff","s.e.","z-stat","p-val"},              // column
headers
             "%#10.4f", theta_FIML ~
sqrt(diagonal(cov_FIML)')~(theta_FIML./sqrt(diagonal(cov_FIML)'))~2*tailn(fab
s(theta_FIML./sqrt(diagonal(cov_FIML)'))));     // format to have three
significant digits
      print("\nFIML LR test\n");
      print("\nLR test of INdepence Eqns:\n", LR_Indep);
      print("\nLRI:\n", LRI);
}
```

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