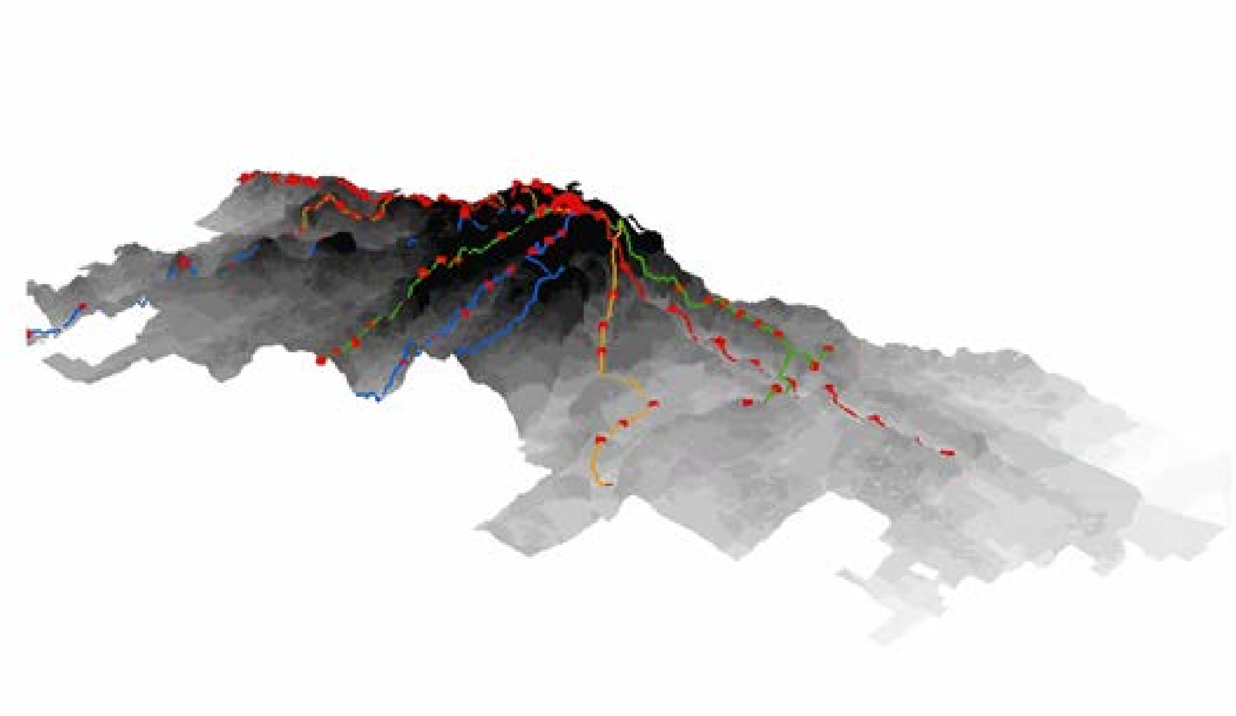
Sustaining Mass Transit through Land Value Taxation? Prospects for Chicago



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Contents

1. Introduction

Interest in the relationships between transportation and land use remains strong for a wide-range of reasons, including growth management, housing affordability and equity, access to employment, concerns about public health, greenhouse gas emissions, etc. Within a given government jurisdiction, the land use and transportation policy domains often occupy separate institutional spaces, with different organizational structures, values, objectives, and cultures. Nonetheless, transportation and land use are inextricably linked by inter-dependent policy outcomes. Understanding these subsystems' interactions is thus critical to developing strategies to meet agencies' goals as well as the broader social and economic objectives and goals of cities and metropolitan areas.

In this paper, we focus specifically on the economic link between transportation and land use as exhibited in property values, with the express purpose of viewing how this link should and can be exploited as a transportation finance tool. In particular, we examine the land value created by urban rail transit access. Metropolitan areas face countervailing forces that drive growth patterns – positive externalities of agglomeration draw people and firms together, while negative externalities like congestion push them apart. Public transit offers a partial solution to the congestion problem by creating a mass rapid transportation option for individuals, businesses, visitors, etc. The benefits of transit investments to the local economy should be reflected in business profits, individual income, and property values. We focus on this last source – the one most tangible for local government revenue generation.

The idea of "capturing" the land value created by transit development as a source of project finance is not new, but the current lack of sustainable transit finance exhibited throughout the United States underscores the urgency of exploring viable alternatives to the status quo. By the end of the 1970s, as Anas (1982) discusses, a confluence of factors had already led to ongoing public transport financial crises in U.S. cities. Most of the problems then remain today, both in terms of operating and infrastructure costs. Highway competition, land use policies that poorly coordinate development with infrastructure, pressure for greater geographic coverage of transit networks, insufficient fare box revenues, under-priced transportation substitutes, lack of reliable funding from other governments; the confluence of these and other factors make it difficult to efficiently and effectively manage transit services in urban areas. Transit systems persist, however, because they bring value to the residents and businesses that they serve. Identifying those beneficiaries and devising means of making them contribute a greater share of funding can help stabilize transit agency budgets, improving service quality and, ultimately, supporting local economies.

We examine these effects and possibilities in the City of Chicago, exploring the relationship between urban rail services, accessibility, and residential and commercial property values. Section 2 discusses the theoretical underpinnings of the relationship between accessibility, land value, and transportation finance; explores different taxing mechanisms; and reviews empirical evidence. Section 3 reviews the context of transit finance in the Chicago Metropolitan Area and previous studies of Chicago transit investment and land value capture. Chapter 4 introduces our hedonic pricing models, through which we estimate the impact of proximity to mass transit stations on property values in Chicago. In Chapter 5, we evaluate the potential revenues that could be generated in Chicago using land value capture to fund public transit and discuss implementation scenarios. Chapter 6 offers concluding thoughts.

2. Accessibility, Land Values, and Transportation Finance

Basic economic theory suggests that households and other locating agents make trade-offs between accessibility, land area, and other relevant attributes in their location decisions. Accessibility measures the ease of reaching desired destinations from a given location. Most basically, the value of land, as an immobile asset, partly reflects the relative accessibility (ease and value of movement) to/from that land, depending on the use of the land. This conceptualization finds its roots in the work of von Thünen, who in the early 1800s theorized that land rent for agricultural activities can be explained by the relative productivity of that land (its yield) and the cost of transporting that yield to market.[1] Presuming a centrally located market surrounded by farmland, this model leads to concentric rings of agricultural products radiating out from the market center. The amount that a farmer will pay for cultivating land – equivalent to the land value – will vary based on the productivity of the land for a particular product (land use) and the distance to market. Assuming transportation costs proportional to distance, all else equal a farmer will pay a decreasing amount for land rent as distance from market increases, resulting in a set of rent gradients for different land uses, extending in all directions from the central market.

Almost 140 years later, Alonso (1964) extends upon von Thünen's basic model and adapts it to urban land uses, deriving the theory of a bid rent function for urban location choices.[2] Alonso bases his model in microeconomic theory, whereby a locating agent's utility depends upon consumption of a generalized good, property size, and distance to the central business district (CBD). This agent aims to maximize utility, subject to an income constraint – the resulting bid-rent function represents the amount an agent is willing to pay for rent at different locations, with different distances to CBD (and, subsequently, different transportation costs), while maintaining the same levels of utility. The model reveals a clear trade-off between location and lot size and can somewhat straightforwardly be adapted to firm location choice, with profit-maximization substituting for utility-maximization. Rosen (1974) provides a direct link between the bid-rent model, willingness to pay, and hedonic price theory, deriving the willingness to pay function based on indirect utility, which allows us to estimate the value of a good's attributes based on the observed prices for the good. With the right data, one can use hedonic models to estimate the relative contribution of location to the value of a unit of land in a given study area.

Alonso's model followed von Thünen's in an important aspect: the assumption of the city as a flat plain, with a single central market (the CBD) and transportation costs directly proportional to distance to CBD. These simplifications produce the traditional monocentric city, represented economically by a rent gradient with land values declining per unit distance from the CBD. Yet, empirically, the monocentric city had already become somewhat anachronistic at the time (e.g.,

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[1] $R = Y(p-c) - Ytd$, where R is rent, Y is yield per unit land, p is the price per unit of yield at the market, c is the production cost per unit of yield, t is the transportation cost per unit yield and unit distance to market, and d is the distance to market.

[2] See Alonso (1964) for a more detailed history of the relevant early theoretical contributions.

Yeates, 1965).[3] The residential property value as a function of distance to CBD perspective rests partly on the assumption that journey-to-work is the most important travel-related variable in a locator's decision and that jobs are concentrated in the CBD. The validity of this assumption has declined over time.

Various technological, demographic, social, fiscal, political and other factors had already contributed to changes in metropolitan areas' socioeconomic geography, making the polycentric – or, at least, the *less*-CBD-centric – city already a reality in the United States. The growth of two- (or more) worker households means that individual households may possibly need to balance between access to different employment locations when making residential choices. The growth in automobile ownership and roadway development increased accessibility across metropolitan areas (at least for auto owning households). The growth of non-work travel as a share of households' total travel (Santos et al, 2011) theoretically increased the importance of accessibility to a much wider range of potential destinations in the household location decision.

In some sense, most of the location attributes for a potential residence can be considered accessibility-related, as reflected in, for example, access to certain schools, environmental amenities (e.g., backyards, parks), social and demographic "networks," retail districts, and the like. Given a fixed income, households aim to maximize their utility, which includes some desired mix of accessibilities (local and regional, to various different opportunities), residential attributes, and other relevant characteristics. Again, a somewhat analogous situation exists for firms, which require accessibility to labor (of different types), clients, material and other inputs, and the like.

Understood in this way, accessibility across a metropolitan area can clearly be influenced by changes in the transportation and the land use systems, with changes in one feeding back into the other.[4] A major transportation investment will change the accessibility profile across a metropolitan area, impacting where trips begin (origins) and where they may end (destinations). These effects will be capitalized into land values; all else equal, these changing land values will, in turn, influence urban development patterns. The impact of transportation investments and services on accessibility and, thus, land values, ultimately depends on the relative accessibility benefits conferred and households' and firms' sensitivities to accessibility.[5] For example, a new highway in an area previously "unconnected" from the rest of the network may generate relative "windfall" accessibility gains. Additional infrastructure connections; however, may produce lower gains; that is, accessibility gains likely reach a point of diminishing returns, reflected in lower incremental impacts on land values.

Overall, transportation infrastructures and services impact a metropolitan area's accessibility profile in a systematic manner, and impacts may be uneven across space, leading to differential

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[3] Alonso (1964) does conceptually extend his model to cities with multiple centers and with different patterns of transportation networks.

[4] The effects might also transfer into "secondary markets," such as for transportation technologies. For example, purchasing a motor vehicle (or an additional motor vehicle) might be influenced by the relative accessibility value gained, conditional upon location choice.

[5] Transportation investments may also enable location-specific "scale economies" – e.g., economies of agglomeration; these can, in fact, be considered a type of accessibility effect as, for example, when mass transportation service might enable a greater concentration of firms and employees to locate in close proximity.

impacts on land value. A transportation investment in, say, a large new roadway, will change an area's accessibility profile, impacting a range of possible trip origins and destinations, benefiting some more than others and with the total effects diminishing with (network) distance from the infrastructure. In theory, and *all else equal*, a transportation improvement to a specific area of land will increase the value of that land equivalent to the travel time savings that the improvement generates. For residential land, the impact on value will partly reflect the cost of travel from that location to other locations of interest. For commercial land, similar value effects should manifest themselves (due to, e.g., lower costs of getting goods to market). Under such conditions, all else equal, households and firms should be willing to pay more for places with better transportation service, due to the improved accessibility conveyed.

Literally capitalizing on these theoretical interactions has a long history in urban development in the U.S., and elsewhere. Indeed, entrepreneurs led the urban economic theorists in this regard, as real estate developers in the late 1800s were already developing rail projects with the express purpose of increasing the value of their land holdings, in the form of "streetcar suburbs" (e.g., Warner, 1962).[6] By as early as the 1920s, residential and retail developers would soon follow the auto-mobility enabled by roadway development and increased household auto ownership (e.g., Muller, 2004), though perhaps not as explicitly in the "joint development" approach of the streetcar suburb entrepreneurs. In most of these roadway-driven cases, developers were capturing the value created by public investments in roads. Some analysts have hypothetically examined, ex-post, the degree to which value capture techniques could have provided an alternative financing source for highways in the U.S. (e.g., Batt, 2001). A number of authors have also pointed to land value increases as an "under-utilized" source of funding for public transit (e.g., Smith and Gihring, 2006).

2.1. Accessibility and Transportation Finance: The Fiscal Federalist Context

When considering the possibilities for utilizing land value impacts for metropolitan-level transportation finance purposes, we should first properly situate the instruments within the broader public finance context. A decentralized, fiscal federalist[7], public finance system should follow several normative principles in deploying specific finance instruments. *Fiscal equivalence* refers to the need for matching public goods' beneficiaries with those who pay (Olson, 1969) – this suggests that the majority of public goods should be produced at the sub-national level. This would contribute to *efficiency* (marginal benefits equal to marginal costs) and accountability/transparency and links directly to *externalities*, which can be inter-system (e.g., automobile pollution impacts the health system), intra-system (e.g., bus operations influence automobile operations), and inter-jurisdictional (e.g., taxes by one government influence revenues of another government).

We also have the important and related dimension of *equity*, which, while partly addressed via *fiscal equivalence*, introduces additional challenges because society determines that many goods – either technically or politically "public" goods – should have a minimal guaranteed level of

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[6] As Warner (p. 23) says: "To real estate men the simple procedure of placing a coach on iron rails seemed a miraculous device for the promotion of out-of-town property."

[7] Fiscal federalism refers to the attribution of relevant public finance functions (taxing and revenue-raising powers) among different levels of government (e.g., federal, state, local).

provision to all (e.g., clean water). How we measure *equity* depends on how we define the term in the context of transportation and public finance. We must then determine which aspects of *equity* in the broad sense are supported by *fiscal equivalence,* which aspects are challenged, and whether and under which conditions these conflicts are reconcilable.

Recent studies have attempted to more clearly frame concepts of *equity* to facilitate analysis of public finance options for transportation policy. Lari et al. (2009) offer a set of criteria for *equity,* with conflict possibly arising when objectives of "benefit equity" clash with objectives of "capacity-to-pay equity." PATS (2002) synthesized concepts of fairness and equity along four dimensions: territorial equity, ensuring a level of access to goods and services across jurisdictions; horizontal equity, embodying the concept of equality of opportunity (e.g., user pays); vertical equity, encapsulating fairness of distribution across groups; and longitudinal equity, or avoiding the reduction of benefits in formulating new policies. Opportunities for conflict abound, most clearly between vertical and horizontal equity. Taylor and Norton (2009) frame the varying definitions of *equity* as specifically related to transportation finance, which they describe as a function of two criteria: the underlying philosophical view of distributional justice and the unit of analysis. With respect to the former, objectives of *equity* depend upon whether the observer's concept of distributional justice or fairness is rooted in equality of outcome (egalitarianism), equality of opportunity (analogous to vertical equity), or market equity (analogous to horizontal equity). Desired outcomes are further shaped by the unit of analysis, whether it be based on geography (e.g., city, state, etc.), group (e.g., poor, wealthy, etc.), or the individual (Taylor and Norton, 2009).

Taken together, and ignoring for the moment the units of analysis, it would appear that *fiscal equivalence* tends to promote social justice interpretations through the prism of horizontal/ market/benefit equity, ensuring taxpayers or users in a given locale receive benefits in rough proportions to taxes and fees paid. Adherence to *fiscal equivalence* helps discipline political leaders against providing excessive benefits to favored consumers of a given public good at the expense of users of a different good or service. This does not mean that transfers cannot be warranted within a fiscal federalist framework, but expenditures that are redistributive in nature should align the objectives of revenue sourcing and expenditure programs as consistently as possible (e.g., progressive income taxes can fund food and other types of aid to lower-income families). Less clear, however, is whether *fiscal equivalence* will naturally promote vertical/ opportunity/ability-to-pay equity. This depends, in part, on the socio-economic profile and distribution of incomes across a given area and the types of policy instruments employed.

For the purposes of this research we assume that a policy that promotes *fiscal equivalence* is generally consistent with horizontal equity and related concepts. Thus, our analysis and consideration of the term *equity* will consider the realm of vertical equity and related concepts, which we assume will vary depending upon the *fiscal equivalence* properties of a given public finance instrument. From here on, references to *equity,* will encompass the latter definition.

In terms of expenditures, local governments should be subjected to "*hard budget constraints*" to ensure adequate consideration of costs and benefits. This implies that, at minimum, transfers from higher levels of governments should not be too large and should be designed in such a way that local government finances the marginal costs of service extension (Oates, 2002). This, in turn, means that local governments should have access to the appropriate instruments to generate the resources necessary to finance their operations, introducing the issues of *administrative ease* of the possible instruments and *adequate assignment* of them.

Metropolitan transportation investments and services are highly germane to the topic of fiscal federalism. Many if not most of the benefits of metropolitan transportation investment accrue to residents and businesses located within the same geographic area. Moreover, metropolitan transportation systems produce numerous *externalities* across local government boundaries, positive and negative, which might include labor productivity benefits produced by increased mobility, air pollution costs, inter-modal network effects between public and private transportation modes, congestion, etc. Since most private automobile travel in metropolitan areas in the United States is underpriced (i.e., the price paid by the user at the time and place of travel does not reflect the full social marginal cost, especially roadway congestion costs), subsidizing public transport offers a “second best” way to correct these *externalities* (“subsidizing a substitute”; e.g., Wijkander, 1985).[8] Finally, society seems to value transportation (or mobility or the accessibility provided) as some form of a public good, a basic level of which should be guaranteed for all; however, given the broad interpretation of what constitutes *equity*, implementing publicly funded transportation investments remains technically, financially and politically contentious.

The case of *metropolitan* transportation in the United States offers an interesting portrait of the fiscal federalism in practice. Nearly all large metropolitan areas in the United States cross a number of local jurisdictions (municipal/city governments), implying, in theory, the need for some “other” level of government, below the state (and in some cases, across state lines) but above the municipal, to finance metropolitan-level transportation. The U.S. Federal Government required the creation of metropolitan planning organizations (MPO) in the 1960s to coordinate transportation policy among state and local authorities, and has since empowered these bodies with developing long- and short-range metropolitan transportation plans. The Transportation Improvement Plan (TIP), a minimum four-year plan which is fiscally constrained by projected available funding and must be approved by both MPOs and state governors, serves as a programming guideline for most federal transportation expenditures (FHWA and FTA, 2007). Rarely does the MPO adequately fulfill the role prescribed by fiscal federalism, however, as MPOs typically do not have directly elected representatives and rarely have direct recourse to taxes or responsibility for investment/service provision.

Ultimately, authority for metropolitan transportation policy is commensurate with the powers to tax and spend. Thus, the finance system is a critical, if oft-overlooked, factor in determining the institutional structures, objectives, and priorities underlying metropolitan transportation investment. Thus, it is important to understand the principal revenue sourcing instruments for funding transportation investments in metropolitan areas. Table 2-1 outlines some of the most prominent revenue-raising methods in the United States for financing transportation, summarizing how well each instrument delivers on fiscal federalism at a metropolitan scale.

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[8] A number of other reasons may exist for subsidizing public transit, such as scale economies (Mohring, 1972), enabling of agglomeration economies, equity, among others, though whether automobile users, rather than society more generally, should be responsible for the relevant subsidies implied is unclear.

Table 2-1. Fiscal Federalism: Revenue-Raising Options for Metropolitan Transportation

Financial Instrument	Fiscal Equivalence	Efficiency	Externalities	Equity (Vertical)	Administrative Ease	Comments
Fuel Taxes	+/-	-	-	+/-	+	• Fiscal equivalence vs. equity: donor vs. “donee” states • Paid by producer/exporter; not variable with time/space/externality • Equity effects depend on substitutes and cross-price elasticity [a]
Other Vehicle Taxes and Fees	+/-	-	-	-	+	• If implemented locally, aligns tax with location of wear and tear • Not variable with time/space/externality • Generally regressive [b]
Road Charge	+	+/-	+/-	+/-	-	• In theory aligns pricing, marginal social costs, and investment [c] • Actual demand/location-based tolls (i.e., congestion) are rare [d] • Equity depends on the income groups of users [e]
Public Transportation Fares	+	+/-	+/-	+/-	+	• Same as road charging, except fares rarely in practice cover costs [f] • Lower fares paradoxically generate positive externalities through scale economies of density (i.e., the “Mohring effect”) [g] • Equity effects depend on income class of riders/beneficiaries [h]
General Taxes – Income, Sales, etc.	+/-	-	-	+/-	+	• Fiscal equivalence if administered locally (e.g., LOTTs [i]) • Not variable with time/space/externality • Income-based is progressive; sales-tax based is regressive
Land Taxes [j]	+	+/-	+/-	+/-	+-	• Not variable with time/space; can promote efficient development • Equity depends on resident incomes, but often slightly regressive • Simple in theory, but split land/improvements taxes are rare in US
Land/Property Value Capture Variants	+	See Table 2-2				• Efficiency/Externalities, Equity, and Administrative Ease will vary greatly depending on the instrument employed.

Key: (+) meets criterion; (+/-) partially meets; (-) mostly fails; Notes: [a] Parry and Small, 2005; Dill et al., 1999; [b] Dill et al., 1999; [c] Mohring and Harwitz, 1962; Vickrey, 1969; Small, 1993, etc.; [d] Some private-run operations have crude congestion charging. Also see Whitty, 2007 for details of the Oregon distance-based user fee pilot project; [e] Schweitzer and Taylor (2008); [f] NCHRP, 2006; Mallett, 2007; [g] Nelson et al., 2007; Parry and Small, 2009; [h] Ibid.; [i] Local Option Transportation Taxes (LOTTs): increasingly applied for funding transportation, usually via dedicated sales taxes (Goldman and Wachs, 2003). [j] Lari et al., 2009.

Fuel Taxes

Any discussion of transportation finance in the United States begins with fuel excise taxes. State and federal fuel taxes combined comprise the single largest source of transportation revenues raised in the country (e.g., NCHRP, 2006; Puentes and Prince, 2003). In Fiscal Year 2010, the Federal Government collected $34 billion in fuel tax proceeds, almost all of which was earmarked for highways and transit programs; state and local fuel taxes generated $38.9 billion in 2009 of which about $34.5 billion was expended on highway and transit programs (FHWA, 2011a).

Federal and state governments typically apply some fuel excise tax revenues to cross-subsidize public transportation expenditures. Federal fuel tax revenues were earmarked exclusively to the Highway Trust Fund (HTF) until 1982, when the Surface Transportation Act apportioned a percentage of federal transportation user-fee receipts for transit. Congress has since customarily earmarked 20% of net gas tax increases to transit. Currently, the HTF dedicates 2.86 cents per-gallon to the Mass Transit Account (MTA) (out of 18.4 cents-per-gallon for gas and gasohol and 24.4 for diesel), as well as various percentages of other alternative fuels (FHWA, 2011a). States also have limited flexibility to redirect portions of the much larger highway apportionments to transit (Mallett, 2007). With respect to sub-national fuel tax receipts, 30 States restrict their fuel tax receipts to highway purposes and just four states provide more than 10% of fuel tax receipts for “mass transit purposes” (Puentes and Prince, 2003). Overall, the Federal Government contributes 18% of all transportation revenues to transit ($7 billion in 2004); for states the figure is about 20% ($7.8 billion in 2004) (Mallett, 2007).

One of the primary reasons that the fuel tax persists as the primary financing mechanism for federal and state transportation is the relative *administrative ease* of collection. The national and state fuel taxes enjoy well-established procedures; more “localized” (i.e., metropolitan level) fuel taxes would in theory be more difficult to administer and subject to relatively easy evasion. Moreover, as Puentes and Prince (2003) detail, the fuel tax is collected directly from a relatively small number of importers and producers rather than from individual consumers at the pump.

The fuel tax only marginally fulfills the criterion of *fiscal equivalence* and does a fairly poor job of accounting for *efficiency* and most *externalities*. In terms of equivalency, at the national and state levels, formulae establish the share of fuel tax revenues raised which return to lower-level jurisdictions; this has led to the gas tax revenue “donee”/”donor” debate, both between states (at the Federal level) and within states (basically between rural and urban areas). Generally, but not always entirely, the revenues raised make it back to the respective jurisdiction. In theory, MPOs direct how these funds get allocated to transportation investments, but the actual investment responsibilities rest with the relevant federal, state, or local agency/jurisdiction. In terms of *efficiency*, although called a tax, the federal and state fuel excise taxes (note some states and local governments also impose an additional retail tax on gasoline) are, technically, roadway user fees – somewhat indirect in that the user does not directly pay these fees[9] and levies do not directly vary by size/weight of vehicle, time and place of day of travel, etc., which a direct roadway user fee should, in rigor, reflect.

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[9] They are imposed as “manufacturer excise taxes” and, as such, are passed on to the final consumer (road user) in the form of increased production costs (Puentes and Prince, 2003).

Fuel taxes generally do not target *externalities*. Federal and state fuel taxes could directly charge for greenhouse gas emissions (which can be directly attributed to fuel volumes consumed) and thereby help control the *externality* of climate change risk. In practice, current tax structures do not reflect these costs. Fuel taxes could also indirectly account for local pollutant emissions although, again, the current structure does not explicitly reflect these costs. In terms of intra-system externalities (i.e., benefits transit may provide to the auto system), the cross-subsidies from federal fuel tax receipts to the MTA ostensibly support broader inter-modal mobility (i.e., reducing congestion on highways). As mentioned, many states also use state gas tax receipts for transit, though, generally, only small shares.[10] The federal funds from the MTA can only be used for capital expenditures. This partial and blunt cross-subsidy to transit from highway users provides an imperfect instrument – as public transport benefits to private vehicle users are very time- and place- specific – most likely resulting in over-subsidies in some places and for some technologies and under-subsidies in other places/technologies.

In terms of *equity*, in the broadest sense and particularly in a country like the U.S. with very high auto ownership and auto dependency across socioeconomic sectors, the fuel tax is likely somewhat regressive. The net effects, however, depend on the availability of travel substitutes, price and cross-product elasticities, and how revenues are subsequently spent. Parry and Small (2005) suggest that in the U.S., the gas tax may be “less regressive than is commonly thought” (p. 1277), although Dill et al (1999) estimate the gasoline tax to be among the most regressive of a range of motor vehicle-related taxes and fees.

As a less-than-perfect road user fee, and with increased fuel efficiency and greater use of “alternative-fueled” (or hybrid electric) vehicles, the fuel tax’s days may be numbered as the primary transportation finance mechanism. The likely erosion of the revenues generated by fuel taxes combined with promise of advanced communications technologies enabling electronic collection of road user fees have led to increasing interest by state and federal authorities in vehicle mileage fee collection systems. For example, Oregon completed a pilot road user fee program in 2007, demonstrating the general feasibility of an electronic collection system designed to integrate with the existing fuel tax collection system (Whitty, 2007). At the same time, resistance to changing a user-fee system that is well-known and mostly accepted by users and other embedded interests may prolong the life of the fuel tax beyond its sustainability as transportation finance tool.

Other Vehicle Taxes and Fees

The Federal Government and states impose other taxes and fees linked to transportation system use. The Federal Government assesses heavy duty vehicle fees, taxes on tires bearing heavy loads (e.g., 3,500 lbs. or more), and retail sales taxes on trucks and trailers, with revenues allocated to the HTF, accounting for $890 million, $320 million, and $1.6 billion, respectively, in Fiscal Year 2010 (FHWA, 2011a). These fees can be considered proxies for increased roadway damage incurred by large vehicle use. States and local governments also impose vehicle taxes, registration fees, excise and other vehicle-related taxes, amounting to $31.7 billion in Fiscal Year

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[10] The average share of state gas taxes going to transit is 4% and the median less than 1%; only 11 states transfer more than 5% of their gas tax revenues for transit purposes. A number of states use gas tax revenues for general revenue/non-transportation purposes (Puentes and Prince, 2003; see Table 4).

2009 (FHWA, 2011a). Depending on the local structure of these fees and taxes, they can roughly proxy for roadway wear-and-tear charges, space occupancy, and system management/administration costs more generally. Such taxes and fees satisfy the requirement of *administrative ease* and, if primarily locally implemented, can satisfy *fiscal equivalence* in the general geographic sense, presuming most of the public costs implied by vehicle ownership accrue at the local level.

Whether or not the vehicle taxes and fees can be considered *efficient* depends on the specific structure/purpose of the fee. Such fees still fail to adequately price road use in time and space, although the latter criterion is at least partially satisfied if administered as locally as possible. Pollution externalities can be, but rarely are, directly accounted for (to the degree to which the fee structure represents size and/or emissions profiles, for example), but such a purpose would likely be a grossly second- (or third-) best mechanism. Inter-system externalities are somewhat accounted for; to the degree to which such fees reduce automobile (truck) ownership, they might, at the margin, have system efficiency effects by decreasing auto use and increasing transit (rail freight) use. Overall; however, most of these types of fees bear no relationship to transportation system *use*.

With respect to *equity*, vehicle ownership fees and taxes can be regressive, depending on the type, structure, and implementation of the instrument employed and the distribution of the resources generated. Examining the California case, Dill et al. (1999) find vehicle sales and transfer taxes to be the least regressive of relevant types of fees, followed by vehicle license fees, a flat vehicle registration fee, and a flat driver's license fee. Of course, the relative ranking of these tax options would potentially vary in other jurisdictions with different socioeconomic and mobility profiles.

Road Tolls and Public Transportation Fares

Roadway tolls and public transport fares represent the most direct transportation user charges. Such user fees can nicely fulfill the principles of *fiscal equivalence* and, depending upon how they are structured, promote *efficiency* and account for many *externalities*. If properly employed in space and time and with adequate safeguards, they can also largely fulfill most of the *equity* concerns, although the issue of incidence across different income groups can be problematic in the case of some road toll projects. Theoretically, highly differentiated road tolls, including congestion costs, would produce "efficient" system operations (i.e., economically efficient levels of congestion) and would also generate an adequate stream of revenue to finance the roadway infrastructure (e.g., Mohring and Harwitz, 1962, Small, 1993) – economists have been calling for congestion pricing for at least 50 years (e.g., Vickrey, 1969).

In practice, however, congestion pricing of roadways in metropolitan areas of the United States remains quite limited, as do road tolls more generally.[11] Tolling is not permitted on most segments of the Interstate Highway System, though this is slowly changing. The previous federal transportation reauthorization (SAFETEA-LU) created half a dozen tolling and pricing demonstration programs (FHWA, 2009) and greatly expanded federal loan and loan guarantee programs supporting public-private income-generating transportation facilities through the

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[11] In the U.S., only $6.6 billion was raised from road tolls in 2004 (NCHRP, 2006), approximately 10% of revenues raised by Federal and state fuel taxes.

TIFIA Program. Eligible projects included just about any type of transportation infrastructure or inter-modal facility (FHWA, 2011b). Thus, the Federal Government is signaling increased support for more direct user-fee-financed transportation programs, though it might take many years before direct road pricing becomes the dominant method of project finance. Meanwhile the pilot projects and public-private initiatives should, in time, provide empirical evidence of the strengths and weaknesses of different road pricing alternatives.

Historically, *administrative ease* was a problem in implementing congestion pricing and road pricing more broadly; advanced technologies have largely overcome these challenges and the principal barriers today appear to be political. In terms of the *equity* implications of congestion tolls (or tolls more generally), again, the ultimate effects “depend,” in part on the alternative financing mechanisms. For example, Schweitzer and Taylor (2008) find that, relative to sales taxes, a particular tolled facility in Southern California (the “value-priced” high occupancy toll (HOT) lane SR91 in Orange County) is progressive in absolute terms as higher-income groups tend to pay more overall but also regressive for lower-income groups which use the facility less often but suffer higher relative impacts on income compared to benefits. Middle-class groups appear to gain the most (Schweitzer and Taylor (2008).

Widespread road tolling, including with congestion pricing, seems increasingly feasible, at least technologically, given advances in electronic collection capabilities. As mentioned in the discussion on fuel taxes, the United States has already seen one state-level pilot mileage fee program implemented, in Oregon (Whitty, 2007), although the specific system tested would not enable dynamic pricing. Such systems are being developed and tested in various settings, although the ongoing concerns of privacy invasion, cost, reliability and political acceptability remain somewhat formidable.

Public transportation fares are similar to road user charges within the fiscal federalist framework. There are, however, a few differences, mainly with respect to *administrative ease* and *efficiency*. In the former case, users are accustomed to paying fares for entry into public transit systems, and agencies can limit ingress and egress easily with relatively simple technology. While fare collection is presently easier to administer than road user fees, the concept of *efficient* public transportation fares is much more complicated.

Three basic reasons exist for having public transportation fares below full marginal cost prices (NCHRP [2006] and Mallett [2007] both estimate that, on average, public transportation agencies cover only about 40% of operating costs from fare box receipts). One relates to the under-pricing of private road transportation; absent a fully congestion-priced road system, subsidizing public transportation use can be justified as a “second best” solution – subsidizing the substitute (Wijkander, 1985). In partially-tolled systems (e.g., the bridges into Manhattan), an argument can be made that allocating some toll revenues to finance public transportation is justified on the basis of system-wide benefits (e.g., positive inter-modal externalities) and, in fact, some transit agencies (including in New York City) have access to revenues raised from road tolls.

Even if full social marginal cost pricing were in place for the roadway system, a second argument for public transportation subsidy suggests that public transportation exhibit scale economies (the right-of-way and capital investment costs are largely insensitive to demand volumes) and returns to scale of frequency (the so-called "Mohring effect") (e.g., Mohring, 1972; Nelson et al., 2007). Parry and Small (2009) find current operating subsidies for transit systems in Washington, DC, Los Angeles, and London to be justifiable on *efficiency* grounds; Nelson et al. (2007) similarly find that bus and rail system benefits (considering only reduced congestion and increased travel options) in the Washington, DC, Metropolitan Area exceed the subsidy levels.

Lastly, in highly motorized societies, the costs of transportation can be prohibitive for many households, challenging traditions that value accessibility as a basic "right" for all citizens. For households that cannot afford automobile transportation, subsidies for public transportation may also be justified on equity-of-accessibility grounds, although one might question whether such subsidies could more efficiently provided directly to the users as opposed to the transit providers (e.g., Mayers and Proost, 2003). Furthermore, given the spatial distribution of transit provision and relative costs, the *equity* implications may be counter to expectations; in their assessment of the Washington, DC-area, Nelson et al. (2007) find that the transit system disproportionately benefits wealthier travelers.

General and Special Taxes

States and local governments employ a number of other taxes to fund transportation. Among these, general tax funds factor prominently in covering many costs of transportation improvements and services. In 2004, general taxes (e.g., from income, property, sales taxes) accounted for $43.9 billion of highway and transit expenditures (approximately one-quarter of total expenditures); most of the general tax revenues going to transportation expenditures come from state ($11.3 billion) and local ($28.4 billion) sources (NCHRP, 2006).

The appropriateness of general tax revenues for transportation investment depends in large part on the source of funds and the explicit investment objective. An attractive element is the *administrative ease*, as most general revenues derive from stable and time-tested mechanisms. *Fiscal equivalence* may be satisfied to the extent that general fund sources are collected from the primary beneficiaries of a given investment (e.g., property taxes to fund local roads), though this is often not the case (e.g., federal and state income taxes funding local investments). Regarding *efficiency* and *externalities*; however, general tax sources generally bear, at best, an indirect relationship with transportation *use* (e.g., perhaps the economic activity associated with sales tax receipts is enabled by transportation investment, etc.). And since sales taxes are generally thought to be regressive – lower-income households tend to spend a higher percentage of income on taxed goods and services – *equity* is achieved only if investments disproportionately benefit these households.

General revenue sources used for transportation can also have important positive *equity* effects, depending once more on the sources and expenditures. For example, the use of income tax revenues to fund the equity-based operating subsidies for public transportation would likely be more progressive than providing such financing from transportation-based revenues, per se. Furthermore, if transportation infrastructure investments generate external economic benefits, such as enabling agglomeration effects, general funds from all relevant revenues can be justified as a source for expenditures.

The past several decades have witnessed the emergence of a new subset of transportation financing derived from traditionally general-revenue sources. Goldman and Wachs (2003) document how local option transportation taxes (LOTTs) have become increasingly popular, partly in response to widespread opposition to general increases in local taxes beginning in the 1970s. LOTTs are distinguished from most general revenue financing mechanisms in that local voters have typically explicitly approved such measures with the express purpose of dedicating the revenue stream generated to transportation needs. While some of the revenue instruments are sourced from transportation (e.g., fuel taxes and vehicle registration fees), the authors identify other emerging approaches intended to fund transportation, including income, payroll, employer, and, especially, sales taxes. Over the last decade, general fund revenues and specialized taxes have grown more rapidly than "traditional" transportation revenues (e.g., motor fuel taxes, vehicle taxes, tolls and fares) (NCHRP, 2006).

The increasingly prevalent use of sales tax increments to finance local transportation in the U.S. poses a range of transportation- and regional-planning specific problems. Primarily, this trend pushes transportation finance further from user-fee pricing (Hannay and Wachs, 2007), with its inherent efficiencies in efficiently assigning costs and rationing use of the transportation system. Furthermore, use of sales taxes leads to public finance-related distortions in a fiscal federalism sense as the beneficiaries of transportation investments are subsidized by consumers of other goods and services (e.g., Zodrow, 2007).

From a transportation finance perspective, most of the LOTTs (with the exception of those employing fuel- and vehicle-tax/fee instruments) inadequately address fiscal federalist principles. Adherence to principles of *fiscal equivalence* depends on the revenue instrument, though it should be mentioned that there are transparency and accountability advantages, which allow taxpayers to help better direct how these funds are invested. Local government and its citizens must arrive at some explicit agreement on the rates; the taxes tend to have finite lives; specific transportation projects are often identified through voting; and the resources remain firewalled from other uses (Wachs, 2003). However, LOTTs are poor proxies for user charges, having little potential in terms of *efficiency* and inter-system and intra-system *externalities*. Depending on how they are implemented, LOTTs can be helpful in addressing inter-jurisdictional externalities if, for example, a local option transportation sales tax were implemented by all the local governments within a transit service area, thereby reducing tax competition. By and large, however, LOTTs have no direct effect on transportation system use.

With respect to *equity*, again the specific effects depend on which revenue instrument is employed. Sales taxes tend to be highly regressive (though the population may not perceive them as such), but other elements of *equity* (e.g., across multiple modes in a transportation system) might be satisfied with a sales tax in that everybody contributes to the pool of funds as opposed to, say, just highway users in the case of fuel taxes (Goldman and Wachs, 2003).

Land and Property Taxes

As discussed, land presents a potential transportation finance source since the accessibility benefits that transportation infrastructures and services bring to locations should, in theory, manifest themselves in land values. All else equal, and following the basic idea of von Thünen, a location's value increases with improved transportation which lowers travel costs to/from (e.g., increases accessibility of) the location. Such travel time/accessibility benefits should be capitalized into location value (i.e., land rent); in theory, the *net* accessibility[12] gains should equal the land rent premium. Thus, property owners receive these benefits based solely on the relative location of their respective properties. Capturing some of the land value "gained" from accessibility enhancements thus seems an attractive potential finance mechanism.

The most basic and theoretically direct land tax instrument is the land value tax (LVT), made famous in the U.S. by Henry George[13] and his call for a single tax on land. As opposed to the more common property tax, whereby some of the tax burden falls on buildings and other improvements, a pure LVT taxes a good (land) with very inelastic supply, which produces fewer distortions. Furthermore, an LVT carries other benefits such as incenting investment in buildings and the development of land (more intensive use and less vacant parcels). In *efficiency* and *externality* terms, LVT would help provide better investment signals to land developers about relevant and relative infrastructure costs; however, the instrument would send only crude signals to transportation users (since it sends no direct price signals to users regarding, e.g., temporal effects of travel decision costs).

Equity effects depend on context. How regressive/progressive the tax would be depends in part on building-to-land-value ratios, among other factors. Weir and Peters (1986) assessed the graded tax ratio (tax rate on land to tax rates on improvements) in Pittsburgh, suggesting LVTs generally shift the tax burden from single-family homes to multi-family residential properties in poorer neighborhoods and to older commercial and industrial properties. England (2003) applied a simulation model using regional input-output modeling to test a revenue-neutral shift to a state-wide LVT from uniform property taxes in New Hampshire. The model, which considers economic output, employment, population growth, suggests positive total economic effects, but with geographic variation across the state.

Administratively, an LVT can take advantage of existing local government taxing capability (property assessments and taxation), though this introduces the non-trivial task of valuing land and improvements separately. Use of "pure" LVT in the U.S. is non-existent, although some places such as Pittsburgh (until recently) have applied split-rate property taxes. Moreover, land- and property-value taxes face political challenges. High visibility to property owners creates sensitivity to any changes, property-based taxes are already committed (justifiably) to financing other local public goods, and local taxpayers are often reluctant to cede local any autonomy of property tax administration to any authority crossing multiple jurisdictions (e.g., a regional transit authority).

Land- and property-value based taxes are, in the broadest sense already major contributors to financing local transportation investment. Most instruments are applied to the combined

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[12] **Net** accessibility here can be interpreted as net utility (utility less disutility), accounting for, e.g., any additional costs associated with the improved accessibility (such as tolls, fares). Accessibility, theoretically, should account for all relevant activity (e.g., to work, school, shopping, etc.) benefits.

[13] While Henry George is typically credited with popularizing calls for the LVT in the US (and elsewhere), others before him, including Adam Smith in *The Wealth of Nations*, made calls for land value taxation as an appropriate source of government revenue, particularly vis-à-vis taxes on structures.

contributions of land and improvement to property value as, again, pure LVT is rare in the U.S. On average, property taxes comprised about 20 percent of local highway funding in 2003 in the United States (NCHRP, 2006).

Land/Property Related Variants

In practice local governments deploy a number of financing tools based loosely on the principles of LVT to deliver infrastructure and other types of investment. These variants are typically applied at a district level within larger local jurisdictions, essentially taxing properties to help cover the costs of infrastructure investments and/or services that will support area development and/or otherwise serve residents and businesses. This structure inherently implies, at least in theory, adherence to *fiscal equivalence*. Different methods, however, will produce slightly different outcomes vis-à-vis other principles embodied in fiscal federalism. Table 2-2 summarizes each of the major land/property value capture schemes. Generally, district financing schemes do little to control actual use of the transportation system, though some schemes offer specific advantages for *efficiency* and *externalities* when considering the larger land use and transportation systems. Concerns about *equity* and *administrative ease* vary widely.

These instruments can be grouped into general categories. Value capture-type tools (such as betterment taxes) aim to recapture from property owners a portion of the increased values presumably accruing from public investments. Impact fee-type tools (or, more generally, *exactions*), on the other hand, charge developers for the impacts that new developments will have on infrastructure (and/or service) requirements. Impact fees tend to be used to finance infrastructure for new developments in high-growth areas, while value capture tools aim to recapture (at least part of) the increased property values created by new infrastructure in built-up areas (Zegras, 2003).

Tax Increment Financing (TIF) and Special Assessment Districts (SAD) fund current improvements with future revenue streams from increased property taxes (the former) or through contributions proportional to estimated property-specific benefits (the latter). Impact-fees like Development Impact Fees (DIF) and Negotiated Exactions charge developers (and thus future property owners) for the estimated cost impacts of new development on existing infrastructure capacity and levels of service. Transportation Utility Fees (TUF) are property-specific fees for the costs associated with expected demand on the infrastructure network, with charges based on estimates associated with property attributes rather than direct metering of use. Joint Development (JD) and Air Rights are more administratively complex approaches that take advantage of synergies between transportation and land use systems in dense, high-value areas to help deliver large-scale infrastructure and development projects. TIF/SAD are typically most viable for recapturing (at least part of) the increased property values created by new infrastructure in built-up areas; impact-fees tend to be used to finance infrastructure for new developments in high-growth areas; TUFs are particularly useful in locations with many non-taxpaying property owners (e.g., universities, places of worship, etc.); and JD/Air Rights schemes work best in small, dense, high-land-value areas like CBDs and upscale intensely-developed residential and commercial clusters (Lari et al, 2009; Zegras, 2003).

Table 2-2. Fiscal Federalism and Land and Property-Related Instruments[a]

Funding Mechanism	Description	Efficiency, Equity[b], and Administrative Ease
Tax Increment Finance (TIF)	• Captures all or part of a property value increase in a defined area to finance the catalyzing transportation improvement	• Few price signals to users, but strong signals to developers • Potential negative land value effects elsewhere in metro • Deprives overlapping tax districts of revenue • Potential favoritism to politically favored groups • Regressive on low- and fixed-income households • Setting district in setting-up bond issue can be complicated
Special Assessment Districts (SAD)	• Special non *ad valoreum* tax in a defined area over a period of time to pay for an improvement • Can be "tiered" based on relative benefits of location	• Similar efficiency concerns as TIF • Equity concerns similar to TIF, but it is possible to modify to compensate losers • Similar ease of administration concerns as TIF
Transportation Utility Fees (TUF)	• Fee, rather than tax, based on property attributes, whose demand impacts are estimated	• Can efficiently factor demand impact, but lacks signal for use • Regressive, but discounts can be targeted • Shifts responsibility to commercial/industrial, but hard to enforce
Development Impact Fees (DIF)	• One-time impact fee to cover related off-site transportation improvements, typically from formula estimating impacts	• Price signal on demand costs to city, but lacks signal to users • "Free ride" for existing residents (e.g., intergenerational equity) • Developers may forgo low-income housing due to added costs • Simple to administer and enforce, thou developers may oppose
Negotiated Exactions	• Less-formal type of DIF, often of on-site public improvement or in-kind consideration	• Similar to DIF in efficiency, if localized • Same intergenerational equity concerns • Simple to administer and enforce, but developers more supportive
Joint Development	• Spatially coincidental development, where transport and land development cross-subsidize one another	• Integrates market willingness-to-pay, but lacks signal for use • Neutral to progressive; typically viable in commercial or higher-end residential • Complex, with high administrative needs/transaction costs
Air Rights	• Sale/lease of development rights over a transport facility	• Same as joint development on efficiency and administrative ease • Equity is about neutral

[a] Derived from Lari et al., 2009; [b] Generally speaking, the relative equity depends on property types, as multi-family residential owners pass costs on to renters, but single-family home-owners pay the tax without seeing financial benefits until selling the property (CTOD, 2008);

In a TIF district, all or part or all future incremental property taxes (e.g., net of existing property tax receipts) attributed to a transportation improvement are essentially pledged to pay back the cost of the initial investment. Basically, the relevant authority (e.g., municipality) defines the improvement zone, holds as fixed (for some defined time period) the original (i.e., pre-TIF) assessed value of the properties in the zone (the “base”), and uses tax revenue proceeds from the increased increment in property values to finance relevant costs (e.g., of infrastructure improvements). The base tax revenues go to the original taxing jurisdiction, as does the TIF share of the revenues at the end of the TIF lifetime. TIFs are fairly widespread in the U.S., used in nearly all the states (Dye and Merriman, 2000). *Administrative ease* is relatively high, requiring only the segmentation of incremental property tax revenue appreciation in the TIF district. *Efficiency* is enhanced by encouraging more productive development of land, though TIF can lead to net social costs when the instrument directs development from productive to less-productive areas and localized benefits may be offset elsewhere in the metropolitan system (Lari et al., 2009, Dye and Merriman, 2000). Despite exhibiting general “benefit equity”, TIF pushes up local taxes, adversely affecting low- and fixed-income residents in the district; deprives overlapping tax districts of revenue, and often benefits politically-connected developers (Lari et al., 2009).

SADs are similar to TIFs in terms of fiscal federalism profiles. A few important differences in structure and administration merit attention. Property owners agree to pay a special tax over a period of time to help finance a given transportation improvement. Though property values are sometimes used as the basis for assessments, the revenues generated are considered non-*ad valorem* assessments based in theory on benefits to the property from district expenditures. SAD tax rates are often “tiered” on the basis of distance from a given investment to reflect proximity effects (Lari et al., 2009). For example, in 1985 the State of California created two “Special Benefits Districts” in the vicinity of rail transit stations to fund the extension of rail transit, where fees were assessed in a graded fashion depending upon proximity to stations (Smith and Gihring, 2006). Other examples in the U.S. include Los Angeles’ Metro Red Line; recent streetcar projects in Portland, Oregon and Seattle, Washington (Vernez Moudon et al., 2007); and, the expansion of Washington DC’s Metro into Northern Virginia (i.e., the Dulles Rail Transit project) (CTOD, 2008).

TUFs are fees, not taxes, assessed on properties in a similar manner as a utility bill. They are probably more *efficient* than TIF/SADs in that the fee aims to align capital costs with actual demand, albeit crudely, though costs are still up front. Costs are often weighted more heavily on commercial and industrial areas, which theoretically supports benefit equity (e.g., these land use types typically generate more system demand), but the tax is still regressive on lower- and fixed-income households. Discounts can be made for some groups (e.g., seniors) which might improve *equity* at the cost of *efficiency* (the same can be done for SAD). Implementation will be challenged by enforcement difficulties, which would require excluding delinquent payers from using the road network, and setting fees in a manner than can withstand legal scrutiny (Lari et al., 2009).

DIF and Negotiated Exactions are the most prevalent forms of the impact fee class of value capture. Local governments may impose either up-front fees (DIF) ostensibly to cover the cost of off-site transportation improvements needed to serve a new development, or require that developers provide some in-kind transportation improvement to improve local mobility (Negotiated Exactions). They advance *efficiency* in the sense that fees or exactions can proxy as price signals for land and transportation system development. While administrative ease is high, DIF and Negotiated Exactions often face intense legal scrutiny[14], though developers are often more willing to agree to the latter. *Equity* concerns are complex. DIF and Negotiated Exactions shift the burden to new development, which may be less regressive if existing land-owning households are lower-income, but developers are less likely to build new low- or moderate-income housing due to the need to recover these costs. Furthermore, assigning all costs to new properties may introduce issues of intergenerational equity (Lari et al., 2009).

Finally, JD and Air Rights represent important but limited financing tools for local governments. The latter case is usually limited to densely-populated, high-land-value locales, with land development typically occurring above a transportation asset (i.e., transit-oriented development, buildings suspended over depressed highways, etc.). JD involves the spatially-coincidental development of transportation and land such that each supports the financial viability of the other. Approaches include various mixes of private, public and public-private ownership, cost/revenue sharing, etc. (Lari et al., 2009). The late 19th and early 20th century "Streetcar Suburbs" (Warner, 1962) demonstrate an example of private-private JD. Recent public-private use of JD for infrastructure and land development includes agreements along sections of the Washington Metro, and the ground lease of public land to a developer near Portland International Airport to finance light rail (AECOM, 2007).

JD and Air Rights probably promote economic *efficiency* better than other district finance schemes given their intensely-local application, the fact that the outcomes of negotiations tend to support market pricing signals, revealing the developer's "willingness to pay," and often support broader economic development. In terms of *equity*, such schemes tend to be progressive, in that they tend to be viable only in areas of high-cost commercial or residential clusters. Nevertheless, *administrative ease* is low, as local governments either need to develop or hire the requisite expertise (technical, legal, financial, etc.) associated with such complicated transactions (Lari et al., 2009).

2.2. Capturing the Value of Public Transportation Investments and Services

Across the United States, public transportation is suffering from a more general transportation funding crisis. At a national level, public expectations regarding transportation provision have come to epitomize a "free lunch" (or at least a "reduced-price lunch") mentality. While many despair the condition of our nation's transportation infrastructure and any potential cuts to services, few seem willing to bear the costs implied in "fixing" it. Fuel taxes have not increased in nearly twenty years, yet most politicians fear the wrath of voters should they vote to increase these levies, which remain the principal means of financing new, and repairing existing, infrastructures. Meanwhile, the nation finds itself in a long-brewing transportation funding crisis, at the national, state and local levels. One estimate put the national shortfall to simply "maintain" the nation's highway and transit systems at $51 billion in 2007, increasing to $66 billion by 2017 (NCHRP, 2006).

Given the current fiscal challenges to financing public transportation investments, local government could step into the vacuum. Fiscal federalism suggests that a more local and/or

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[14] Courts generally require that local governments pass the "rational nexus" test, demonstrating that these fees/ extractions bear some semblance of a relationship to actual impacts (see Lari et al., 2009).

metropolitan approach would lead to greater efficiency in pricing and investment decision-making. Nonetheless, the Federal Government still accounts for almost 50% of transit capital funding (TCRP, 2003), with state and local governments accounting for about one quarter, and "directly generated" sources accounting for the other quarter.[15] Sales taxes (LOTTs) are the fastest growing source of transit revenues, followed by "other" taxes (property, income, other) and funds (NCHRP, 2006). As discussed, however, LOTTs do not represent a particularly efficient nor equitable means to finance these requirements.

Fiscal federalism principles suggest that increasing user-fee (e.g., fare box) based financing is theoretically the most *efficient* means for financing most public transportation operations. Practically speaking, however, land value capture may offer an attractive infrastructure financing tool since transit user fees are typically insufficient to cover costs and theoretically need not finance all related infrastructures. If well designed, value capture offers many of the same advantages as user-fee financing from the standpoint of *fiscal equivalence*, by assessing costs over roughly the same geographic space as most benefits accrue with, in some cases, minimal additional administrative effort to implement (once benefits are estimated). Concerns about *equity* will be highly dependent on the structure of fees and/or tax levies, but can be managed based on local community values.

Challenges exist, however, to effectively mobilizing value capture in the public transit case. These include resistance of existing property owners, challenges of maximizing land value capture potential in highly-developed areas, and self-interested behavior of local governments and developers. Other economic, social, and institutional limitations exist.

Property owners, for example, might object to land value capture since increased land value is typically illiquid, particularly for single-family homeowners. While rental property owners might be able to raise rents immediately and thus recoup the additional taxes, owner-occupiers will not realize direct financial gains until they sell their properties. Thus homeowners will likely resist the increased property taxes. Granting homeowners tax exemptions in assessment districts will help increase likelihood of implementation, but may have adverse *efficiency* and *equity* effects. In the case of rental properties (residential or commercial), owners may not be able to immediately pass along increased property costs due to long-term leases, rent control, etc. (CTOD, 2008).

Value capture appears more viable in areas of new development than for public transportation improvements to a highly-developed area. New development can be designed comprehensively to maximize the financial upside of the new transit infrastructure. In highly-developed areas without transit, land development patterns are shaped by other forces (e.g., highways) other than public transportation stations. Due to long building life-cycles and the existence of many small landowners, it could take many years for development patterns to reorient towards the highest and best use given the presence of transit access. Therefore, incremental gains in land value will accrue slowly over time. Furthermore, value capture could be administratively and politically easier to implement in undeveloped areas. Owners of undeveloped property may see the

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[15] "Directly generated" is dominated by taxes and tolls levied directly by a transit agency which, likely, includes for example roadway bridge tolls hypothecated to a transit agency – in other words, this is probably a *generous* definition of "directly generated" source.

investment as worthwhile due to the high potential appreciation of land value, whereas for many residents of developed areas, higher land assessments may be perceived as new taxes for lower marginal benefits.

This last point bears further attention. Ryan (1999) notes that property values will likely accrue the most where time-value savings are the greatest. In other words, if the change in accessibility is sufficiently large (e.g. a new metro in a public transport-poor metropolitan area) then palpable time savings will accrue to segments of the population that use the new transit stations. This time savings will then, in theory, be capitalized in land values. Where a public transportation investment supports only modest accessibility gains, land values will be affected to a lesser degree (whether because accessibility was already good or existing development is too disperse, etc.). It follows that new development could benefit most from transit investment since the change in accessibility will be relatively high and market-driven development will aim to maximally internalize these benefits.

Ideally, value capture mechanisms should be in place prior to the transportation system improvement, as no *ex post* incentive exists to dedicate proceeds from increased land value to fund a transportation (or any infrastructure) improvement once the asset has already been delivered (AECOM, 2007). Without a pre-existing agreement, the developer receives a windfall gain from the transportation improvement while the taxing jurisdiction benefits through property taxes; the infrastructure/service provider (if not the local taxing jurisdiction) has little recourse, as removing the improvement (e.g., the transit station) is unlikely (AECOM, 2007).

In the face of these and other constraints to implementation, what are the feasible alternatives to apply value capture to finance public transit? Value capture will work best when various factors align. For example, an area with large amounts of surface parking might make an ideal candidate. In this case, transit might simultaneously reduce parking demand while opening up otherwise vacant land for higher-value development. Additionally, transit access may increase the attractiveness to developers of higher-density development, who will offset higher land costs by charging rental premiums. CTOD (2008) concludes that value capture will only be feasible when:

1. a development or redevelopment opportunity exists;
2. local conditions are favorable to new (higher density) development; and
3. cooperation exists among parties (e.g., transit agency, local jurisdiction, developer).

This latter condition again points to institutional hurdles. Most property-based tax and fee systems in the U.S. are inherently local, generating revenues that relevant authorities are generally not keen to cede. Public transit in the U.S., however, tends to be operated by public agencies that do not have independent revenue-raising capability outside of, perhaps, fare-setting. Furthermore in metropolitan areas, transit agencies often cover a number of local jurisdictions, with variations in financing participation depending on the specific context.

Even if most implementation-related and institutional constraints can be overcome, other economic and social concerns merit careful consideration. First, future land value increments from a public transportation investment are highly uncertain, making it difficult to forecast whether revenues from TIF or other recurrent land value mechanisms will be sufficient to cover investment costs. Thus, taxpayers in the wider jurisdiction (or beyond) may end up having to foot part of the bill. Furthermore, according to Anas (1982), value capture is “sound economic practice” (p. 192) if pursued with lump sum taxation and compensation (e.g., reduced taxes and rebates – for the losers). This points to an important, but often ignored, dimension in a general equilibrium sense: if transportation service increases land values in one part of a metropolitan area it would, *all else equal*, reduce land values by a comparable amount in another part of the metropolitan area (if no additional new benefit such as productivity or agglomeration gains materialize). Thus, does a value capture mechanism need to account for “winners and losers”? Is it a “zero-sum” game?

Land value capture offers a potentially valuable tool to partially mitigate the funding crises experienced by many public transportation agencies, particularly for service expansion into less densely-developed areas. In many respects, a value capture financing regime can help approximate solutions more consistent with principles of fiscal federalism. Despite the challenges to implementation and other institutional constraints, land value capture has been applied to support public transportation finance since at least the 1970s. We now briefly summarize the empirical evidence.

2.3. Value to Capture?

While value capture has been formalized in theory and implemented in various forms, a key question remains: How much revenue can one reasonably expect to derive from land value appreciation as a *direct* result of a new transportation facility? A number of recent scholarly papers have reviewed the large body of previous empirical research on transportation and land value effects (e.g., Ryan, 1999; RICS, 2002; CTOD, 2008; Rodriguez and Mojica, 2008; Martinez and Viegas, 2009). The research differs in empirical contexts, analytical approaches, types of properties analyzed, types of infrastructures and services considered, etc., but more recent studies tend to apply partial equilibrium hedonic pricing models employing spatial econometric methods, and focusing on travel time savings (or reasonable proxies). They also tend to (more so than earlier research) identify positive relationships between transportation facilities and land values.

In this sub-section we briefly summarize this past research, the evolution of methodological approaches, and the empirical evidence of the magnitude of land value impacts associated with transportation infrastructure investments. This provides a background for understanding contemporary approaches and their strengths and weaknesses. We also aim to clarify the methodological shortcomings in previous research, which may partially account for some of the inconsistencies in the empirical evidence.

Variation in results across empirical studies owes in part to different analytical approaches and, importantly, differences in variables and data used to represent attributes of the transportation system. Analytical approaches include: cross-sectional analysis, test and control groups, before/after and other time-series-related comparisons, descriptive and qualitative analysis, or some combination of these approaches. Most contemporary studies employ econometric methods to estimate impacts, typically employing hedonic price models, which attempt to estimate the independent contribution of various factors to the sum price of a given unit of land or property (further explained in Section 4.1), and are often modified to reflect complications of measuring spatial phenomena. Simulations, applying more general equilibrium models, are sometimes also employed in an attempt to predict land value impacts of transportation improvements.

Ryan (1999) reviews 29 relevant studies, including eleven covering highway effects, beginning in the late 1950s, and eighteen measuring rail transit effects, beginning in 1972. Generally, Ryan notes that first-generation highway studies (1950s and 1960s) primarily employed before-and-after analyses, while subsequent highway and nearly all transit analyses (beginning in the 1960s) applied varying forms of econometric modeling. She notes the important question is whether a given facility improves travel time for travelers and, if so, for which travelers? She finds that results vary wildly when using distance-based measures of accessibility, but also suggests consistently positive impacts on land values across research where travel time savings are employed to measure accessibility and regional accessibility measures are controlled. Ryan also notes that, irrespective of the chosen measure of accessibility, studies that consider more localized areas of impact (within about 1 mile for highways and 1/3 mile for rail transit) tend to exhibit more conclusive positive impacts on land value. She concludes that: “The results of this review suggest that researchers should return to the fundamental question of ‘how do new (or existing) transportation facilities influence regional and local travel times for various populations of users?’” (p. 423).

The Royal Institute of Chartered Surveyor’s (RICS, 2002) report for the UK Office of the Deputy Prime Minister provides a wide international review of empirical literature on public transportation impacts on land value, focusing on evidence of impacts and methodological approaches in North America and Europe. RICS reports a wide range of approaches and results, which vary depending upon the type of public transport mode considered (e.g., heavy rail, metro, light rail); the type of property under study (e.g., residential, commercial); the distance threshold by which significant impacts are implied; the extent to which distance measures employ non-linear “decay rates” (i.e., measuring the relative dis-utility of increased distance to stations); and whether or not temporal effects are factored. RICS’ review show the variation in how results are reported, including average property value impacts, percentage impacts, incremental impacts based on distance from transit stops/stations, etc. The report also indicates the difficulty generalizing estimated impacts across cases, due to differences in measurement, the definition of affected areas, treatment of temporal influences and, especially, the influence of local context (e.g., the condition of existing land use and transportation networks in a given location). Nonetheless, as a whole RICS concludes that most studies show some form of positive land value effects resulting from public transportation investment.

Turning to a few specific recent precedents,[16] Baum-Snow and Kahn (2000) estimate the impacts of urban rail transit improvements on transit use, land values, and stakeholder groups in five U.S. cities using before-and-after survey data and hedonic price models. To proxy travel benefits in affected areas, they estimate the change in distance of census tracts to the nearest transit station (or, where previous service did not exist, to the CBD) before and after a transit investment. Their analysis includes a quadratic specification for the “distance variable” (to account for expected exponentially declining impacts from station entry points), while controlling for numerous

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[16] A large body of literature exists on integrated land-use and transportation and other simulation models, but we limit the scope of this discussion to hedonic price models.

demographic variables, accessibility-related variables, and city-specific effects. Their results suggest that reducing census tract distance to a rail transit station from 3 to 1 km will increase transit mode share by 1.42% (1.24% from existing residents), lead to travel time savings (for journey to work only) estimated as high as $1,200 per year, and yield increases in rent of $19/month and in total property value of $5,000.

Martínez and Viegas (2009) apply a hedonic price model to assess the impact of accessibility gains from past and ongoing Metro (urban heavy rail) investments on property values in Greater Lisbon, Portugal. The authors control for various property, neighborhood, and accessibility attributes and consider two model forms: ordinary least squares (OLS) and econometric techniques that correct for spatial dependence (to be discussed in Section 4.1). The authors estimate three different models employing different variables to represent accessibility impacts of proximity to rail stations: binary measures based on a distance threshold, a continuously decreasing inverse logistics measure, and system-wide measures of gravity-based accessibility. Their estimations indicate that the spatial lag model employing the continuously decreasing distance measure is the most robust, with coefficients for proximity to one station suggesting property value impacts of up to 8.75% of total value, and impacts of proximity to two stations of up to an additional 12.48%.

While much of the literature on public transit land value impacts focuses on urban and suburban rail, Rodríguez and Targa (2004) explore the impacts of bus rapid transit (BRT) on multi-family housing rents along a heavily-used corridor in Bogotá, Colombia. The authors employ a hedonic pricing model (of rental asking price) to estimate the impacts of walking time to BRT stations, while controlling for spatial dependence, property improvements, neighborhood socioeconomics, and regional accessibility (represented by line-haul travel times to key destinations and a weighted index of travel time to other BRT stations). The analysis suggests that rental prices decrease by 6.8% to 9.3% for every additional 5 minutes of walking time to a BRT station, translating to property (almost entirely multi-family) value increases of 1.84—2.63% ($439-653) per 0.1 km of distance to a station.[17] The authors indicate that this is comparable to empirical estimates of property value effects of heavy rail service in Los Angles and Washington, DC. Interestingly, their results suggest no accessibility benefits, which might indicate the station-area proximity effect is actually capturing other unobserved characteristics (such as public space amenities corresponding to the stations).

Hedonic price models face methodological challenges. For example, implying a partial equilibrium analysis, hedonic price models will not account for impacts elsewhere in the transportation and land use systems. McDonald and Osuji (1995) and McMillen and McDonald (2004) acknowledge this fact, but assume that such impacts will be small within the larger scope of the metropolitan area. Furthermore, econometric analysis cannot simulate equilibrium changes in prices of transportation, land, and related goods since shifts in demand and supply functions cannot be separated (Anas, 1995). Additionally, many of the empirical studies employ, for the dependent variable, proxies for land and property values rather than actual sale prices, which are at least market clearing (i.e., supply equals demand) at the time of the sale. Martínez and Viegas (2009) and Rodríguez and Targa (2004) use seller asking prices and rental asking rents, respectively; Baum-Snow and Kahn (2000) use average housing values from census tracts.

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[17] Capitalizing rent into a land value appreciation estimate using a discount rate of 10% over 20 years.

Other weaknesses include the difficulty of inferring causality (i.e., can one conclusively attribute property sale appreciation to the new transportation improvement?); specifying the correct control variables for isolating local and system-wide accessibility effects; and accounting for autocorrelation in spatial effects (Rodríguez and Targa, 2004).

While the research summarized in this section generally acknowledges methodological shortcomings of hedonic pricing and econometric analysis generally, it also provides insight on how to mitigate these factors. For example, using before-and-after and time-series analysis can help demonstrate causality, and repeat sales models (e.g., McMillen and McDonald, 2004) can help eliminate problems with omitted variables that do not vary with time. Furthermore, econometric techniques, such as including in the model specification regressors which account for unique issues with spatial analysis, can be used to detect and eliminate the effects of spatial autocorrelation and spatial error in hedonic price models (Martínez and Viegas, 2009; Rodríguez and Targa, 2004).

Finally, we must consider that, while transportation facilities hypothetically bring positive land value effects due to accessibility benefits, such facilities may also bring negative externality effects due to proximity to dis-amenities, such as highway or transit operations' noise and vibrations (e.g., McDonald and Osuji, 1995; McMillen and McDonald, 2004; Rodríguez and Targa, 2005). Some communities in the U.S. have fought local public transportation stations due to concerns about increased crime or other perceived negative social effects. Theoretically, however, the opening of transit stations could increase or decrease crime, with the limited empirical analysis available suggesting the effects depend on neighborhood characteristics (Ihlanfeldt, 2003).

Overall, public transit infrastructure and services do seem to increase adjacent property values. At the same time, a growing number of transit agencies around the world are facing increasing financial difficulties. Historically, the public investments in mass transit systems usually accrue to private property owners (Armstrong, 1994; Smith and Gihring, 2006). Can and how should public-sector agencies capture some of these benefits to help finance transit capital improvements?

3. Research Context and Precedents

The third most populous metropolitan area in the United States, the Chicago Metropolitan Area (CMA) rests on the southwestern banks of Lake Michigan in northeastern Illinois.[18] The CMA is home to over 8 million persons, nearly 3 million households and 4 million jobs. While the CMA has a well-developed highway network, the region has a low density of freeways (measured as center-miles per capita or center miles per square mile) relative to the 40 largest metropolitan areas in the United States (FHWA, 2011a). This is partly due to the city's long history (incorporated in 1837), relatively high-density urban core, and its relatively extensive public transit services. The CMA is one of the least automobile-dependent metropolitan areas in the

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[18] There is no single widely used term to refer to the Chicago metropolitan area; we use CMA for ease of abbreviation. According to the Chicago Metropolitan Agency for Planning (CMAP), the CMA consists of seven Illinois counties including Cook, DuPage Kane, Kendall, Lake, McHenry, and Will.

United States.[19] Nonetheless, the automobile still accounts for about 87% of all trips in the CMA, while public transportation accounts for only about 2% (USDOT, 2009).

Three public agencies provide public transportation in the CMA: the Chicago Transit Authority (CTA), which operates the nation's second largest transit system, serving the city of Chicago and roughly 40 surrounding suburbs with rail and bus service; Metra, which operates one of the nation's largest suburban rail systems on 11 lines; and Pace, which operates suburban bus services. The Regional Transportation Authority (RTA) has financial oversight over, and carries out planning activities for, the CMA's three public transportation agencies. The CTA services account for more than 75% of total public transportation use (CTA buses account for just over 50% of total public transportation use and rail accounts for about 25%) (Warade, 2007). CTA operates services 8 rail lines covering over 222 miles of track

In our analysis of residential properties in this paper, we focus on the City of Chicago, which accounts for 33% of the CMA's population (as of 2008) and 6% of the land area. We limit our focus to this area in part due to ease of data comparability (e.g., on crime rates, school performance). Furthermore, the CTA system operates almost entirely in the City of Chicago. For commercial properties, we expand our scope to include all of Cook County to increase the number of observations. Cook County includes most of the City of Chicago[20], plus 120 other jurisdictions (townships, cities, villages, towns).[21] The City of Chicago accounts for over 50% of Cook County's total population.

3.1. Transit Finance in Chicago

Transit finance challenges are not new to Chicago. Responding in part to persistent deficits in the 1970s and 1980s (Anas, 1982), the Illinois legislature passed the RTA Act in 1983, which attempted to reform public transit finance (Antos, 2007). The funding structure created by the RTA Act allocates to RTA an increment added to the statewide 6.25% sales tax collected only in a six-county region[22] to subsidize public transport operations in the CMA. The Act also required, overall, that fares in the system cover 50% of operating costs. This basic structure has remained unchanged, but long-term fiscal stability has not followed. In 2008, the state passed amendments to the RTA Act, increasing the sales tax rate in Cook County by 0.25% and by 0.5% in the five surrounding counties (RTAMS, 2011).[23] While the system has been able to basically meet the 50% coverage of operating costs requirement, financial stability remains precarious.

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[19] Using the ratio of total daily vehicle miles traveled (VMT) to annual public transport passenger miles traveled (PMT) as a crude metric of relative auto-dependency, Chicago is the second least auto-dependent metro area in the country after New York; using the ratio of total daily vehicle miles traveled (VMT) to annual unlinked public transport passenger trips, Chicago is the fourth least auto-dependent metro area, after New York, Honolulu, and Washington, DC (based on data from TTI, 2007). The difference between the two may partly result from Chicago having longer relative public transport distances (e.g., from higher relative share of longer-distance suburban rail service).

[20] Part of western Chicago is in DuPage County.

[21] According to Cook County (*2004 budget annual appropriations volume 1*), there are 121 municipalities, 29 townships, 236 special districts, and 152 school districts.

[22] The equivalent of 1% in Cook County, which includes the City of Chicago, and 0.25% in five suburban counties; In 2005, these generated $876 million, or around 80% of all public subsidies to transit operations (Antos, 2007).

[23] In the "collar counties," however, only half the tax proceeds go to RTA, with the remainder staying in the county of origin to be used for transportation or public safety purposes (RTAMS, 2011).

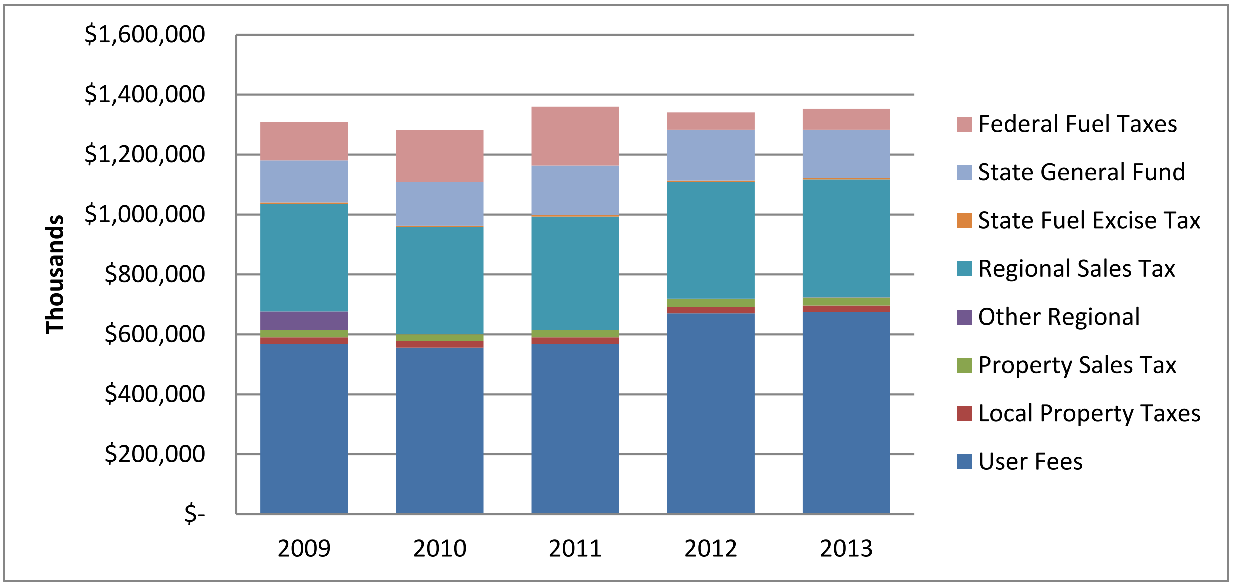
Antos (2007) carried out a systematic analysis of impacts of RTA *operations*, attempting to estimate the social benefits produced by RTA services. He concludes that RTA-financed services (including the CTA) generate social benefits – in the form of air quality improvements, traffic safety, reduced congestion, and enhanced mobility – worth on the order of $2.5 billion per year, greater than twice the amount of the current operating subsidies for the RTA as funded by the RTA Act. Based on this analysis, Antos suggests structuring a new funding mechanism based on revenues from the automobile system, including increasing the sales tax and gas tax, collecting mileage-based fees, parking tax and road tolls. Antos' focus was on system operations and he purposefully did not explore fixed cost infrastructure financing and the possible role of the property tax system in Chicago.

Ideally CTA would recover operating costs primarily from user fees and cross-subsidies as suggested by Antos (2007), but the current system does at least succeed in sourcing most revenues at a local and regional scale. Thus, CTA operations meet the minimum threshold of fiscal equivalence that most costs are paid for within the geographic boundary of benefits. Figure 3-1 details the CTA budget by source of funds. Over the five-year period from 2009-2013, CTA has or is projected to receive between 74-82% of operating funds from local and regional sources, 9-16% from the State, and 4-10% from the Federal Government.

For CTA, the largest share of operating subsidies comes from the system's share of the RTA sales taxes. Additionally, the State must match 25% of all sales taxes authorized in the 1983 RTA Act from general revenues. The 2008 amendments referenced above upped the state match to 30% for both the existing RTA sales tax as well as the newly-authorized sales tax increments (RTA, 2011). The City of Chicago also subsidizes a portion of CTA's operating budget, through a variety of mechanisms. An important source comes from a dedicated portion of Chicago's Real Estate Transfer Tax (RETT), implemented as part of the 2008 RTA Act amendments. The current RETT rate is $5.25 per $500 of value assessed on any real property transfer, of which $1.50 goes to CTA ("CTA portion"). The CTA portion of the tax generates about $20 million per year, to which the State also matches at a rate of 30% (RTA, 2011; CTA, 2011b). The RTA Act also requires that the City of Chicago and Cook County contribute $3 million and $2 million, respectively, for CTA operations (CTA, 2011b); the City of Chicago contributes its $3 million from its state allocation of Motor Fuel Tax funds (e.g., City of Chicago, 2009; 2010). Finally, the CTA (2011a) reports that the City of Chicago provides approximately $22 million annually in in-kind security services through the Chicago Police Department's Public Transportation Section, ostensibly funded from local property taxes.

Capital financing for infrastructure improvements remains a high priority for RTA and CTA assets. The CTA estimates a $9.6 billion financing requirement to achieve a system-wide "state of good repair" during the 2009-2013 cycle, of which 43% went unfunded. For the 2010-2014 period, the estimated financial need for a "state of good repair" was $9.6 billion, of which a forecast 70% will go unfunded. Furthermore, in recent years, CTA has been authorized to use some federal money for capital programs to fund preventative maintenance, technically considered an operating expense (See "Fuel Excise Taxes" in Figure 3-1) but ostensibly intended to reduce the long-term costs of capital investment and rehabilitation (CTA, 2011b).

Figure 3-1. CTA Operating Budget: Source of Funds (2009 Actual & 2010-2013 Estimates)

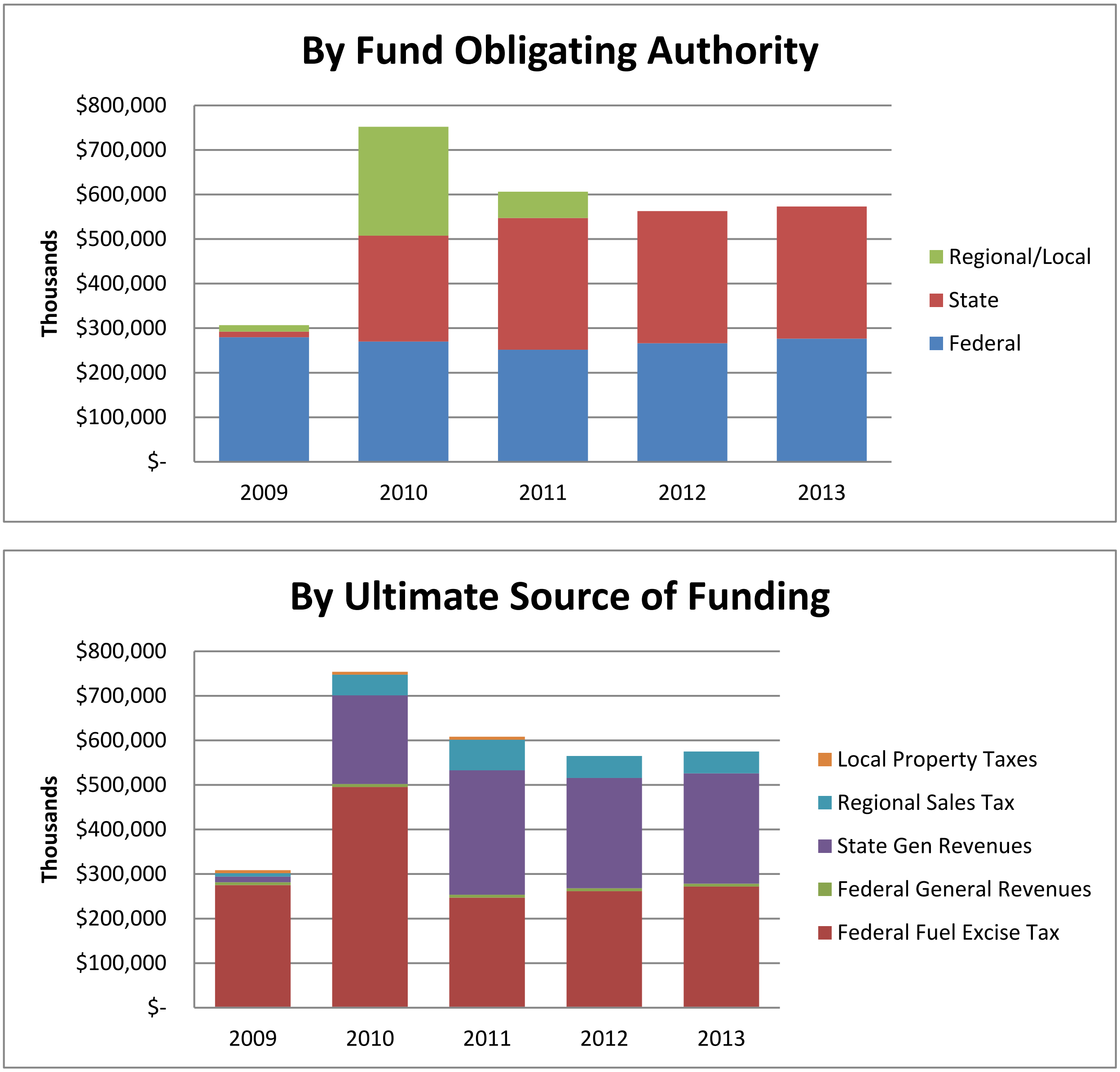


Sources: RTA, 2011; CTA, 2011b; City of Chicago, 2011. Notes: For new revenues authorized by the 2008 RTA Act amendments, we impute a 62.5 (State) -37.5% (RTA) split of revenues from sales taxes and state general taxes (e.g., statutory matching grants) based on an approximation of 2011 data.

CTA's capital budget depends primarily on three sources: Federal Transit Administration (FTA) formula funding and grants, State of Illinois general obligation bonds, and a mix of RTA general obligation bonds and discretionary funds and CTA revenue bonds (to which future FTA formula grants are pledged for debt service). Figure 3-2 depicts the CTA capital budget in two ways: first by the obligating authority and, second, by the ultimate source of funds to pay for the incurred obligation. We do this because much of the capital funding from state, regional, and local sources is in the form of bonds, which are payable through debt service payments funded by a variety of sources, not necessarily the issuer. FTA funds primarily support direct capital expenditure by CTA or cover debt service on CTA bonds. Unlike State and RTA bonds, however, debt service on CTA bonds is considered part of the capital budget rather than the operating budget. State general obligation bonds are typically paid back with a mix of direct state general fund aid and RTA funds from the regional sales tax. We estimate that in 2011, the State covered about 83% of debt service on State bonds, including both direct debt service payments and indirectly through subsidies to RTA's budget, and assume this percentage breakdown is about constant across each budget year. RTA loans and capital grants are financed through a number of funding mechanisms, but primarily the regional sales tax (we estimate about 37.5%) and state general fund matches (62.5%) (CTA, 2011b; RTA, 2011).

Ultimately, the majority of capital funding for the CTA system comes from sources outside the CMA; primarily Federal fuel excise taxes and State general funds. Thus, CTA capital programs deviate substantially from principles of fiscal federalism. Arguments can be made to justify these transfers, such as the fact that much of the fuel tax revenue generated in the CMA offers better accessibility returns if invested in transit. Nonetheless, the existing mechanisms provide inadequate price signals to users and policymakers, probably skew investment decision-making in favor of meeting federal priorities (i.e., to qualify for discretionary grants), and, as evidenced by the difficulties of re-authorizing Federal surface transportation programs, create instability in planning for long-term capital needs.

Figure 3-2. Fiscal Federalism: Revenue-Raising Options for CMA's Transportation



Sources: RTA, 2011; CTA, 2009, 2010, 2011a,b. Note: For bonds, the funding breakdowns are prorated based on the percentage of debt service typically covered by each source. CTA bond issues as well as debt service are combined as capital funds from Federal fuel excise taxes.

Apparently, then, value capture could serve as a viable alternative in the long-term for financing transit capital programs in Chicago. Direct precedents exist. For example, Chicago has by some accounts used TIF more extensively than most, if not all, major cities in the United States (Weber et al., 2007). The city typically applies TIF to support public and private development aimed at reducing blight and creating employment opportunities. Chicago currently supports 166 TIF projects, funding anything from road and other infrastructure, to environmental remediation, to site preparation, etc. (City of Chicago, 2011). The city first made use of TIF in 1984, and added about four new districts each year over the next decade. Between 1998 and 2002, Chicago's program increased substantially such that, by the end of 2005, the City had 136 TIF projects (in addition to 237 TIF projects created elsewhere in Cook County suburbs) (Lari et al., 2009). Estimates suggest that, by 2005, TIF districts consumed nearly 10 cents of every property tax dollar collected in Chicago (equal to about $386 million) and 26 percent of the city's total acreage. If TIF were included as a line item in the city's 2005 budget, it would have ranked as Chicago's fourth largest budget category (Quigley, 2007).

TIF has factored prominently in transit capital project finance in the CMA in the recent past, as documented by Lari et al. (2009). According to that study, TIF has supported numerous subway station projects in the City of Chicago, including the Randolph/Washington Station ($13.5 million), the Dearborn Subway-Lake/Wells ($1.2 million), and several other downtown Central Loop transit projects (about $24 million) (Lari et al., 2009). From 1990 to 2004, the City of Chicago allocated $773 million for CTA and Metra infrastructure improvements, including about 100 transit stations across 50 TIF districts (NCBG, 2010). While Lari et al.'s (2009) review suggests that TIF-enabled improvements have led to real property value appreciation, controversy exists. Dye and Merriman (2000) find evidence that TIF adoption may slow city growth, by inducing real estate development in less productive areas. Quigley (2007) faults the city's use of TIF as eating into tax revenue use for other purposes and notes the general lack of transparency, oversight, planning and participation in deployment. Farris and Horbas (2009) make similar criticisms.

3.2. The Relationship between Public Transportation and Land Use in Chicago

Researchers have long been interested in the relationship between transportation and land values and development patterns in Chicago. Hayes (1957), for example, examined 1953 residential land values along the C.B. & Q. suburban railroad line, which runs about 15 miles southwest from downtown Chicago.[24] Hayes found evidence of land value gradients originating at the stations; lower land values along the actual rail right of way (interpreted as negative externalities due to proximity to noise, pollution, etc.); a time-based value gradient relative to the CBD (i.e., a monocentric gradient); and negative effects of proximity to industrial areas. More broadly, Yeates (1965) looked at the spatial variation in land values from 1910 to 1960 in Chicago, finding an apparent declining land value effect over time of the distance to CBD and distance to mass rail transit, while also suggesting an apparent increase in land value as a function of distance to amenities (proxied by distance to Lake Michigan). Yeates also finds an overall declining role of spatial variation in explaining land values. We can interpret this to suggest an increase in the poly-centricity of Chicago and, in general, a decline in the relative importance of rail accessibility in the age of increasingly ubiquitous auto-accessibility.

More recently, a number of previous studies have estimated positive land value impacts attributed to rail transit accessibility. McDonald and Osuji (1995) employ a before-and-after hedonic price model to measure impacts on land values resulting from the anticipated opening of the Midway Line (i.e., the present Orange Line), an urban rail connection that opened in 1993 running 11 miles from downtown Chicago through southwestern suburban areas and terminating

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[24] Apparently today's Metra/BNSF suburban line to Aurora.

at Midway Airport. The model uses properties near the new metro line in 1980 to 1990 and controls for neighborhood socioeconomics, as well as other local and regional transportation variables such as distance to the line itself (negative) and distance to the CBD (quadratic). The authors suggest that line planning and construction alone increased residential land values by 17.4% within a 1/2-mile buffer of the new stations, on average, due to anticipated travel time savings from future improvements.

In 1997, Gruen Gruen + Associates (GGA, 1997) evaluated the effect of the Chicago Transit Authority (CTA) and Metra stations on residential property values, specifically single family homes. The authors also use a hedonic modeling approach, sampling residential properties in 16 "study areas" covering 95 CTA and Metra stations. The station areas were selected to represent different service areas/station types and service quality levels, location characteristics, and socioeconomic characteristics. The analysis employs a relatively small sample and limited number of control variables (for, e.g., relative location of the property in the city) and reveals an estimated price premium of up to $36,000 for a home located 500 feet from a station instead of 2,500 feet from a station – an annualized value of $3,400 per year.

McMillen and McDonald (2004) consider Chicago's Midway/Orange Line after completion, combining a hedonic price formulation with a repeat sales model[25] (to account for temporal effects) to estimate the increases in property values within a 1.5-mile buffer of the Line. Comparing price estimates in annual increments from 1986 (planning) to 1999 (full operation), and controlling for distance to the CBD and a variety of property improvement and neighborhood socioeconomic factors, they estimate that, on average, property values within the 1.5-mile buffer appreciated in value by 6.9% or $6,000. In aggregate, the authors estimate a sum total land value appreciation of $215 million due to this investment which, adjusting for inflation, effectively translates into about 47% of construction costs of the Line.

More recently, Warade (2007) estimated a series of spatial regression models in an attempt to assess the impact of transit accessibility, measured at the level of the traffic analysis zone (TAZ),[26] on TAZ residential and commercial development intensity, proxied by households and jobs per acre, respectively. He does not estimate land value effects, explicitly, although presumably higher density development means, *all else equal*, higher land values. Warade uses a gravity-based measure of accessibility to households and jobs, for both auto and transit. Among the relevant results, he finds that – based on calculated elasticities – transit (combined bus and rail) accessibility to jobs and households has the strongest or one of the strongest positive effects on household and job density, respectively. He also finds significant effects of zoning (e.g., density requirements, parking requirements), urban design (TAZ block density), and location (e.g., proximity to Lake Michigan).

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[25] The repeat sales model essentially calculates the impact of distance from stations in a hedonic price model by isolating the station effects on the parameter estimate for distance from time (e.g., inflation) and other effects.

[26] The TAZ refers to the spatial unit of analysis used in transportation forecasting models. TAZ construction aims to create homogenous areas with respect to socioeconomics and trip-making. Model outputs in the form of TAZ-to-TAZ travel characteristics (e.g., matrices of travel times or costs) by construction aggregate those outputs based on performance from the TAZ centroid. The Chicago model area is partitioned into 4002 total TAZs, of which Warade used 3153 within 25 miles of the Chicago Loop (Warade, 2007).

In terms of simulation studies, Anas (1982) developed an integrated equilibrium supply/demand model for travel and residential choice in order to analyze various transportation investments and policies, including rail transit investment – specifically, the potential Midway/Orange Line. Based on estimated impacts on journey to work travel times and mode choices, Anas estimates that incremental taxes aimed to capture the gains in existing home values, which he pegs at no more than \$20 per month, would amount to 14% to 18% of the rail transit operating plus construction costs or about 36% to 40% of capital costs. The analysis further suggests that an expanded bus system could be financed via incremental taxes on housing of about 5% or less of annualized housing values. Anas also suggests that a one-time lump-sum property assessment would be a more efficient mechanism for capturing land value for capital improvement costs than annual assessments. This is akin to assessing an up-front sales tax, which would maintain the actual value of the property in future years.

In general, the evidence reveals positive associations with proximity to transit facilities, including for urban rail investments in Chicago. The studies suggest, at least for neighborhoods near new Midway/Orange Line stations, a significant positive impact on housing values. The approaches and outputs vary by case, although a high-level summary across cases suggests cost recovery in the range 33% to 50% of transit capital expenditures. Each case also suggests a rent/land value gradient developing around new CTA stations, adding empirical evidence to the proposition that investments which substantially reduce transit times will enhance land value. These studies provide helpful insight on the types of property improvements, neighborhood socioeconomic, and relative locational factors that also impact property values in Chicago in addition to transit station-enabled accessibility.

3.3. Property Taxes Administration in Chicago

If there is value to capture, how might it be done? We now examine the most logical mechanism currently available to tap CTA’s land value creation in order to finance capital improvements: the local property tax system. Cook County administers property taxes on behalf of itself, the City of Chicago, and all other local tax agencies within these areas. In this section, we briefly summarize Cook County’s property tax administration.

The Cook County Assessor’s Office is tasked with setting values for each of Cook County’s approximately 1.8 million parcels. The Office recalibrates property values on a triennial cycle, meaning 1/3 of all residential properties are reassessed in a given year and on a rotating basis. This involves reviewing sales over a three-to-five year period, using a multiple regression analysis to evaluate key attributes, and then applying these parameters to estimate the value of all properties analyzed during that year’s triennial cycle. The result is the Estimated Market Value. To calculate Equalized Assessed Value (EAV), or the value against which the property tax rate will be applied, the Assessor’s Office then makes several straightforward calculations. For residential properties, the Estimated Market Value (from the regression analysis) is multiplied by an “Assessment Level” which is 10% (commercial properties are assessed at 25%). This figure is then multiplied by the State Equalizer[27] to obtain the EAV, which is then often adjusted

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[27] The State of Illinois requires that non-farm property assessments reflect one-third of aggregate property market value, though there can be variation across properties, districts, counties, etc (State of Illinois, 2011). For Cook County the State Equalizer multiple was 3.3701 in 2009 (Cook County, 2011b).

downward if one of several exemptions applies. The property tax amount is then calculated for each parcel by multiplying the post-exemption EAV by the tax rate (Cook County, 2011b).

The Cook County Clerk is responsible for establishing the property tax rates, which it does in the following basic way:

1. Each local taxing agency (>1,500 agencies in Chicago and suburban Cook County[28]) submits its levy (i.e., the amount of total revenue requested for collection from the property tax);
2. The Clerk calculates the tax rate based on the amount levied by the taxing agency and the taxable value of all property located within the agency's boundaries;
3. The levies are adjusted to the maximum allowable amount under Law (Cook County, 2010a).

Tax rates vary depending upon where a property is located within Cook County and are updated each year. Illinois State Law imposes ceiling ("tax caps") on the total revenue increases (relative to previous year) by most taxing agencies to the lesser of inflation or 5%. "Home rule" agencies, which are counties or any municipality with a population of 25,000 or greater that votes to become such, are not subject to these caps (State of Illinois, 2011). The City of Chicago is the only "home rule" tax district in Cook County besides the County itself. Though "home rule" agencies are not subject to "tax caps," the year-over-year increase in total property taxes is mitigated by several exemptions. Principally the 7% Expanded Homeowner Exemption reduces the taxable value of any owner-occupied residential property so as to limit the annual year-over-year increase in property taxes to 7% (Anderson and McGuire, 2008; Cook County, 2011b). In 2006, the year for which we have analyzed data in subsequent sections, tax rates (on EAV) on property owners were composed of Cook County (0.500) and City of Chicago (1.012) "home rule" rates; additional City rates if the property is located in one of the then 46 (now 48) Special Service Areas (0 to 2.679); and, a number of other rates associated with various county tax agencies (i.e., school districts, libraries, environmental and recreation agencies, etc.) (Cook County, 2011a).

In terms of the ultimate uses for these revenues, more than half of property taxes went to education, almost 20% to the City of Chicago, and the next largest share went to Cook County (see Figure 3-3). Overall, in 2006, Cook County forecast to derive $721 million from its property tax levy, about 23% of its total revenues. Chicago, in 2006 was expecting to generate about $900 million from property taxes (all agencies), about 17% of the City's annual budget (Cook County, 2011a).

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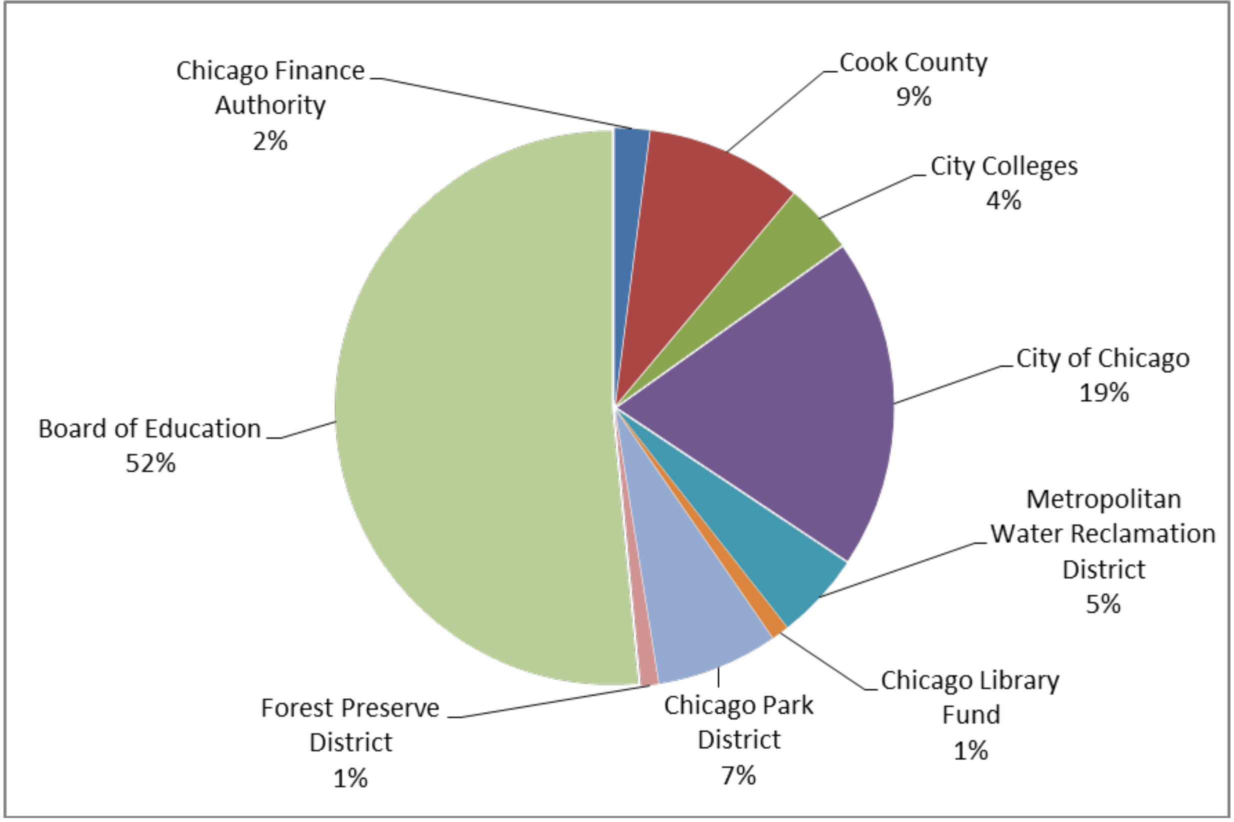
[28] The County Treasurer's Office says 2,200, and the Clerk says 1,500 (as of 2009). We use the Clerk's figures for consistency.

Figure 3-3. Distribution of Property Tax Dollars to Different Taxing Agencies in City of Chicago: A "Typical" Taxpayer (2006)



Source: Cook County 2006.

4. New Estimates of the Relationship between Transportation and Land (Property) Values in Chicago

We now expand upon the previous research for Chicago to empirically estimate property price impacts of the CTA infrastructure. We examine a range of different property types, under the premise that any land value capture-related mechanism should apply equitably across land under different uses. In addition, we attempt to employ more theoretically rigorous "level-of-service" controls for the region's accessibility. That is, city-wide hedonic models of land prices often presume an underlying monocentric city model by, for example, controlling for distance to the CBD. We relax this assumption by utilizing accessibility measures, based on estimated transportation levels of service and relative distribution of activities across space. We also employ spatial econometrics techniques to control for the potential role of space in violating the basic assumptions of OLS.

We summarize the results of our spatial hedonic models in this section, while the Appendix provides a detailed description of the spatial units of analysis, the variables used, how they were constructed and from what sources, and the descriptive statistics. In Section 5 we use the results to estimate the revenues that could potentially be captured and how.

4.1. Spatial Hedonic Model

Hedonic Pricing Model

A hedonic price model attempts to infer the contributing value of different attributes of a good, based on the overall value of the good as measured, for example, by price. In the case of properties, we can specify a general hedonic price model assuming three sets of attributes ultimately influencing sales prices:

$$p = f(I, N, T) \qquad [4.1],$$

where:

p is the property sales price;
I is a vector of attributes of the improvements on the parcel, such as number of bathrooms, number of floors, and age;
N is a vector of attributes of the neighborhood, such as quality of public facilities and services (including schools) and socioeconomic characteristics; and,
T is a combined vector of attributes of the transportation-related locational accessibility of the parcel, such as proximity to transportation services (including transit), relative accessibility to opportunities across the broader metropolitan area, etc.

The linear equation can be presented as:

$$p = X \cdot \beta + e \qquad [4.2],$$

where X is a combined vector of I, N and T as in Equation [4.1], β is a vector of unknown coefficients, and e is the error term.

Based on this basic model, we develop hedonic pricing models for single family homes, multi-family homes, vacant land, and commercial properties as will be discussed in Section 4.2.

As already mentioned, one important issue related to the accuracy of the hedonic model estimation for property values is spatial dependence – essentially the prospect that a value associated with any one location may depend on values at other locations. Two basic causes exist: spatial lag, whereby, for example, a poorly maintained house may negatively influence the value of neighboring houses; and spatial error, whereby, for example, the measurement for a particular variable, like crime rates, is influenced by the spatial approach to measurement. Spatial dependence will violate the assumptions (e.g., errors are uncorrelated with each other and with the independent variables, and have equal variance) of OLS regression, producing results that will be biased and/or inconsistent (Anselin, 2001). Practically, spatial dependence can be accounted for in spatial regression models.

Spatial Lag Model

In the case of spatial lag, a "spatial lag" term is introduced to the linear regression (i.e., Anselin, 2001):

$$P = \rho \cdot \mathbf{W}P + \mathbf{X} \cdot \beta + \varepsilon \qquad [4.3],$$

where P is the vector of property value p's, ρ is a spatial autoregressive parameter, **W** is a spatial weights matrix, **X** is the matrix whose rows are the observed vector X 's in Equation [4.2], and ε is a vector of error terms.

Spatial Error Model

A spatial error model can deal with spatial dependence in the presence of: 1) spatially correlated omitted variables, 2) spatially correlated aggregate variables, or 3) spatially correlated errors in variable measurement. A spatial error model can be formulated as follows:

$$P = \mathbf{X}\cdot\beta + \varepsilon \qquad [4.4]$$

and

$$\varepsilon = \lambda\cdot\mathbf{W}\varepsilon + \mu \qquad [4.5],$$

where $\mathbf{W}\varepsilon$ is a vector of spatially weighted averages of error terms in neighboring areas, μ is a vector of error terms that meet the OLS assumptions, and the other notations are as before.

Procedurally, we first estimate our best hedonic pricing models, using White's heteroscedasticity-corrected standard errors (Gujarati, 2003), for each of the four types of properties (single family homes, multi-family homes, vacant land, and commercial properties) sold in Chicago between the years 2003 and 2005. We then employ the software package GeoDA^{TM}, developed by Anselin (2001) and his research team, to diagnose the existence of spatial autocorrelation in the base hedonic pricing models using the Lagrange Multiplier (LM) test statistics and their robust forms for spatial lag and spatial error dependence (Anselin et al., 1996). If both errors were shown to be significant, we select the best alternative by comparing the LM statistics as well as their robust forms.

4.2. Model Specification

We use the natural logarithm of the property sales amount (in 2004 dollars) as the dependent variable for all four types of properties and specify the following generic (OLS) hedonic model:

$$\ln P = \beta_0 + \mathbf{I}\cdot\beta_I + \mathbf{N}\cdot\beta_N + \mathbf{T}\cdot\beta_T + \varepsilon \qquad [4.6],$$

where:

$P = (p_1, \ldots, p_n)'$, p_i is the sales price of property i ($i = 1, \ldots, n$);

$\varepsilon = (\varepsilon_1, \ldots, \varepsilon_n)'$ is an $n \times 1$ vector of error terms;

$\mathbf{I} = (X_{I,1}, \ldots, X_{I,k_I})$ is an $n \times k_I$ matrix of property characteristics and improvements to the parcel;

$\mathbf{N} = (X_{N,1}, \ldots, X_{N,k_N})$ is an $n \times k_N$ matrix of the property's neighborhood socioeconomics/ demographics and amenities;

$\mathbf{T} = (X_{T,1}, \ldots, X_{T,k_T})$ is an $n \times k_T$ matrix of the property's transportation and accessibility levels;

$\beta_I = (\beta_{I,1}, \ldots, \beta_{I,k_I})'$ is a $k_I \times 1$ coefficient vector of the variables in **I**;
$\beta_N = (\beta_{N,1}, \ldots, \beta_{N,k_N})'$ is a $k_N \times 1$ coefficient vector of the variables in **N**;
$\beta_T = (\beta_{T,1}, \ldots, \beta_{T,k_T})'$ is a $k_T \times 1$ coefficient vector of the variables in **T**.

Details on the data used for the dependent variables (price) and the various vectors of independent variables can be found in the Appendix. Previous research on transportation and land value for Chicago, including studies reviewed in Section 3.2, helped us define key variables (see Appendix 8.1 for a review of the data sources and geocoding approaches for the property and other data; Appendix 8.2 for the descriptions of property and other attributes available, and Appendix 8.3 for descriptive statistics). Here we provide a brief discussion of the most salient points. For single family and multi-family homes, since we have more observations, we analyze data only for 2004. However, for vacant land, since the number of sales in a single year is limited, we combine sales observations for 2003, 2004 and 2005, converting the values into 2004 dollars by using the Consumer Price Index (US BLS, 2009). We use the same approach for commercial properties, again due to the limited number of observations for a given year.

Property Characteristics/Improvement on the Parcel (*I*)

We use all of the relevant data available for each property type. The most complete property information is available for single family homes (Table 8-3), including lot and building size, construction type, bathrooms, attic, basement, fireplace, garages, age, row-/town-house. Multi-family home records (Table 8-4) have similar data, although detailed information on the characteristics within each unit is unavailable – we understand the multi-family home data to represent sales of multi-family buildings, not the units within buildings. For commercial properties (Table 8-6), available property attributes included building size, number of stories, building class (four classes as determined by the commercial data provider, with “Class A” being the most highly valued), location on block, building materials, intended use (retail or hospitality), parking spaces, and age; a major constraint for the commercial properties model ended up being the limited number of observations available.[29] Vacant land has the least information available – essentially only the lot size (Table 8-5).

Neighborhood Characteristics (*N*)

We include a range of potentially relevant and available characteristics, including socioeconomics and demographics, local opportunities (shopping, recreation, public administration, etc.) and the relative mix of these (measured by a “diversity index”; Rajamani et al., (2003)); see Equation [8.1] in Appendix), crime levels, school achievement scores, environmental quality as estimated by proximity to green spaces and Lake Michigan, and whether the property resides in a TIF zone. Appendix 8.2 describes in detail the data used, the spatial units, and calculation approaches for the different variables and provides example maps of spatial distributions. We calculated “neighborhood” variables at various levels: census block group (e.g., socioeconomics), census tract (e.g., crime), traffic analysis zone (TAZ) (e.g., opportunities), other spatial forms (TIFs), or straight line distances (e.g., parks). Most of these neighborhood attributes can actually be interpreted as local accessibility characteristics (e.g.,

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[29] We obtained commercial property data from a commercial data provider, CoStar, so we were limited to the data they provided. Furthermore, as we were working with sales data, the number of sales of such sites is apparently limited in any given year.

school quality accessibility, local accessibility to a mix of opportunities, accessibility to different income groups, accessibility to areas with low crime).

Transportation and Accessibility (*T*)

We attempt to measure both local and regional effects of transportation infrastructures and levels of service. For regional accessibility – that is, the locational benefits of each property vis-à-vis estimated transportation system performance and the locations of potential destinations across the metropolitan landscape – we implement two different types of measures, in separate models. First, we use a traditional distance to CBD measure, which in some sense presumes a mono-centric city predominates, with relatively similar transportation levels of service emanating out in all direction from the CBD (e.g., akin to Alonso's basic model described in Section 2). To loosen the monocentric city assumption, we also develop a measure of regional accessibility which attempts to show the relative ease of reaching different opportunities across the CMA, based on the concentration of those different opportunities and the estimated performance of the transportation system. Appendix 8.2 provides details on the approach. Essentially, we calculate a gravity-based accessibility measure for each TAZ, using zone-to-zone travel times for auto and public transport, estimated from a network model calibrated for Chicago, and the concentration of opportunities (12 different categories) and population (5 different income categories) within each zone. Figures 8-8 and 8-9 in Appendix 8.2 show some examples of the resulting measures.

The figures confirm an overall monocentric accessibility pattern, although with a skew towards the north of the city; furthermore, the figures show, as we might expect, a more uniform accessibility gradient for automobile travel, while transit accessibility concentrates, relatively, along the transit corridors. The individual accessibility measures (by mode and destination) cannot be incorporated independently into each model, due to high collinearity among them. Instead, we first carry out principal component analysis (PCA) on the 34 individual accessibility measures for each zone. The PCA yields two composite components, together explaining 97% of the variance in the 34 individual accessibility measures (see Appendix Table 8.2). The first component represents a weighted sum of transit and auto accessibility to opportunities and persons; the second component basically represents zones with high auto accessibility relative to transit. Incorporating these components directly into a regression model poses a consistency problem because the components include measurement error by dropping error terms (Ben-Akiva *et al*., 1999). So, instead, the PCA results guide us to develop a more generalized, aggregate accessibility measure, one for auto and one for transit (see Appendix 8.2). We then attribute these regional accessibility measures by mode, calculated for the TAZ, to the properties in each TAZ, thereby enabling a partial "control" for the relative regional locational benefits of each property and allowing us to isolate any additional local effects of transportation infrastructures and services.

For the "local" components of the *T* vector, we include a range of variables that attempt to capture the potentially positive and negative effects of transportation infrastructures and levels of service. In an attempt to measure potential *negative* local effects of transportation infrastructures and operations, we include several variables representing proximity to elevated and at-grade rail lines and major highways; presumably, the accessibility that these infrastructures may provide comes at a cost (air, noise and visual pollution, etc.) to adjacent properties.

Finally, as our primary aim is to understand whether and how much mass transit stations influence property values, we include measures accounting for property proximity to these stations. For the CTA's urban rail network, we use a walk impedance function based on the straight-line distance of the property to the nearest CTA station – the impedance function is essentially a decay rate, reflecting the relative discomfort of walking, as derived from empirical evidence on reported walking behavior, such that greater distances get "penalized" (reflecting the relative disutility of longer trips, all else equal; see Appendix 8.2 for additional details on the calculation method and results).[30] We also include distance to Metra suburban rail stations, with a traditional, more straightforward, distance-based buffer (as well as similar distance-based measures to Metra line rights-of-way). For other local-level transportation level of service effects, we include proximity to bus stops and major roadway arterials.

Specification Summary

Our specific hedonic models of property values in the Chicago case aim to isolate the price effects of proximity to rail transit stations, holding constant other potentially confounding effects, including transportation levels of service. The basic theory underlying our specifications is that proximity to rail-based transit stations brings *additional* value to properties, beyond the value brought by the transportation system – both auto and public transportation – as can be observed via the estimated accessibility and other variables included in the models. This additional value, if it exists, may derive from the local convenience, perceived permanence, or other intangibles not easily captured in the regional accessibility measures, which, ostensibly, already approximate for the enhanced transportation level of service implied by rail transit presence in a property's "neighborhood."

4.3. Model Estimation Results

Tables 8-7 to 8-14 in Appendix 8.4 provide the full model estimation results for the final model specifications employed, using several different estimation techniques: "robust" OLS, with the White's heteroscedasticity-corrected (robust) standard errors (Gujarati, 2003); and the two alternative spatial autocorrelation corrections (i.e. spatial lag and spatial error), as presented in Section 4.1. Model test statistics suggest that the spatial error model is more appropriate relative to the spatial lag model,[31] therefore our final model estimates are based on the spatial error corrections offered in GeoDA^{TM}. For both techniques, we run four separate models testing different regional accessibility controls: no regional controls, distance to CBD, the composite index for system-wide automobile accessibility, and both composite indices for system-wide automobile and transit accessibility. The model specifications vary across property types, depending upon the variables available and relevant. We believe our best models are for single-family homes, since we have the most complete property-specific information available for this type. Table 4-1 presents the results from our "best" hedonic model for each property type. The results tend to confirm our intuition/theory, although not in all cases.

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[30] We use the same impedance function approach to calculate the gravity-based regional accessibility measures discussed in the previous paragraph.

[31] Wang and Ready (2005) suggest that spatial error more intuitively captures the spatial autocorrelation of housing prices, reflecting "contagious" and "non-contagious" errors.

The following sub-sections describe, briefly, the notable effects detected for properties and neighborhoods. Since our main interest regards transportation impacts, particularly CTA station effects, most of the discussion focuses there.

Property Characteristics/Improvement on the Parcel (*I*)

For single-family homes, the results are for the most part consistent with expectations and the findings of McMillen and McDonald (2004). *All else equal*, home prices are positively associated with built size and lot size, masonry construction, number of bathrooms, central air conditioning and a fireplace, and one- or two-car garages. Home prices are negatively associated with multi-story homes, unfinished basements or crawlspaces (relative to no basement or finished basements), attic space as living (relative to no attic, or unfinished/apartment attic), home age, and being a row or townhouse.

For multi-family homes, we find similar results, again consistent for the most part with expectations. Multi-family homes are positively associated with building and lot size, three or more story structures, masonry construction, a large number of bathrooms, basement space, and larger than three-car garages. Building age is negatively associated with building price.

For vacant land, the only relevant property attribute available, lot size, performs as expected, positively influencing sales price. For commercial properties, despite the small sample and limited characteristics available, we find positive effects of built area, Class B space, whether the space is designed for retail or hospitality use, and relative parking provision. Similar to the residential properties, building age has a negative effect on price. The fact that the parameter for Class B space is ten times that of Class A space appears dubious, but since the latter variable does not appear statistically significant at even the 10% level, this may be due to small sample size.

Looking at the few variables comparable across the models: the relationship between built size and commercial properties’ prices is more than double that for single- and multi-family units; the relationship between lot size and price is roughly the same for single-, multi-family properties and vacant land, reflecting a consistent size effect on underlying land value; and commercial properties’ prices are much more sensitive to building age than single- or multi-family home prices.

Neighborhood Characteristics (*N*)

For single-family homes, prices are positively associated with nearby parks/forests, proximity to Lake Michigan, good school achievement scores, the density of high income residents, and the density of non-residential activities. Conversely, prices are negatively associated with increased distance to cemeteries (somewhat oddly implying cemeteries are a neighborhood amenity), the ratio of Hispanic and African American people in the corresponding block group (with the latter having a stronger negative relationship than the former), the density of crime in the census tract, and whether the home is in an industrial or mixed-use TIF district.

For multi-family homes, prices are positively associated with the local density of high income residents and the local land use mix, suggesting that multi-family housing is more attractive in mixed-use neighborhoods. Similar to single-family homes, we see the apparent amenity effect of cemetery proximity, negative effects associated with the percentage of Hispanic and African American residents, and being in an industrial TIF district.

For vacant land, again the cemetery effect appears. Vacant land sale prices also appear even more negatively associated with the percentage share of Hispanics and African Americans in these areas. In terms of zoning effects, vacant land zoned for residential has lower sales prices, as does land with greater restrictions on lot size; higher permitted FARs are associated with higher land prices, logically. For commercial properties, once more we see the negative relationship with share of minority residents. A positive relationship with mixed-use and dense, non-residential neighborhoods is evident, suggesting commercial area agglomeration benefits, while locations near Lake Michigan carry a positive impact on price.

Overall, the most consistent similarity across property types is a negative association with share of minority populations, but of course one could question the direction of causation and/or the role of unobserved variables. The same can be said for the relationship between the density of high-income households and price for single- and multi-family homes. Additionally, while single-family home prices are positively influenced by the density of opportunities and multi-family homes more positively influenced by the mix of such opportunities, commercial properties are positively influenced by both.

Local and Regional Transportation/Accessibility (*T*)

Finally, for local and regional transportation and accessibility, we begin with the “dis-amenity” effects associated with transportation infrastructures. For single-family homes, being within one-half mile of an at-grade CTA Line has a negative association with sales prices, evidencing a declining effect with distance; a negative relationship also appears for being within one-quarter mile of a Metra suburban rail line and one-half mile to a highway. At the half-mile distance, the negative effect of highway, Metra and CTA is roughly comparable. The model, interestingly, indicates no effect of proximity to the *elevated* CTA lines. In terms of positive effects, higher regional accessibility by auto and transit is associated with higher sales values; with auto accessibility exhibiting an effect almost double to that of transit. Controlling for regional accessibility, we can see that house prices are positively correlated with proximity to local arterials, distance to Metra stations, and proximity to CTA rail stations (i.e., shorter walking distance to CTA stations is associated with higher property prices). We will focus on the implications of this finding in the following section. We find no effect associated with presence of CTA bus stops.

For multi-family homes, somewhat similar results emerge, although with some important differences. In terms of dis-amenities, again a negative effect associated with highway proximity is evident, comparable in magnitude to that for single family homes. However, only very close proximity (within one-eighth mile) to at-grade CTA lines appears negatively associated with multi-family homes (the effect for Metra Lines is not quite statistically significant at the 5 percent level). Again, the lack of a negative effect associated with elevated CTA lines is a bit surprising. Regarding positive effects, we see no statistically significant association with regional transit accessibility, but a positive auto accessibility relationship with price, similar in magnitude as for single-family homes. Controlling for regional accessibility, local arterials have no discernible relationship with multi-family home prices, nor do number of bus stops. For Metra stations, a rent gradient emerges, dropping off more rapidly than for single-family homes; for CTA rail stations, we also see a positive relationship with shorter walk distances, although the effect is roughly one-half of that for single-family homes.

Vacant land has fewer discernible relationships with transportation and accessibility variables. No dis-amenity effects appear. Vacant land sale prices are positively associated with regional automobile accessibility and have a positive, roughly constant relationship with distance to Metra stations (between one-eighth- and two-miles distances). For commercial properties, no significant effects appear, although regional transit accessibility and immediate proximity to Metra stations have positive affects, statistically significant at the 10 percent level.

Table 4-1. Best Spatial Error Hedonic Model Results for various Property Types

Variables	Single Family		Multi-Family		Vacant Land		Commercial	
	Coeff.	z-value	Coeff.	z-value	Coeff.	z-value	Coeff.	z-value
LAMBDA	***0.513***	***34.58****	***0.427***	***18.53****	***0.331***	***14.39****	***0.607***	***17.63****
CONSTANT	***8.100***	***60.21****	***8.659***	***44.68****	***10.175***	***28.27****	***6.376***	***17.98****
<u>Property/Land Attributes</u>								
Built Area	***0.338***	***24.36****	***0.267***	***14.80****		--	***0.791***	***21.77****
Lot Size	***0.143***	***11.69****	***0.152***	***8.51****	***0.197***	***6.26****		--
1.5 to 1.9 stories	***-0.044***	***-3.40****	*0.001*	0.03		--		--
2 stories	***-0.035***	***-3.44****	*0.035*	0.98		--	-0.064	-0.88
3 stories	0.029	1.17	***0.081***	***2.05***$^{\times}$		--		--
Multi-level	***0.041***	***2.08***$^{\times}$		--		--		--
3-4 stories		--		--		--	-0.033	-0.39
5+ stories		--		--		--	0.078	0.62
Number of Apartments		--	See	notes		--	--	--
Building Class A		--		--		--	0.045	0.71
Building Class B		--		--		--	***0.480***	***3.27****
Corner property		--		--		--	0.061	1.07
Retail use		--		--		--	***0.495***	***3.15****
Hospitality use		--		--		--	***0.349***	***3.12****
Frame masonry	***0.023***	***2.01***$^{\times}$	-0.002	-0.11		--	-0.063	-1.07
Masonry	***0.051***	***6.48****	***0.046***	***5.05****		--	--	--
Metal frame		--		--		--	0.081	0.31
Reinf. Concrete		--		--		--	-0.029	-0.26
Steel frame		--		--		--	0.202	1.54
Wood frame		--		--		--	-0.225	-0.81
Stucco	0.029	1.26	0.033	0.73		--		--
2 full bath	***0.040***	***4.73****	See	notes		--		--
3+ full bath	***0.129***	***7.19****	See	notes		--		--
6 full bath		--	***0.118***	***2.01***$^{\times}$		--		--
7+ full bath		--	***0.460***	***3.05****		--		--
1 half bath	***0.020***	***2.74****	See	notes		--		--
Basement has apt.	-0.205	-1.41	0.021	1.43		--		--
Basement has rec.	-0.020	-1.86	0.024	1.81		--		--
Basement Unfin.	***-0.019***	***-2.02***$^{\times}$	***0.038***	***3.78****		--		--
Basement Crawl	***-0.154***	***-6.91****	0.026	-1.20		--		--
Attic has apt.	-0.010	-0.07	0.011	0.51		--		--
Attic has living	***-0.042***	***-3.39****	0.010	0.58		--		--
Attic unfinished	0.000	0.03	0.004	0.39		--		--
Central AC	***0.026***	***3.41****	0.011	0.83		--		--
1 fireplace	***0.039***	***3.70****	0.009	0.38		--		--
2+ fireplace	0.025	1.28	-0.028	-1.33		--		--
1-car garage	***0.034***	***4.33****	0.013	1.21		--		--
2-car garage	***0.049***	***6.85****	0.004	-0.46		--		--
3+car garage	-0.008	-0.23	***0.067***	***3.13****		--		--
Parking/1,000 f^2		--		--		--	***0.043***	***3.34****
Building age	***-0.001***	***-4.08****	***-0.001***	***-4.98****		--	***-0.005***	***-3.39****
Row or townhouse	***-0.183***	***-10.89****		--		--		--

Notes: For detailed variable descriptions and descriptive statistics see Appendix 8.3. Single Family, Multi-Family, and Vacant Land models are SEM 4 from Tables 8-8, 8-10, and 8-12, respectively; Commercial is SEM 3 from Table 8-14. ***Bold italic*** indicates statistical significance at the 5 percent level; * p≤0.01; $^{\times}$ p≤0.05. "--": not available/applicable for that model. For Multi-family, # apartments (≤6), # full bathrooms, and # half bathrooms were also tested (see full models in Appendix), but not significant and excluded from this table due to space constraints.

(Continued on following page)

Table 4-1. (continued)

	Single Family		Multi-Family		Vacant Land		Commercial	
Neighborhood Characteristics	Coeff.	z-value	Coeff.	z-value	Coeff.	z-value	Coeff.	z-value
< 1/8 mi. to park/forest	**_0.028_**	**_3.64*_**		--		--		--
< 1/4 mi. to park/forest		--	0.000	-0.04	-0.024	-0.53		--
Dist. to cemetery	**_-0.044_**	**_-11.10*_**	**_-0.061_**	**_-14.72*_**	**_-0.105_**	**_-6.23*_**		--
Lake Mich.<1 mi.	**_0.082_**	**_3.34*_**	-0.009	-0.42	0.164	1.65	0.212	1.71
Avg School score	**_0.001_**	**_2.43×_**	0.001	1.48	0.000	0.13		--
Ratio Hispanic	**_-0.003_**	**_-10.22*_**	**_-0.002_**	**_-6.06*_**	**_-0.006_**	**_-3.29*_**	**_-0.006_**	**_-3.17*_**
Ratio African Am.	**_-0.007_**	**_-31.82*_**	**_-0.005_**	**_-18.43*_**	**_-0.014_**	**_-11.51*_**	**_-0.005_**	**_-4.31*_**
Crime Density	**_-0.016_**	**_-5.55*_**	-0.001	-0.33	-0.001	-0.06		--
Density Low Inc.	-0.006	-1.43	-0.004	-1.16	-0.011	-0.56		--
Density Med.Inc.	-0.005	-0.83	-0.003	-0.48	0.060	1.84		--
Density High Inc.	**_0.018_**	**_7.93*_**	**_0.023_**	**_10.75*_**	0.017	1.35		--
Population Density		--		--		--	0.003	1.21
Opportunity Density	**_0.005_**	**_3.86*_**	-0.002	-1.54	-0.001	-0.74	**_0.001_**	**_2.37×_**
Opportunity Mix	-0.024	-0.44	**_0.183_**	**_2.80*_**	0.348	1.35	**_0.511_**	**_2.22×_**
Residential TIF	0.233	1.72	0.114	0.77	-0.046	-0.20		--
Mix Use TIF	**_-0.050_**	**_-3.38*_**	0.000	0.02	0.060	1.14		--
Commercial TIF	0.042	0.61	0.056	0.75	0.357	1.15		--
Industrial TIF	**_-0.054_**	**_-2.04×_**	**_-0.072_**	**_-2.54*_**	0.098	1.07		--
Zoned Bus./Comm.		--		--	0.337	0.84		--
Zoned Manuf.		--		--	0.035	0.43		--
Zoned Residential		--		--	**_-0.112_**	**_-2.01×_**		--
Lot Size 2.5K-5K ft^2		--		--	**_-0.157_**	**_-2.61*_**		--
Lot Size => 5K ft^2		--		--	0.181	1.95		--
FAR 2-3		--		--	**_0.198_**	**_3.23*_**		--
FAR 3-5		--		--	**_0.394_**	**_3.82*_**		--
Local/Regional Accessibility								
<1/8 mi. bus stop	-0.011	-1.71	-0.006	-0.81	0.043	0.96	-0.071	-1.00
CTA station walk impedance	**_0.150_**	**_4.44*_**	**_0.084_**	**_3.11*_**	0.025	0.16	0.147	0.87
<1/8 mile Metra Station	**_0.241_**	**_5.54*_**	**_0.252_**	**_3.88*_**	0.272	1.40	0.247	1.71
1/8-1/4 mi. Metra Station	**_0.330_**	**_9.81*_**	**_0.179_**	**_4.99*_**	**_0.374_**	**_2.59*_**	-0.110	-0.88
¼-1/2 mi. Metra Station	**_0.281_**	**_9.58*_**	**_0.208_**	**_7.17*_**	**_0.259_**	**_2.08×_**	0.056	0.50
½-1 mi. Metra Station	**_0.246_**	**_9.49*_**	**_0.197_**	**_7.71*_**	**_0.309_**	**_2.95*_**		--
1-2 mi. Metra Station	**_0.193_**	**_7.70*_**	**_0.180_**	**_7.19*_**	**_0.306_**	**_3.10*_**		--
2-3 mi. Metra Station	**_0.126_**	**_5.16*_**	**_0.083_**	**_3.11*_**	-0.042	-0.39		--
<1/2 mile to Arterial	**_0.049_**	**_2.68*_**	0.014	0.69	0.059	0.56	-0.011	-0.143
<1/8 mi. @grade CTA Line	**_-0.150_**	**_-4.91*_**	**_-0.065_**	**_-2.64*_**	0.181	1.42		--
1/8-1/4 mi @grade CTA Line	**_-0.093_**	**_-3.55*_**	-0.026	-1.44	0.151	1.26		--
.25-.5 mi. @grade CTA Line	**_-0.048_**	**_-2.49×_**		--	0.007	0.07		--
<1/8 mi. Elev. CTA Line	-0.002	-0.06	0.008	0.33	0.001	0.008		--
1/8-1/4 mi Elev. CTA Line	0.019	0.70	0.029	1.50	0.108	0.97		--
.25-.5 mi. Elev. CTA Line	0.012	0.63		--	-0.103	-1.22		--
<1/8 mi. Metra Line	**_-0.059_**	**_-3.22*_**	-0.030	-1.66	0.020	0.25		--
1/8-1/4 mi. Metra Line	**_-0.043_**	**_-2.70*_**	-0.027	-1.89	-0.014	-0.19		--
¼-1/2 mi. Metra Line	-0.004	-0.30	-0.005	-0.43	0.047	0.76		--
<1/2 mi. to Highway	**_-0.036_**	**_-2.55×_**	**_-0.037_**	**_-2.84*_**	-0.018	-0.30	-0.035	-0.48
Auto Accessibility	**_1.694_**	**_12.32*_**	**_1.989_**	**_12.07*_**	**_1.958_**	**_2.79*_**		--
Transit Accessibility	**_0.924_**	**_5.53*_**	0.177	1.03	0.130	0.16	1.032	1.85
Summary Statistics								
Observation No.		14,263		2,112		3,344		383
R-squared		0.754		0.882		0.374		0.899
Log Likelihood		-4,274.46		-970.13		-4,676.72		-272.90
Akaike info criterion		8,678.92		-1816.26		9,445.45		609.81

Notes: For detailed variable descriptions and descriptive statistics see Appendix 8.3. ***Bold italic*** indicates statistical significance at the 5 percent level; * p≤0.01; × p≤0.05. "--": not available/applicable for that model.

Variations by Model Approach/Specification

The various modeling approaches employed enable some illuminating diagnostics regarding the effects of model approach and specification on the results of specific interest; that is, walk proximity to CTA stations (see Table 4-2). First, as would be expected, for single- and multi-family homes and vacant land the hedonic models vastly overestimate the size of the association between CTA station walk proximity and sales price when no relative locational controls are included. For the residential properties, at least twice the station proximity effect is detected; for vacant land, after controlling for relative location, no CTA station effects remain.

For multi-family homes, it makes little difference how one controls for relative location with this particular data set – the relative effects vary little when using distance to CBD versus our auto/transit accessibility measures; furthermore, little difference emerges between the robust OLS estimation and the spatial error model. So, presuming a monocentric rent gradient in this case seems like a reasonable simplification, if necessary, and the spatial error model, while technically "better," has little practical implication. There seems to be only modest spatial autocorrelation for multi-family dwellings in Chicago. Where this result comes from and whether it holds true for a different and/or a larger sample would require further examination.

Table 4-2. Summary of Coefficient Estimates for CTA Station Walk Impedance

Property Type	**No Relative Location Controls**		**Controlling Distance to CBD (mono-centric presumption)**		**Controlling Regional Auto Accessibility**		**Controlling Regional Auto & Transit Accessibility**	
	Robust OLS	**SEM**	**Robust OLS**	**SEM**	**Robust OLS**	**SEM**	**Robust OLS**	**SEM**
Single-Family	0.401* (19.92)	0.494* (14.39)	0.161* (8.08)	0.195* (5.97)	0.190* (9.63)*	0.229* (7.37)*	0.095* (4.25)	0.15* (4.44)
Multi-Family	0.197* (9.35)	0.228* (8.21)	0.089* (4.65)	0.072* (2.72)	0.113* (6.13)*	0.095* (3.80)*	0.091* (4.54)	0.084* (3.11)
Vacant Land	0.241$^{\times}$ (2.14)	0.338$^{\times}$ (2.47)	-0.112 (-0.9)	0.004 (0.03)	-0.077 (-0.62)	0.032 (0.22)	-0.103 (-0.78)	0.025 (0.16)
Commercial	0.531* (4.4)	0.362* (2.92)	0.476* (3.45)	0.313$^{\times}$ (2.11)	0.296† (1.80)†	0.147 (0.87)	0.295† (1.78)	0.15 (0.88)

Notes: t-statistics (for OLS)/z-value (for SEM) in parentheses; * indicates statistical significance at the 1 percent level, $^{\times}$ at the 5 percent level, † at the 10 percent level; see full model specifications in Appendix Tables 8-7 – 8-14.

For single-family homes, the spatial error model estimates a higher coefficient for station walk proximity across the different specifications and estimation approaches. The spatial error correction in the accessibility model actually returns a CTA station effect comparable to the effect detected in the CBD models. The reasons for this particular outcome as well as the much lower station effect in the robust OLS accessibility model, are worth exploring further. However, this is outside the scope of this study.

For commercial properties, the CTA station proximity effect shows little difference between the model with no relative location controls and the distance to CBD model, although larger differences emerge in the OLS versus spatial error models. When accessibility is included in lieu of CBD distance, no significant effect is detected in the spatial error model, while robust OLS returns a coefficient significant at the 10 percent level. The variations in these effects across model specification and estimation approach once more warrants further investigation in the future.

5. Implications for Property Values, Taxes, and Local Transit Finance

From the results of the spatial hedonic models in Section 4, we can see that regional accessibility contributes positively to single- and multi-family home prices (and likely for commercial property prices, although with greater uncertainty). After controlling for regional accessibility, however, we find that walk access to CTA stations (measured by the walk impedance index – Equation [8.3] in Appendix 8.2) still positively influences sales prices of single-family homes and multi-family homes. For commercial properties, we find uncertain effects, perhaps in part due to the small sample size and broad geographic distribution (many observations beyond the City of Chicago boundaries, which we needed to include due to the small sample of properties in Chicago proper). Commercial properties may also value regional transit accessibility more than the localized effect of transit station proximity. As for vacant land, perhaps in part due to limited information about the parcels' actual characteristics, the models we estimated do not suggest significant effects of local transit accessibility on land prices.

In this section we review the implications of the hedonic price model estimates for property values and local taxation, focusing on residential properties, i.e., single-family and multi-family. We also consider commercial properties, with the caveat that coefficient estimates should be viewed as tentative and uncertain, since the commercial model is estimated on a limited number of observations and displays considerable variation across specifications and estimations.

5.1. Estimated Property Price Effects of CTA Stations

This section presents price effects in three different ways. First, and perhaps the most opaquely, we interpret the relative effects due to a change in the walk impedance value. Second, we modify that approach to calculate the equivalent of a station area density gradient vis-à-vis walk time equivalent. Third, we estimate an elasticity of price with respect to walk time.

Referring to the generic hedonic model presented in Equation [4.6], let $X_{T,2}$ represent "CTA station walk impedance" (in Table 4-1), the walk impedance index (i.e., impedance-weighted walk distance) to the nearest CTA station. $X_{T,3}$, $X_{T,4}$, and $X_{T,5}$ are dummy variables representing if a property is within one-eighth mile, between one-eighth and one-quarter mile, and between one-quarter and one-half mile at-grade CTA line, respectively; $X_{T,6}$, $X_{T,7}$, and $X_{T,8}$ are dummy variables representing if a property is within one-eighth mile, between one-eighth and one-quarter mile, and between one-quarter mile and one-half mile of an elevated CTA line, respectively. Whenever there is a change to the CTA accessibility profile, all else equal, the values of $(X_{T,2}, \ldots, X_{T,8})$ change from $(x_{T,2}, \ldots, x_{T,8})$ to $(x'_{T,2}, \ldots, x'_{T,8})$.

Assuming that the values of all the other variables do not change, and for the moment ignoring station line effects, then the impedance effect of this change is given by Equation [5.4]. All else equal, when the value of $X_{T,2}$ changes from $x_{T,2}$ to $x'_{T,2}$, the expected property price will change from p to p', then:

$$\ln\left(\frac{p'}{p}\right) = \Delta \ln p = \hat{\beta}_{T,2} \Delta x_{T,2} \qquad [5.1]$$

$$\text{i.e., } \frac{p'}{p} = \exp(\hat{\beta}_{T,2} \cdot \Delta x_{T,2}) \qquad [5.2]$$

$$\text{or } \frac{p'}{p} - 1 = \exp(\hat{\beta}_{T,2} \cdot \Delta x_{T,2}) - 1 \qquad [5.3]$$

where $\Delta x_{T,2} = x'_{T,2} - x_{T,2}$ and $\hat{\beta}_{T,2}$ is the regression model estimate of $\beta_{T,2}$.

If we define

$$\delta_{\hat{\beta}_{T,2}}(\Delta x_{T,2}) = \exp(\hat{\beta}_{T,2} \cdot \Delta x_{T,2}) - 1 \qquad [5.4]$$

then the property price p' is $100 \cdot \delta_{\hat{\beta}_{T,2}}(\Delta x_{T,2})$ percent higher (if $\Delta x_{T,2} > 0$) or lower (if $\Delta x_{T,2} < 0$) than p.

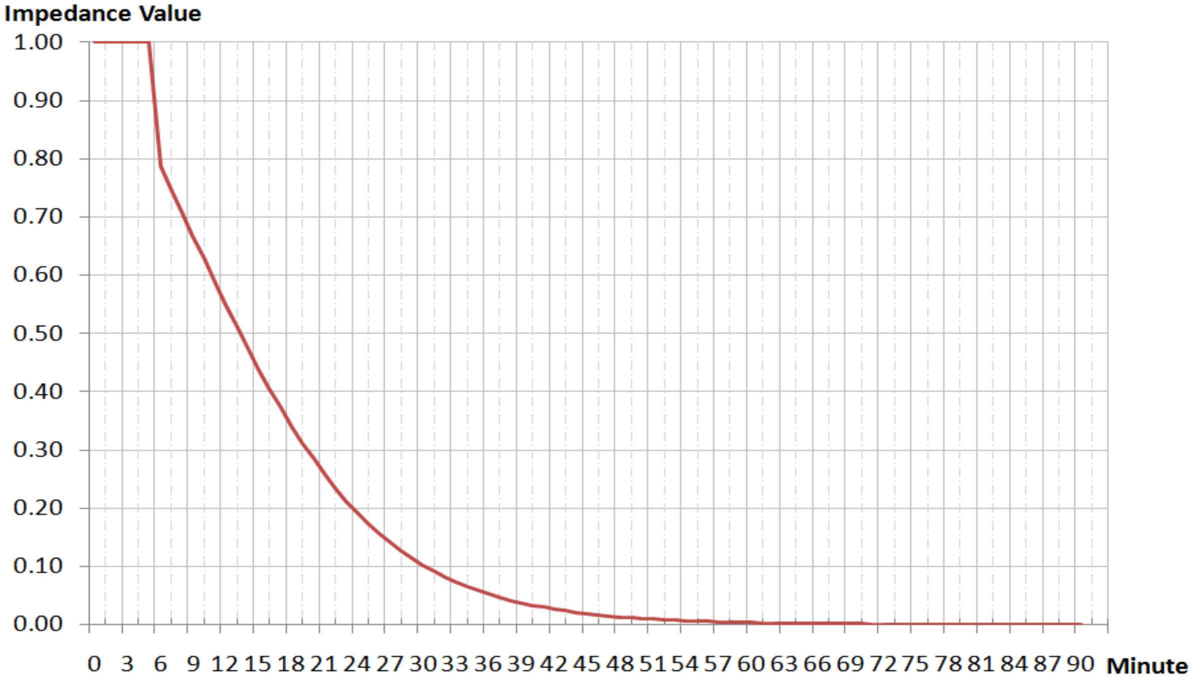
Table 5-1 presents the different expected percentage changes in property sales prices due to a 0.1 increase (i.e., $\Delta x_{T,2}$= 0.1) in the walk impedance index (higher values correspond to shorter travel times). More intuitively, up to approximately the first 20 minutes of walk times, this 0.1 increase in impedance index equals roughly 3 minutes less walking time (see Figure 5-1) or 800 feet (0.15 miles or 240 meters). For each property type, the variations in the estimates arise from the different model estimation (i.e., robust OLS versus spatial error) and specification approaches (i.e., controlling for distance to CBD versus regional auto and transit accessibility). For single-family homes, the 0.1 increase in walk impedance equals roughly a 1% to 2% increase in property values (with 1.5% being the result from our “best” model); for multi-family homes, the range in effects is narrower, 0.7% to 0.9% (with 0.84% being our “best” estimate); for commercial properties, the effects range from 3% to almost 5% (although the full accessibility controlled spatial error model reveals no significant effect at the 10 percent level).

Table 5-1. Estimated Impacts of Change in Walk Impedance Index on Property Prices

Property Type	**Controlling Distance to CBD**		**Controlling Regional Accessibility**	
	OLS	**Spatial Error**	**OLS**	**Spatial Error**
Single-Family Home	1.62%*	1.97%*	0.95%*	1.51%*
Multi-Family Home	0.89%*	0.72%*	0.91%*	0.84%*
Commercial Properties	4.88%*	3.18%×	2.99%†	1.51%

Notes: Based on a 0.1 increase in the walk impedance index ($X_{T,2}$) (see Appendix 8.2, Eq.8.3), equivalent to an approximately 3-minute decrease in walk time (or 800 feet/240 meters walk distance); the different price increases are calculated based on equation [5.4] using different estimated coefficients for $X_{T,2}$ (see Table 4-2); * indicates statistical significance at the 1 percent level, × at the 5 percent level, † at the 10 percent level.

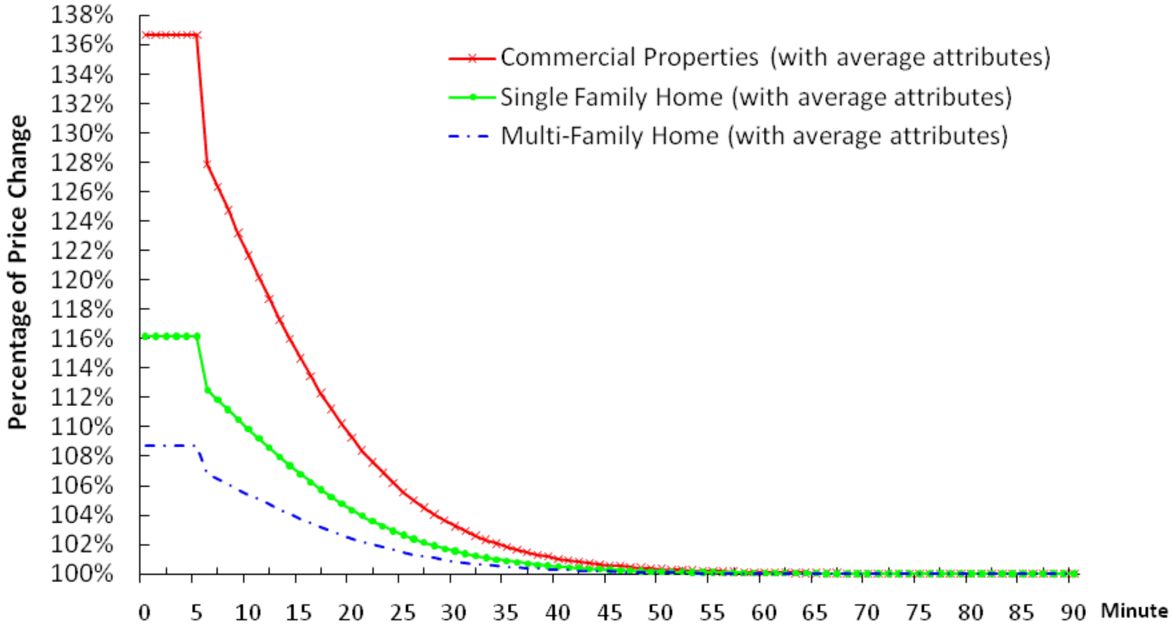
Figure 5-1. Walk Impedance Value versus Walk Time (in minutes): Chicago



Notes: Assumes walking speed = 3 mile/hour = 1/20 mile/minute; 1 mile = 20-minute walk; ¼ mile = 5-minute walk; within ¼ mile, or equivalently, 5-minute walk time to station assumed to have constant walk impedance value, 1).

Figure 5-2 shows the relationship between property prices and CTA station distance in the form of a rent gradient. The figure shows the normalized percentage change in the property price for an "average" property of each of the three types (single-family, multi-family, and commercial), controlling for all other variables except the walk time to the nearest CTA rail station. For the commercial property gradient, we apply the CBD-controlled spatial error model parameter estimate for walk impedance, as this is the best model estimate providing a variable significant at the 5% level.

Figure 5-2. Effects of walk convenience to local rail stations on property values: Chicago.



	Minute	5	15	30	45	60	75	90
SF	Price ($)	236,499	217,414	206,732	204,163	203,695	203,614	203,600
MF	Price ($)	379,180	361,738	351,681	349,229	348,780	348,702	348,689
Com	Price ($)	3,200,416	2,684,945	2,416,935	2,354,675	2,343,411	2,341,472	2,341,141

Note: Single family and multi-family are based on accessibility-controlled spatial error models; commercial is based on CBD-controlled spatial error model (see coefficients in Table 4-2).

Finally, the regression model estimates can be used to derive elasticities of property values with respect to walking time. Such elasticities can be calculated in several ways; the values obtained will vary based on the actual distribution of properties' distances to CTA stations (and the size of the time change considered, although technically the calculation should be done at the limit; i.e., at a very small change). Utilizing the population of residential properties and the sample of commercial properties and changing each property's walk time to a CTA station by a fraction of time produces average elasticities ($ value of property with respect to minute of station access walk time) of 0.056 for single family homes, 0.039 for multi-family home, and 0.115 for commercial properties.[32]

To demonstrate how the elasticity of sales price with respect to CTA station walk distance varies by the property's distance to CTA stations, we calculate the elasticity for the two residential property types and for commercial properties at different station distances. Figure 5-3 shows the

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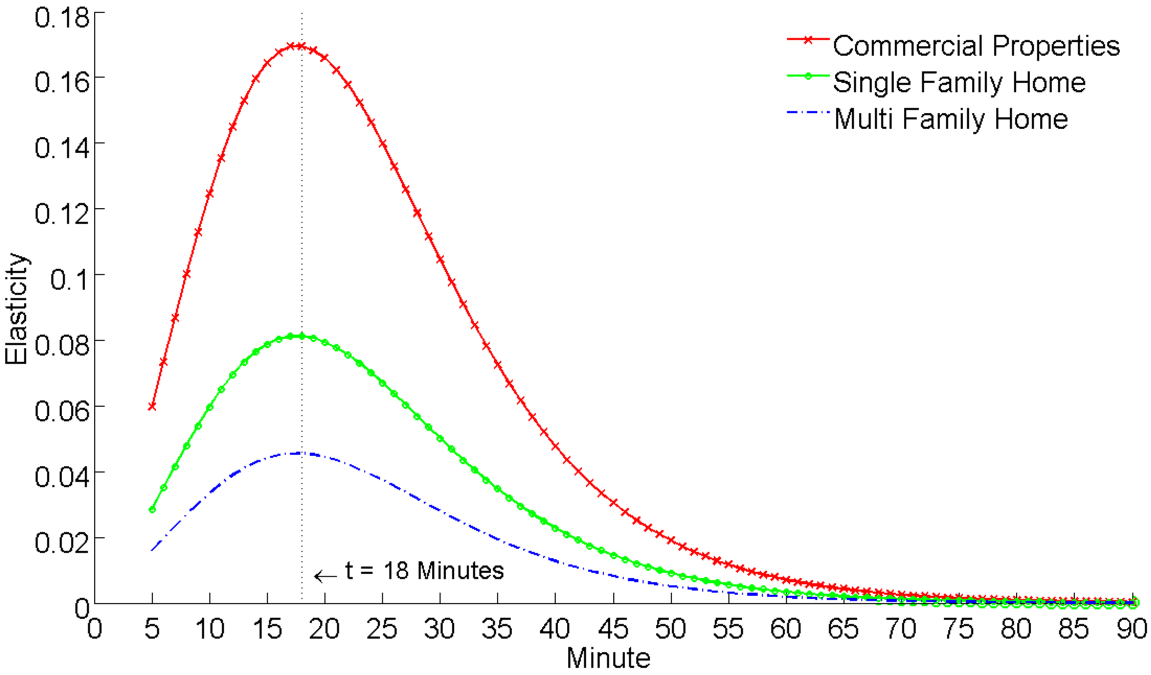
[32] Not exactly the full population of residential properties was used, since only 94% of single family homes and 86% of multi-family homes were able to be geocoded; we were unable to get adequate information on commercial properties to do a full population elasticity estimate. The average elasticity of property value (*V*) with respect to walk time to CTA (*t*) is calculated with the following formula and a change in walk time at the limit (10^{-6} minute change) for each property:

$$E_{V,t} = \frac{\sum_{i=1}^{n}(V_{i1}-V_{i0}) \Big/ \sum_{i=1}^{n} V_{i0}}{\sum_{i=1}^{n}(t_{i1}-t_{i0}) \Big/ \sum_{i=1}^{n} t_{i0}} = \frac{\frac{1}{n}\sum_{i=1}^{n}(V_{i1}-V_{i0}) \Big/ \frac{1}{n}\sum_{i=1}^{n} V_{i0}}{\frac{1}{n}\sum_{i=1}^{n}(t_{i1}-t_{i0}) \Big/ \frac{1}{n}\sum_{i=1}^{n} t_{i0}} = \frac{\overline{\Delta V} \big/ \overline{V_0}}{\overline{\Delta t} \big/ \overline{t_0}}$$

. In this case we use only the robust OLS model results since the weight matrix cannot easily be calculated for the full number of geo-coded residential properties (i.e., 280,256 single family units, and 100,012 multi-family units) in the City of Chicago and the spatial error accessibility model is not significant for commercial properties. This results in a conservative estimate for single family homes and commercial properties (excepting the possibility of no effect in the case of the latter) and a slightly higher effect for multi-family units (see, again, Table 4-2).

variation in the property value change, showing that the greatest relative “value added” is realized at a station walk time of about 18 minutes. That is, the effect of being closer/further to/from a CTA station is most pronounced in about the 15-20 minute average station walk time. Note that this particular result and the shape of the curve derive directly from the empirically determined walk impedance function (Equation [8.3] in the Appendix).

Figure 5-3. Variation in Elasticity of Property Value with Respect to Walking Time Based on Properties’ Walk Times to CTA Station.



Note: Based on the accessibility-controlled spatial error models for residential properties and the CBD-controlled spatial error model for commercial properties (see Table 4-2).

5.2. Estimated “Total” Value Added

While Section 5.1 illustrates our hedonic price model-generated rent gradients resulting from the location of CTA stations, we must also consider CTA infrastructure negative externalities. Specifically, proximity to at-grade CTA lines has a statistically significant negative association with single-family home prices within one-half mile straight-line distance and with multi-family homes within one-eighth mile (see Table 4-1). Since properties may be located near CTA at-grade lines but not near stations, there is a possibility that the overall impact of CTA rail transit will be negative. In fact, our best OLS specification for single-family homes suggests that about all accessibility gains accruing to properties within one-eighth mile of a CTA station will be nullified if the given property is also within one-eighth mile of an at-grail CTA line. Thus, calculating the *net* property value gains attributable to CTAe must include the value-depressing effects of negative externalities.

Using a similar method to deriving Equation [5.4], we can estimate the CTA line effects on property prices as follows:

$$\delta_{\hat{\beta}_{T,3,8}}(\Delta x_{T,3,8}) = \exp(\sum_{k=3}^{8} \hat{\beta}_{T,k} \cdot \Delta x_{T,k}) - 1 \qquad [5.5],$$

where $\Delta x_{T,3,8} = (x_{T,3}, \dots, x_{T,8}) - (x'_{T,3}, \dots, x'_{T,8}) = (\Delta x_{T,3}, \dots, \Delta x_{T,8})$.

Combining Equations [5.4] and [5.5] we can then calculate the total effects on property price due to changes in walk impedance (e.g., the CTA "station effect") and the presence of CTA lines as follows:

$$\delta_{\hat{\beta}_{T,2,8}}(\Delta x_{T,2,8}) = \exp(\sum_{k=2}^{8} \hat{\beta}_{T,k} \cdot \Delta x_{T,k}) - 1 \qquad [5.6],$$

where $\Delta x_{T,2,8} = (x_{T,2}, \ldots, x_{T,8}) - (x'_{T,2}, \ldots, x'_{T,8}) = (\Delta x_{T,2}, \ldots, \Delta x_{T,8})$.

For single- and multi-family homes, we estimate the total value-added to Chicago's residential properties[33] due to CTA station proximity and including the negative externalities detected in the models due to CTA infrastructure. We approximate the CTA infrastructure total *net* value added by estimating:

1. The "without CTA" situation – for every property type, simulating the *baseline value* of each individual property, using the regression model estimates and, *all else equal*, assuming *no* CTA station presence and *no* CTA at-grade rail infrastructure.
2. The "with CTA" situation – simulating the value of each individual property, again using the regression model estimates, and with the property's *actual* station impedance value and negative effects associated with its relative location vis-à-vis at-grade CTA infrastructure.
3. The total property "value added" due to the CTA station proximity – subtracting the result of Step 1 from Step 2.

In this approach, we utilize the results from the robust OLS to simulate the with/without cases, not the spatial autocorrelation model, because using the latter would require deriving a spatial weights matrix for all residential properties in the City of Chicago. As can be seen in Table 4-2, using OLS will not produce major differences for multi-family homes, but will *underestimate* the value added for single family homes.

Admittedly, this represents a somewhat crude estimation approach. For example, the "counterfactual" (estimated under Step 1) is unrealistic – the City of Chicago would be a very different city without the CTA rail transit system (or, more precisely, with all residential properties at least 50 minutes walking distance from a CTA transit station). Furthermore, we only account for the loss of CTA stations, but not the changes in regional accessibility such a loss would entail (due to changes in levels of service for public transit and auto travel). Nonetheless, since we cannot observe the counterfactual, we utilize this approach to provide a basic sense of the magnitude of value added to residential properties in Chicago due to their proximity to CTA infrastructure. The calculation also provides a point of comparison to other estimates. Ultimately, the calculation, while illustratively interesting, is not critical for the subsequent tax revenue estimations.

Table 5-2 presents our estimates of the total value added to single- and multi-family homes due to the CTA infrastructure in the City of Chicago, including positive effects of station proximity and negative effects of line proximity. Note that these estimations likely represent a lower bound, since the geo-coded residential properties with complete variables (as listed in the models in Appendix 8.4) represent only about 94% of the total records from the Cook County Assessor's Office for single-family homes, and only about 86% for multi-family homes; and, we use a lower coefficient value for single-family homes (robust OLS value from Table 4-2). Furthermore, the

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[33] Here, we can only estimate the value added for single- and multi-family homes, since we only have detailed variable values for all properties of these two types in Chicago.

value added is only for residential properties; we do not include non-residential properties due to the lack of necessary information.

Table 5-2. Total Residential Property Value Added by CTA Rail Transit Stations in Chicago (2006)

	In Billion $		
	Single Family (S. F.)	**Multi-Family (M. F.)**	**S. F. + M. F.**
"Baseline" Estimated Market Value (No Local CTA Stations/At-Grade Lines)	74.3	37.1	111.4
Estimated Market Value with Local Transit Stations	76.5	38.9	115.4
Total Value Added (95% Confidence Interval[(a)])	2.2 (1.0 - 3.4)	1.8 (1.0 – 2.7)	4.0 (2.0 – 6.0)
Value Added per mile of CTA rail line[(b)] (95% Confidence Interval[(a)])	0.025 (0.012 – 0.038)	0.020 (0.011– 0.030)	0.045 (0.023 – 0.068)
Value Added per CTA rail station[(c)] (95% Confidence Interval[(a)])	0.018 (0.008 – 0.027)	0.014 (0.008 – 0.021)	0.032 (0.016 – 0.048)

Notes: (a) The 95% confidence interval estimations are calculated according to the 95% confidence interval of the coefficient for the variable "Walk impedance measure to the nearest CTA station" in the Robust OLS Model 4 for single Family and Multi-Family properties, respectively (see Appendix Table 8-7 and Table 8-9); we use the point estimates of coefficients for all other variables in the model. (b) Total length (i.e., 89.15 mile) of the CTA right-of-way within the City of Chicago boundary. (c) The total number of CTA rail stations (i.e., 125) within the City of Chicago boundary.

We estimate that CTA station proximity adds approximately $4 billion in residential property value to the City of Chicago. Considering the length of the CTA rail system, this equates to approximately $45 million per mile of rail line or $32 million per CTA station. Single-family homes account for nearly 55% of the total value added. As a point of comparison, and as previously summarized, McMillen and McDonald (2004) analyze Chicago's Orange/Midway Line (8 stations and 11 miles) and estimate an aggregate increase in single-family home values of $194 million (in 1993) or approximately $251 million (in 2004). This corresponds to roughly $31 million (in 2004) per station (considering the 8 stations "outside the downtown area" (p. 465) of the Midway/Orange Line they analyze) or $23 million per line-mile (considering the full 11 miles of length). Note that our models indicate that CTA's at-grade rail infrastructure implies a "value lost" of $200 million for single family homes.

Finally, Figure 5-4 shows the estimated variation in the distribution of single-family home prices across Chicago based on the variations only in the Transportation and Accessibility Vector (i.e., *T*, in our generic model explained by Equation [4.6]), and evaluating all other variables at the sample average. The figure shows the monocentric form, to a large degree, still prevailing, with higher values towards the north of the city and following transportation corridors, particularly public transportation.

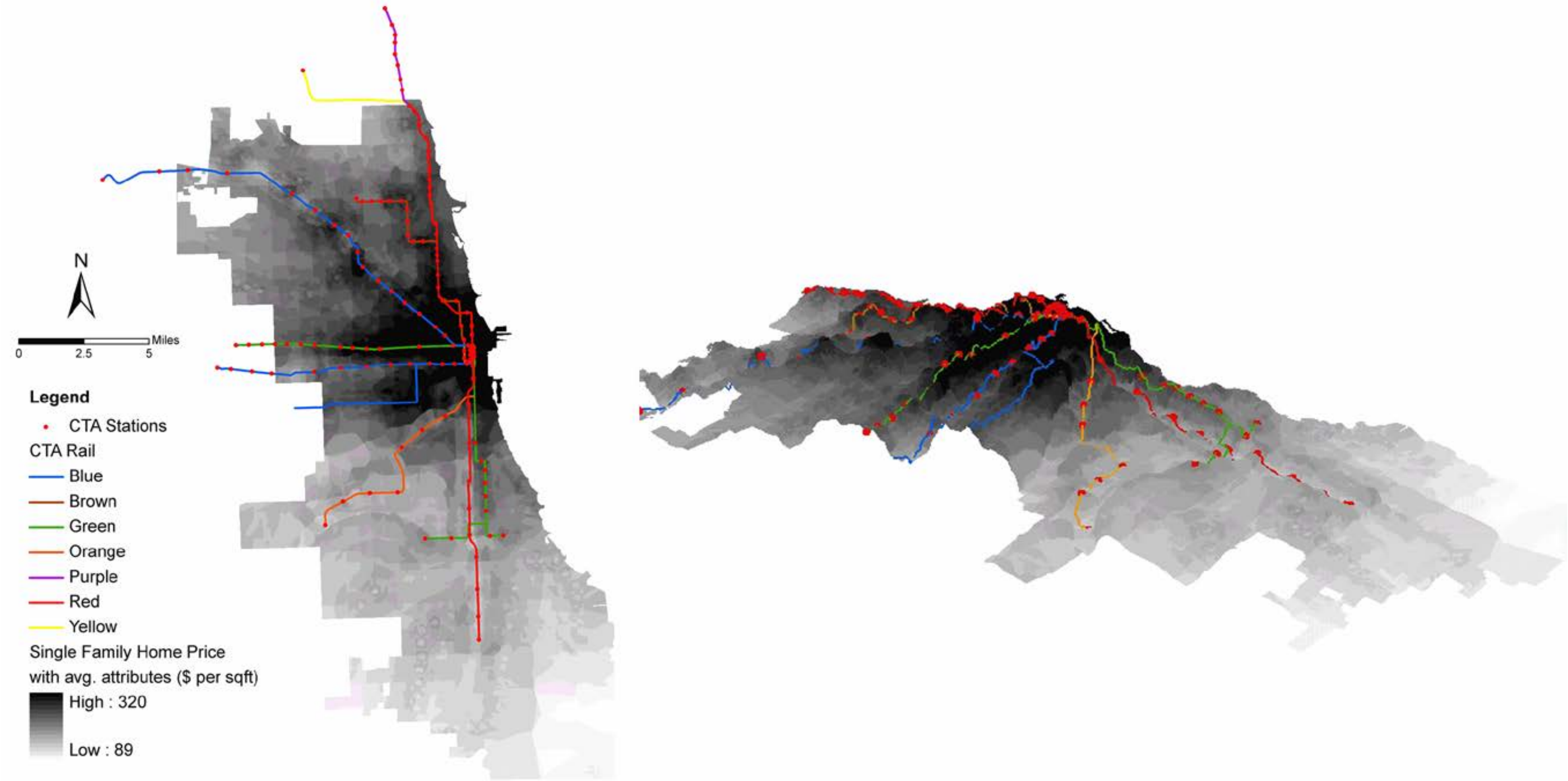

Figure 5-4. Simulated Single Family Home Value ($ per sq. ft.): “Topography” of Local and Regional Accessibility Effects in Chicago, 2004
Note: Simulated using the sample average property attributes and neighborhood socioeconomics characteristics and amenities, and actual property-associated values for distance to CTA stations and other transportation variables.

5.3. Examining Public Finance Implications

We now turn to estimates of the local public revenues, via property taxes, that CTA urban rail stations could potentially generate. Our basic idea is that, if the stations generate some increased property value that ultimately gets transferred to public coffers via property taxes, this property value increment could justifiably be allocated to CTA (e.g., to finance infrastructure and services), for the "value" its stations create. This analysis conforms to the "benefit tax" view of the property tax – essentially serving as a user charge for local public service benefits (Zodrow, 2007).[34] We also briefly explore alternative institutional arrangements where CTA might be able to leverage the incremental land value benefits of proximity to CTA stations to fund capital investment programs under various revenue objectives, subject to legal, political, and practical constraints. Finally, we consider a hypothetical case of CTA urban rail expansion and estimate the potential to finance such initiatives with value capture under different institutional arrangements.

We examine property tax implications for applying value capture methods to finance current system capital reinvestment programs under three scenarios:

1. CTA is granted a "fair share" of the public revenues generated via the current property tax system (i.e., by the current taxing agencies in CTA service areas), thereby retrieving the share of the various agencies' property tax revenues attributable to CTA's value added;
2. CTA functions like another local taxing agency within Cook County, whereby the Agency submits a variable (by distance) levy so as to recover the total property value added within a defined jurisdiction over a period of time; and
3. CTA is granted authority as a local taxing agency within Cook County to base its levy on revenue objectives rather than necessarily its "fair share" of current property assessments.

The first scenario does not require any major institutional changes to current local and regional tax authority and administration, except that a certain "fair" percentage of tax income will be appropriated to CTA. CTA does not become a tax agency, *per se*, but rather a direct recipient of transfers from Cook County, which apportions a percentage of city, county, and other tax district revenues to the Agency. Under this arrangement we assume that taxing agencies are revenue maximizers, subject to rate constraints (i.e., tax caps and the 7% maximum year-over-year residential tax bill increase), and that CTA would receive a portion of property-based taxes from existing tax agencies in proportion to property value created for each property by CTA stations, net of negative effects attributable to CTA lines. One could view the mechanics of these transfers as similar to those of a SAD. Cook County would use a "tiered" system of determining, for each property, the relative benefit (for simplicity as a percent of total EAV), subtract this amount from the total EAV, tax both at current rates, and then transfer the proceeds from the "value added" portion to CTA to cover a portion of ongoing capital expenditures (e.g., maintaining actual investment in right-of-way, infrastructure, and rolling stock).

The second scenario offers a slight institutional variation from the first by authorizing CTA as a local tax agency over a jurisdiction that approximates the benefit boundary, which in this case we limit to an approximate 40-minute walking distance from any CTA station. For this scenario, we

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[34] Justification for the "benefit tax view" depends in large part on the inability for tax-induced housing capital re-allocations, due to zoning constraints or perfect intra-jurisdictional capitalization in fully developed communities (Zodrow, 2007). Such a perspective is arguably accurate in the Chicago case.

assume that CTA submits a property tax levy to Cook County such that the total property value added would be captured over a specified amortization period. Unlike Scenario 1, however, CTA seeks to recover “market” total value added, rather than its fair share of property taxes on assessed value. Furthermore, CTA cannot simply request a lump sum transfer, but rather will need to devise a relatively simple, transparent, and, ostensibly, “fair” property tax rate(s).

The third scenario represents a more radical departure from the first two scenarios whereby CTA would levy a desired tax based on its own revenue objectives rather than, necessarily, its “fair share” of property taxes. In our example, we follow a similar implementation process as in Scenario 2 except that we make capital cost recovery an explicit objective function. CTA would still, however, face legal and political constraints.

Finally, we apply the principles of value capture and our model estimates to explore a hypothetical scenario using TIF to finance new CTA rail infrastructure that would expand service into a currently un-served area of South Chicago. In this case, we propose extending the CTA network via rail rights-of-way currently owned by CSX through South Chicago, terminating in the former South Works industrial location. Once the site of numerous large steel mills, South Works is today essentially vacant but enjoys a prime real estate location along Lake Michigan, for which a developer has proposed a major mixed-use redevelopment project. Although light rail expansion is not currently part of the City’s or the developer’s plans for South Works, we explore the hypothetical opportunity to make use of presumably underutilized CSX infrastructure in the area to increase the potential value of the proposed development project, while capturing the value created via the property tax system to finance the light rail stations. This scenario assumes that light rail stations create the same property value effects as the current CTA heavy rail system.

Scenario 1: Transferring Public Revenues Generated via the Current Property Tax System

Institutionally speaking, this first scenario essentially represents a slight variation of the status quo. Existing local tax agencies continue to charge the same property taxes on properties throughout the CMA. The only difference is that Cook County will transfer a lump-sum annual payment to CTA based on estimated property taxes attributable to the net property value created by CTA, which will come proportionally out of the shares of revenues for “home rule” and special tax agencies. We estimate the “fair share” by determining the percentage of property value solely attributable to CTA station proximity using just the variables corresponding to CTA infrastructure effects: the walk impedance value and the line proximity, as discussed above.

Let $X_{T,2,8} = (X_{T,2}, \dots, X_{T,8})$ and $T_{-(2,8)} = (X_{T,1}, X_{T,9}, X_{T,10}, \dots, X_{T,k_T})$. For a specific property with $X_{T,2,8} = x_{T,2,8}$, $I = I_0$, $N = N_0$, and $T_{-(2,8)} = T_{-(2,8),0}$ (see Equation [4.1] and [4.6]), we can estimate the share of property value added by the local CTA infrastructure, τ, as:

$$\tau = \frac{f(I_0, N_0, T_{-(2,8),0}, x_{T,2,8}) - f(I_0, N_0, T_{-(2,8),0}, x^*_{T,2,8})}{f(I_0, N_0, T_{-(2,8),0}, x_{T,2,8})} \qquad [5.7],$$

where $f(\cdot)$ is defined in Equation [4.1] and $x^*_{T,2,8}$ represents “baseline” values of property characteristics in terms of the local CTA infrastructure effects, such as station walk impedance effects and line effects.

Further manipulation of Equation [5.7] simplifies the calculation as follows:

$$\tau = \frac{\delta_{\hat{\beta}_{T,2,8}}(\Delta x^{*}_{T,2,8})}{1+\delta_{\hat{\beta}_{T,2,8}}(\Delta x^{*}_{T,2,8})} \qquad [5.8]$$

where $\Delta x^{*}_{T,2,8} = (x_{T,2},\ldots,x_{T,8}) - (x^{*}_{T,2},\ldots,x^{*}_{T,8}) = (\Delta x^{*}_{T,2},\ldots,\Delta x^{*}_{T,8})$ and $\delta_{\hat{\beta}_{T,2,8}}(\cdot)$ is as defined in [5.6]. Combining Equations [5.4] and [5.8], we obtain:

$$\tau = \frac{\exp(\sum_{k=2}^{8}\hat{\beta}_{T,k}\cdot\Delta x^{*}_{T,k})-1}{\exp(\sum_{k=2}^{8}\hat{\beta}_{T,k}\cdot\Delta x^{*}_{T,k})} \qquad [5.9].$$

In other words, the proportion of property value attributable to the local CTA transit stations (τ) is determined by each property's walk impedance value to the nearest CTA station and CTA line proximity effects ($x_{T,2,8}$), the predefined baseline impedance value and CTA line proximity values ($x^{*}_{T,2,8}$), and the estimated coefficients associated with these variables ($\hat{\beta}_{T,2} \ldots \hat{\beta}_{T,8}$) derived from our hedonic price models. For properties with impedance values less than the predefined baseline ($x^{*}_{T,2}$) (akin to properties outside the tax boundary), no property tax increment would be attributable to CTA.

One naïve estimate of total property tax revenues accruing to taxing agencies due to the CTA stations would be based simply on the total effective tax rate each property pays and the post-exemption taxable property value (i.e., the EAV). The key assumption underlying this approach is that each tax agency maximizes its levy filed, subject to legal limits and/or political constraints. Another important assumption is that the property value increases near CTA stations are not offset by lower property values elsewhere in the City of Chicago; that is, the property value gains from CTA stations are not zero-sum, possibly because the CTA stations are associated with higher productivity or otherwise increase the attractiveness of the taxing jurisdiction relative to non-CTA areas. Given increased property values vis-à-vis the "no-CTA" case, each taxing agency containing properties affected positively by CTA stations collects additional revenues (equal to share τ) at the same effective tax rate. These agencies, thus, reap the relative benefits from the CTA station-induced property premium – in other words, CTA increases the size of the tax revenue "pie." One could theoretically argue that each agency should transfer the equivalent revenue gained to the CTA. This approach obviates consideration of any first-order effects on property value such as the capitalization effects of changes in property tax levels; however, the reduced public services presumably arising from the reduced revenues accruing to the other taxing agencies would also in theory carry negative property value effects over time.

Using the walk impedance value to the nearest CTA station ($x_{T,2}$) for each property *i*, the predefined baseline impedance values for the vector of CTA attributes ($x^{*}_{T,2} \ldots x^{*}_{T,8}$), and the estimated coefficients ($\hat{\beta}_{T,2} \ldots \hat{\beta}_{T,8}$) derived from our hedonic price models, we calculate the tax transfer rate for each property *i* (τ_i) using Equation [5.9]. For demonstration purposes, we use four different station distance boundaries, beyond which (τ_i) would not be re-directed to the CTA (and setting the baseline ($x^{*}_{T,2}$) value equivalent to the Walk Impedance Factor at each threshold). Table 5-3 shows the result of this calculation for single- and multi-family homes only. At the high end of this estimate, where we assume a boundary at the geographic equivalent of a 40-minute walk from any CTA station; this figure is equivalent to \$600,000 per mile of CTA line, \$430,000 per station, or approximately \$0.33 per rider in 2006. Depending upon where we draw the geographic boundary of CTA's tax jurisdiction, we estimate that \$20 to \$54 million per year in property tax revenues collected by the various taxing agencies could, arguably, be considered revenues primarily generated by CTA. Of course, in practice such an approach has little chance of implementation success: agencies set their levy based on expected revenue needs for the year; there is little likelihood that any agency would willingly transfer revenue shares to the CTA, and CTA would presumably have little political support in claiming access to, say, Board of Education revenues, despite theoretical and empirical justification.

Alternatively, CTA could appeal to only the "home rule" taxing agencies, the City of Chicago and Cook County. In this case, the same approach as above would be followed, but the proposed tax transfer rate, τ, would be applied only to the City of Chicago's property tax revenues (generated from a 1.012 tax rate in 2006) and to Cook County's (generated from a 0.5 tax rate in 2006). The same assumptions hold from the previous cases; these agencies maximize their levy filed, the CTA station area property gains are not offset by equal property value declines elsewhere in the jurisdiction, etc. CTA, thus, has a "right" to a share of the bigger revenue "pie" that CTA station generates for these two tax agencies (see Figure 3-3). In this case, roughly \$5.6 to \$15.1 million per year in property tax revenues collected by the City and Cook County could be considered revenue generated by CTA stations. As a point of comparison, the City of Chicago and Cook County, under the RTA Law, are obliged to provide \$3 million and \$2 million, respectively, towards CTA operations, annually.

The general approach outlined in Scenario 1 is consistent with principles of *fiscal equivalence* and a case can be made that the tax transfer is relatively *efficient*. The tax transfer rate varies based on distance from CTA stations, transferring a "fair share" of the incremental value created – a reasonable proxy of the economic benefits received by property owners. The tax demonstrates an aspect of horizontal *equity* in the sense that beneficiaries are not cross-subsidized by non-beneficiaries. However, reduced revenues for public services may adversely impact less-wealthy residents who depend on those services. This is, however, more of a normative argument about vertical *equity* in government tax levels and expenditures than necessarily a statement about the fairness of the proposed CTA tax transfer. In terms of *administrative ease*, this scenario would require some work re-calibrating hedonic price models and inputs from time-to-time, but most of the technical work could be done at the agency level. Since the end result is a simple transfer between agencies, there would be less pressure to explain this complicated method to the taxpaying public, though this would require a staff capable of running these scenarios (we assume that that the human capital exists or could be hired). A more critical obstacle might simply be gaining public approval for the transfer, and explaining to taxpayers the trade-off between funding CTA capital expenses (which presumably lead to better service) and funding other local services.

Table 5-3. Property Tax in 2006: Potential Transportation Financing Instrument in Chicago

Tax Revenue	**Taxation Boundary Based on Walking Distance from CTA Stations (in Minutes)**				**Total Value Added (in Billions $)**
	40	**30**	**20**	**15**	
Single Family (S. F.) (million $)	34.9	30.0	19.5	12.3	2.2
95% Confidence Interval (1)	(19.9, 49.2)	(17.1, 42.4)	(11.1, 27.7)	(6.9, 17.5)	(1.0, 3.4)
Share of value-added	1.59%	1.37%	0.89%	0.56%	
Multi Family (M. F.) (million $)	19.0	16.8	11.4	7.4	1.8
95% Confidence Interval (1)	(7.2, 30.4)	(6.3, 26.9)	(4.3, 18.4)	(2.8, 11.9)	(1.0, 2.7)
Share of value-added	1.05%	0.93%	0.63%	0.41%	
S. F. + M. F. (million $)	53.9	46.8	31.0	19.7	4.0
95% Confidence Interval (1)	(27.1, 79.6)	(23.4, 69.3)	(15.4, 46.1)	(9.7, 29.4)	(2.0, 6.0)
Share of value-added	1.35%	1.17%	0.77%	0.49%	
Normalized Tax (million $ per mile of CTA rail) (2)	0.604	0.524	0.347	0.221	0.045
95% Confidence Interval (1)	(0.304, 0.893)	(0.263, 0.777)	(0.172, 0.517)	(0.109, 0.330)	(0.023, 0.068)
Normalized Tax (million $ per CTA station) (3)	0.431	0.374	0.248	0.157	0.032
5% Confidence Interval (1)	(0.217, 0.637)	(0.187, 0.554)	(0.123, 0.369)	(0.078, 0.235)	(0.016, 0.048)
Normalized Tax (dollars per CTA rail rider) (4)	0.33	0.29	0.19	0.12	n.a.
95% Confidence Interval (1)	(0.17, 0.49)	(0.14, 0.43)	(0.09, 0.28)	(0.06, 0.18)	n.a. n.a.

Notes: n. a. ="not applicable". (1) The 95% confidence interval estimations are calculated according to the 95% confidence interval of the coefficient for the variable "Walk impedance measure to the nearest CTA station" in the Spatial Error Model 4 for Single Family and Multi-Family properties, respectively (see Table 4-1; and we use the point estimates of coefficients for all other variables in the model. (2) We use the total length (i.e., 89.15 mile) of the CTA right-of-way within the City of Chicago boundary for the normalization calculation. (3) We only count the total number of the CTA rail stations (i.e., 125) within the City of Chicago boundary. (4) We use the CTA rail system annual ridership in 2006 (i.e. 161,966,231 total entries) for the normalization calculation (source: RTAMS, 2011).

Scenario 2: CTA as a Taxing Agency – Authority to Collect Property Value Added

A second alternative might allow CTA to accumulate its "fair share" of property value added by making the CTA a local taxing agency within a defined jurisdiction. Under this scenario the CTA would submit a levy on property values within this jurisdiction like other tax agencies in Cook County (see Figure 3-3). We further assume that the rate associated with the CTA levy will vary proportionate to the share of value added by station proximity; that is, the tax will be a function of the walking impedance index to the CTA station and relative location to at-grade and elevated lines. CTA, under current law, would be subject to Cook County's 7% maximum year-over-year increase in non-home-rule agency residential property taxes, but for simplicity's sake we will assume that the State of Illinois exempts the Agency so as to avoid crowding out effects on other agency's taxes. The benefit to CTA of this alternative is the authority to levy a tax rather than relying on appropriations, funding agreements, etc., with local governments. The downside is that CTA would have the responsibility for actually determining the levy (and for all the associated administrative overhead).

Several assumptions will simplify calculating this scenario's estimated impacts, thus allowing us to investigate the larger institutional picture. Like for Scenario 1, we assume that value created by CTA stations is not offset by lower property values elsewhere in the City. We, again, ignore any first-order effects of the capitalization of property taxes into property values. Thus, we again ignore the potential negative impact on property values due to higher overall tax and/or reduced public services on account of other local taxing agency responses to CTA taxes. Finally, we assume that CTA sets its desired tax levy so as to recover over a period of time its "fair share" of actual "market" value added within the defined tax jurisdiction, as measured in our simulations.

The CTA must also adopt a system to implement its new tax authority that is simple, transparent, and fair. Consistent with these parameters, we model a scenario whereby CTA levies a tax on an "average share" of property value that varies according to three different station distance thresholds: zero to one-quarter mile, one-quarter to one-half mile, and one-half to one mile. This allows for some *administrative ease* in assigning a single rate on property values at discrete geographic intervals that are sufficiently large to ensure clarity yet sufficiently small for meaningful differentiation based on relative accessibility (i.e., the impedance function). This approach carries the obvious problem that two neighbors along the boundaries of a given "tier" may pay vastly different CTA tax rates. We will also have to average the CTA line effects within each tier, whereas in reality the effects may vary widely throughout each zone.

Since we assume value added can be recovered over the approximate life cycle of transportation infrastructure investments, we estimate what the effective CTA tax rates (on assessed values) would be under two different accounting assumptions – a 30-year life cycle and a 40-year life cycle. We calculate these figures in nominal terms, assuming that future tax levels will be adjusted to reflect inflation in property values and we ignore any non-inflationary factors that might affect this discount rate. Analyzing the mean coefficient estimates of impedance from the Robust OLS model with regional accessibility measures and assuming a 30-year amortization period, we estimate CTA tax rates (on property) at 1.7% of assessed value for single-family homes within one-quarter mile (1.4% for multi-family); 1.1% (1.0%) between one-quarter and one-half mile; and 0.7% (0.7%) between one-half and one mile. Assuming a 40-year amortization period, CTA tax rates for single-family homes would be 1.3% (1.0% for multi-family) within one-quarter mile; 0.8% (0.8%) between one-quarter and one-half mile; and 0.5% (0.5%) between one-half and one mile (see Table 5-4 and Table 5-5).

Table 5-4. Scenario 2 Tax Rate for the CTA to Capture the Total Value Added (to Chicago Residential Properties) through 30 Taxable Years

			Distance to the Nearest CTA Station		
			w/in 1/4 mile	**1/4 to 1/2 mile**	**1/2 to 1 mile**
Equalized Assessed Value (in 2006)	**Single Family Home**	Count (# of units)	13,172	33,265	59,382
		Share of total SFU	4.72%	11.93%	21.29%
		EAV in 2006 ($)	1,215,589,444	2,486,590,874	3,129,885,997
		Share of total SFU EAV	8.65%	17.70%	22.28%
	Multi Family Home	Count (# of units)	13,078	25,752	32,804
		share of total MFU	13.11%	25.82%	32.89%
		EAV in 2006 ($)	1,404,290,508	2,496,631,258	2,589,440,720
		Share of total MFU EAV	16.72%	29.73%	30.84%
Total Value Added (in 2004)	**Single Family Home**	Lower Bound ($)	291,246,187	361,842,915	270,260,625
		Mean ($)	566,888,768	760,775,405	615,786,415
		Upper Bound ($)	854,927,290	1,014,787,385	968,724,859
	Multi Family Home	Lower Bound ($)	275,945,981	373,514,153	277,769,928
		Mean ($)	519,775,006	689,530,871	503,659,563
		Upper Bound ($)	773,351,838	1,014,787,385	733,988,451
Tax Rate (taxable year=30)	**Single Family Home**	Lower Bound	0.881%	0.535%	0.317%
		Mean	1.714%	1.124%	0.723%
		Upper Bound	2.585%	1.500%	1.137%
	Multi Family Home	Lower Bound	0.722%	0.550%	0.394%
		Mean	1.360%	1.015%	0.715%
		Upper Bound	2.024%	1.494%	1.042%

Notes: (1) We assume 2006 will be Year 1 of the total taxable years (=30). (2) We assume that within the total taxable years, CTA will be able to collect all the total value added (to the single-family and multi-family homes within one-mile distance to the nearest CTA stations) in the City of Chicago due to the existence of the CTA stations. (3) We assume that within each taxable year, CTA will collect the equalized present value (in 2006). (4) We assume the appreciation rate is 5% from year 2004 to 2006, and the same interest rate applies to the total value added as well as to the Equalized Assessed Value (EAV). (4) The estimated rate for the w/in ¼ mile tax zone is a lower bound because the total EAV includes those properties with zero net value gains (i.e., those properties within 1/8th mile to both a station and an at-grade line; the negative value of the latter cancel out the positive value of the former).

The practical limitations to this approach are immediately apparent. The magnitude of the CTA tax rate estimates reflects a substantial share of all Cook County property taxes assessed within the CTA district in the City of Chicago. For example, the 1.7% CTA tax rate on single-family units within a quarter mile of CTA stations constitutes a tax increase of nearly one-third of the maximum tax rates for all properties within this jurisdiction (~5.5%) and actually exceeds the tax rates assessed on behalf of the City of Chicago and Cook County governments combined.

Table 5-5. Scenario 2: Tax Rate for the CTA to Capture the Total Value Added (to Chicago Residential Properties) through 40 Taxable Years

			Distance to the Nearest CTA Station		
			w/in 1/4 mile	**1/4 to 1/2 mile**	**1/2 to 1 mile**
Equalized Assessed Value (in 2006)	**Single Family Home**	Count (# of units)	13,172	33,265	59,382
		share of total SFU	4.72%	11.93%	21.29%
		EAV in 2006 ($)	1,215,589,444	2,486,590,874	3,129,885,997
		Share of total SFU EAV	8.65%	17.70%	22.28%
	Multi Family Home	Count (# of units)	13,078	25,752	32,804
		share of total MFU	13.11%	25.82%	32.89%
		EAV in 2006 ($)	1,404,290,508	2,496,631,258	2,589,440,720
		Share of total MFU EAV	16.72%	29.73%	30.84%
Total Value Added (in 2004)	**Single Family Home**	Lower Bound ($)	291,246,187	361,842,915	270,260,625
		Mean ($)	566,888,768	760,775,405	615,786,415
		Upper Bound ($)	854,927,290	1,014,787,385	968,724,859
	Multi Family Home	Lower Bound ($)	275,945,981	373,514,153	277,769,928
		Mean ($)	519,775,006	689,530,871	503,659,563
		Upper Bound ($)	773,351,838	1,014,787,385	733,988,451
Tax Rate (taxable year=40)	**Single Family Home**	Lower Bound	0.660%	0.401%	0.238%
		Mean	1.285%	0.843%	0.542%
		Upper Bound	1.938%	1.125%	0.853%
	Multi Family Home	Lower Bound	0.542%	0.412%	0.296%
		Mean	1.020%	0.761%	0.536%
		Upper Bound	1.518%	1.120%	0.781%

Note: (1) We assume 2006 will be Year 1 of the total taxable years (=40). (2) We assume that within the total taxable years, CTA will be able to collect all the total value added (to the single-family and multi-family homes within one-mile distance to the nearest CTA stations) in the City of Chicago due to the existence of the CTA stations. (3) We assume that within each taxable year, CTA will collect the equalized present value (in 2006). (4) We assume the appreciation rate is 5% from year 2004 to 2006, and the same interest rate applies to the total value added as well as to the Equalized Assessed Value (EAV). (4) The estimated rate for the w/in ¼ mile tax zone is a lower bound because the total EAV includes those properties with zero net value gains (i.e., those properties within 1/8th mile to both a station and an at-grade line; the negative value of the latter cancel out the positive value of the former).

The main reason why CTA's desired tax levy would constitute such a substantial percentage of property taxes within the defined tax jurisdiction relative to Scenario 1 is that "fair shares" of property taxes in Scenario 1 are limited to the total amount of current property tax, while in Scenario 2 shares are targeted to reclaim the estimated total value added contributed by the CTA infrastructure (e.g., stations and lines) simulated from our hedonic price models. The nominal aggregate tax that CTA would expect to collect under a 30-year amortization assumption (applying the mean coefficient estimate for the impedance factor) is about $135 million per year ($100 million under a 40-year amortization), approximately $80 million ($50 million under a 40-year amortization) greater than under Scenario 1 (assuming a 40-minute walk boundary).

While Scenario 2 is relatively "fair" in terms of matching the tax proportional to benefits received, the implementation would be politically difficult. Through the lens of vertical *equity*, less wealthy single-family property owners living near CTA stations would be required to pay a new tax, but may not see the monetary benefits until the day they sell their homes.

The *administrative ease* of the zone-based approaches to establishing tax rates ignores often substantial internal variations in spatial impacts. For the second and third tiers, the relative impedance is greater on the edge closer to the station than the edge closer to the next farthest tier. Under this scenario, however, all property owners will pay a uniform tax rate within a tier. Property owners towards the outer edges of the second and third tiers are essentially over-paying while those closer to the inner edges of these zones are under-paying. To solve this problem, it is possible to have a greater number of rings covering smaller territories, or even assign property-specific tax rates based on linear distance from CTA stations – in such cases, the tax rates presented in Table 5-4 and Table 5-5 can be viewed as zone average tax rates. But the greater the differentiation, the more difficult the implementation reflecting the trade-off between *administrative ease* and *efficiency*.

Scenario 3: CTA as a Taxing Agency – Levies Reflect Agency Revenue Objectives

We now examine the case in which the CTA becomes a local taxing agency, but like other tax agencies in Cook County, requests levies on direct property beneficiaries (those within the area of detectable station-area benefits) based on its own revenue objectives. For the purposes of relatively straight-forward implementation as well as comparison with Scenario 2, we draw the tax district boundary at approximately one mile (or a 20-minute walking distance) from each CTA station, we continue to differentiate within the three spatial tiers defined in Scenario 2. We consider the CTA's need-based levy according to the approximate average annualized value of a station, which we estimate on the order of \$1.5 to \$5.6 million,[35] or \$188 to \$706 million per year, for the 125 stations in the City. For the purposes of this analysis, we use \$360 million per year, roughly in line with CTA's capital budget for fiscal years 2006-2010.[36] This figure is slightly higher than total investment levels in recent years.

The calculations are somewhat artificial, but still illustrative. We propose several simple but somewhat arbitrary revenue objective scenarios including 100% cost recovery, 50% cost recovery, and 25% cost recovery. We would not expect this solution to meet goals for *efficiency* and *equity*. Commercial, industrial, vacant, and other property types have not been included in this analysis, each of which should be contributing fair shares. Other benefits, such as corporate profits attributable to agglomerative benefits supported by mass transit, cannot be directly captured from property taxes. In fact, since most capital funding is currently subsidized by the

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[35] In practice, it is difficult to estimate a "station only" construction cost, since available CTA capital budgets tend to not distinguish stations from track, rolling stock and other related capital outlays. We sought a range of comparable costs. Construction costs for an above-grade suburban station planned on the Yellow Line for Downtown Skokie (just North of the City of Chicago boundary) were estimated at \$18 million in 2002, or about \$22 million in 2006 dollars assuming about 5% cost inflation (PB, 2003). CTA (2006a,b) estimates costs of \$85 million to reconstruct the underground, intermodal Howard Station (on the Red Line). Our estimated annualized value range is based on a 6% discount rate and 40 year useful life (CTA, 2006a).

[36] The 2006-2010 Capital Improvement Program estimated \$1.8 billion (\$360 million per year) in total investment over five years; \$1.4 billion from FTA, \$212 million from State, and \$164 million from RTA (CTA, 2006b). The 2011-2015 Capital Improvement Program, CTA estimates \$2.6 billion (\$520 million per year), \$1.575 billion from the FTA, \$1 billion from the State, and \$241,000 from regional/local governments, though this is still insufficient to bring the system to a state of good repair (CTA, 2011b).

Federal Government and the State of Illinois, CTA's revenue objectives for a property tax levy might actually be less than the theoretical fair share if CTA assumes that these revenue sources will continue to be available in the future. Nonetheless, with Federal and State funds drying up, consistent with *fiscal equivalency,* it is worth exploring the basic institutional framework of another revenue-maximizing local tax agency within Cook County.

Not surprisingly, implementing the higher revenue objective scenarios would constitute substantial tax increases on properties, especially those close to stations. For the 100% and 50% cost recovery scenarios, Table 5-6 shows that the required nominal annual capital recovery cost far exceeds the "fair share" of property tax revenue estimated in Scenario 2. For example, under the 100% cost recovery scenario, single-family properties within one-quarter mile distance of a station would see their taxes more than double. The 25% cost recovery is more in line with the Scenario 2 "fair share" estimates, with tax levels and associated revenues falling between the 30-year and 40-year amortization estimates.

Furthermore, CTA would have to consider additional constraints in setting its desired levy if we relax the previous assumptions so that property taxes are capitalized into property value and allow that tax agencies will consider the actions of competing local tax agencies in setting levies. This would be true for each scenario, but in this case CTA would have less concrete methodological grounds for claiming its "fair share."

It appears that, if given leeway to establish a property tax levy based on "need," CTA could not expect to recover much more than about 25% of imputed annual capital costs from residential properties without pushing the boundaries of what this analysis would suggest to be "fair." Benefits accrue to many other parties – users, commercial properties, businesses, etc. – and different taxing methods are needed to extract the "fair share" of costs from these beneficiaries. In this context, land value capture should be seen as a revenue supplement.

Table 5-6. Impact of CTA Cost Recovery Scenarios on Total Revenues and Tax Rates

			Distance to the Nearest CTA Station		
			w/in 1/4 mile	**1/4 to 1/2 mile**	**1/2 to 1 mile**
Annual Revenues (Mean Coefficient Estimate)	**Single Family Home**	**Scenario 2: 30 Years ($)**	20,833,162	27,958,496	22,630,151
		Scenario 2: 40 Years ($)	15,624,872	20,968,872	16,972,613
		100% Cost Recovery ($)	69,767,757	93,629,644	75,785,656
		50% Cost Recovery ($)	34,883,879	46,814,822	37,892,828
		25% Cost Recovery ($)	17,441,939	23,407,411	18,946,414
	Multi Family Home	**Scenario 2: 30 Years ($)**	19,101,731	25,340,260	18,509,489
		Scenario 2: 40 Years ($)	14,326,299	19,005,195	13,882,117
		100% Cost Recovery ($)	63,969,404	84,861,484	61,986,055
		50% Cost Recovery ($)	31,984,702	42,430,742	30,993,027
		25% Cost Recovery ($)	15,992,351	21,215,371	15,496,514
Tax Rate (Mean Coefficient Estimate)	**Single Family Home**	**Scenario 2: 30 Years**	1.714%	1.124%	0.723%
		Scenario 2: 40 Years	1.285%	0.843%	0.542%
		100% Cost Recovery	5.739%	3.765%	2.421%
		50% Cost Recovery	2.870%	1.883%	1.211%
		25% Cost Recovery	1.435%	0.941%	0.605%
	Multi Family Home	**Scenario 2: 30 Years**	1.360%	1.015%	0.715%
		Scenario 2: 40 Years	1.020%	0.761%	0.536%
		100% Cost Recovery	4.555%	3.399%	2.394%
		50% Cost Recovery	2.278%	1.700%	1.197%
		25% Cost Recovery	1.139%	0.850%	0.598%

Note: (1) We assume 2006 dollars for consistency with Scenario 2 tables. (2) We assume that CTA will be able to collect, in nominal terms, $450,000,000 per year in the City of Chicago due to the existence of the CTA stations and CTA lines. (3) We analyze only the mean coefficient estimates, as cost recovery levels would be the same, regardless, under cost recovery scenarios. Tax rates; however, would vary slightly, but generally not by more than about 0.1%.

In terms of fiscal federalism, each of our three institutional scenarios has pluses and minuses. In essence, what we propose is a tax on the net value of the positive proximity effects to urban rail transit services and the negative line-proximity effects capitalized into land value. Scenario 1 offers *administrative ease*, in that most of the estimation and transactions occur at the agency level, but with less transparency, which could lead to political constraints as residents throughout Cook County question the fairness of diverting broad-based property taxes for localized benefits. Scenario 2 provides a more transparent mechanism for assigning costs, but this benefit is not necessarily synonymous with political acceptability Furthermore, CTA would need to employ a clear, transparent, and "fair" system for determining property-specific levies, which will either be administratively complicated (e.g., property-specific variable tax rates) or less *efficient*, such as the "tier" based average tax rate system employed in our models. Scenario 3 offers the benefit of clarity in terms of defining the agency's taxing objectives consistent with actual capital expenditure needs (i.e., cost recovery), but is generally less *efficient*, produces less *equity*, and is probably a political non-starter.

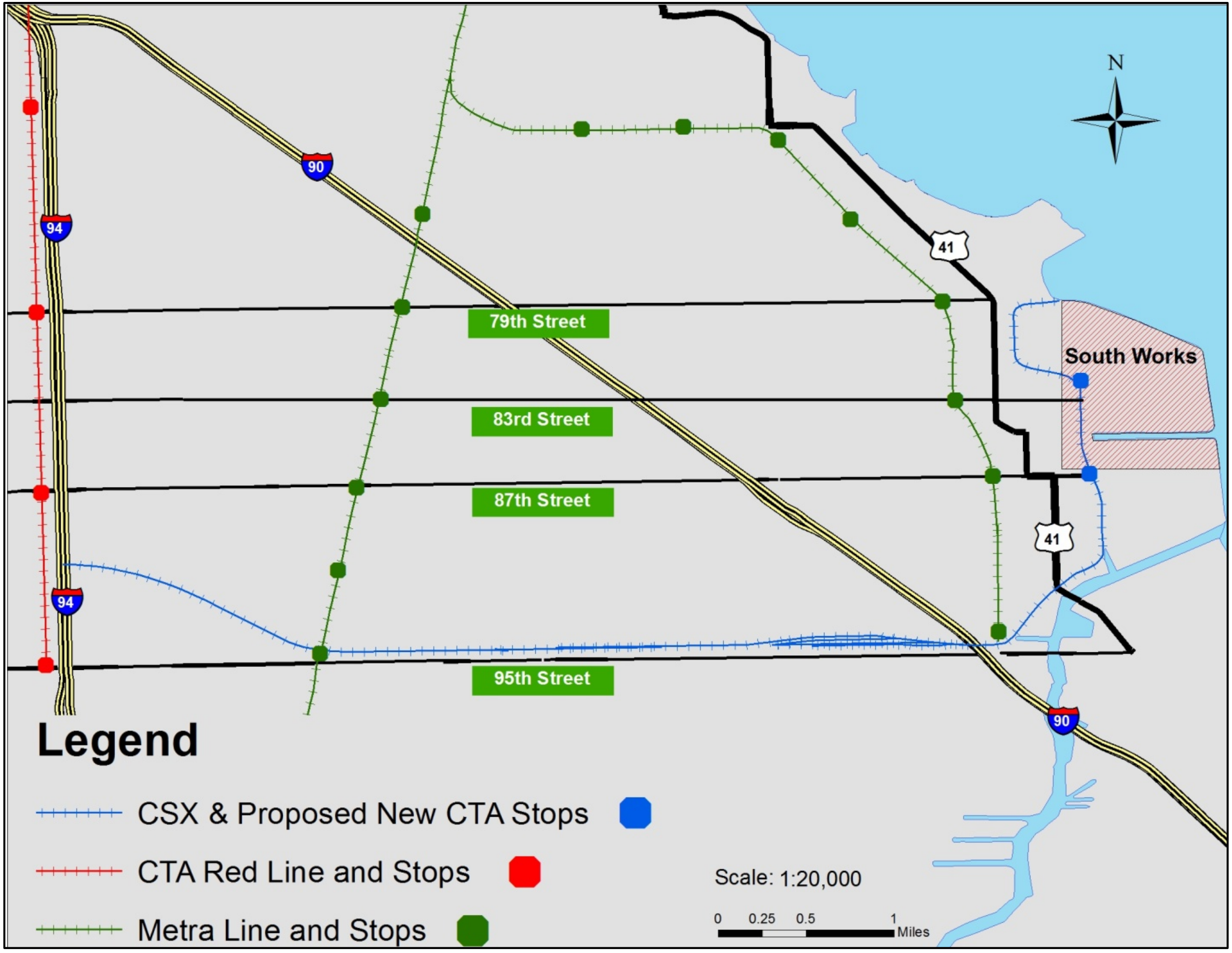
Value Capture Hypothetical: A New CTA Rail Branch in South Chicago

Given the theoretical and *ex post* empirical support for the positive link between transit capital improvements and land value, we now explore the possibility to leverage property taxes to finance urban rail infrastructure expansion in Chicago. Ideally, we could identify a large vacant or underutilized space within the City of Chicago, currently not directly served by the CTA urban rail network but feasibly linked to it in the future. Given such a location, we could apply the estimates obtained from our hedonic price models to simulate the positive impacts on land value that might accrue and the extent to which net revenues from property taxes (under various institutional scenarios tested above) could generate cash flows to support capital finance.

Figure 5-5. Relative Location of South Works Re-development Area in the CMA

The South Works site in South Chicago meets most of the criteria for such a hypothetical analysis. The 592-acre former site of South Works Steel, which is located along Lake Michigan in the southeastern corner of the City of Chicago (see Figure 5-5), once employed as many as 20,000 people. However, the facility closed permanently in 1992, contributing to decades of economic decline in South Chicago (SCDC, 2000). Today U.S. Steel (the owner of South Works) and its development partner McCaffrey Interests, Inc., have proposed a major redevelopment project within a 369 acre area that would include at least 16.9 million square feet of commercial property, up to 13,575 residential units, and about 100 acres of parks and open space. The plan calls for realigning Highway 41 (located about a half mile from the western boundary of the site) through the redevelopment site to provide greater automobile access and phasing the mixed-use components over 25 to 45 years (CLD, 2010).

Figure 5-6. Major South Chicago Transportation Infrastructure and Hypothetical CTA Expansion



Note: (1) The map depicts major east-west arterials (i.e., 79th, 83rd, 87th, and 95th Streets); Interstate highways, and existing transit (i.e., CTA Red Line urban rail and Metra commuter rail services). (2) The map depicts Highway 41 as is. The expected realignment would roughly parallel the proposed new CTA line. (3) The portion of the CSX infrastructure depicted in this map is a subset of larger area, regional, and national networks.

We estimate the possible net property tax revenues that could be gained if CTA negotiated some sort of agreement with CSX to operate a light-rail service connecting the South Works site to the larger urban rail transit network. We are not aware of any current plans to extend rail transit service to South Works; however, CSX owns a number of presumably underutilized short line and regional tracks and right-of-way to and through the South Works site. Based on CSX's system map (CSX, 2011), and capacity permitting, CTA could align the new light rail service through South Chicago to the CTA Red Line, which runs along Interstate I-94 about 6 miles to the west of the South Works site (see Figure 5-6), possibly linking-up at or near the existing 87th Street or 95th Street stations. Alternatively, CTA might connect light rail service from South Works to the Metra network, which would require less track access on the wider freight network. We assume in the model that CTA builds two stations within the South Works redevelopment site at the realigned Highway 41 (currently Avenue O) and 87th Street to the south and 82nd Street to the north. This would roughly place the entirety of the South Works redevelopment plan within a half-mile walk of a CTA station. We also assume the parameters estimated in our hedonic price models are valid for simulating land value creation at the proposed South Works redevelopment site.

Forecasting land price and tax revenues associated with transportation investments faces high levels of uncertainty in land use evolution and market trends as well as in the interactions between the land use and transportation systems. NCHRP (1999) reviews different methods typically employed by state and regional planning departments to assess land use-transportation interactions; naturally, the potential value of representing the relevant dynamics in great deal comes at a substantial cost (time, data, etc.). Much of the literature related specifically to TIF financing of transportation investment tends to rely on a combination of qualitative judgment and relatively static statistical methods. For example, Vadali et al. (2006) use a mix of local land use development comparables and Monte Carlo analysis of several stochastic variables (timing, pace, land use changes upon development, and property tax exemptions) to simulate potential incremental property cash flows for a highway expansion TIF project in El Paso, TX. Gihring (2001) explored the possibility of financing a station along the new urban rail line in Seattle, WA, by converting most of the property tax system to a LVT system and creating a SAD to capture increases in land value gains within a half-mile radius. Girhing mostly used static averages to forecast land value growth under different scenarios to analyze the financing implications.

In this case, we qualitatively judge likely land development patterns and use a combination of static hedonic price model estimates and probabilistic simulation of key variables to estimate CTA stations' impacts on land values and property taxes. Although a general case can be made that transit development would influence the form and density of surrounding land uses, we assume that the South Works redevelopment will proceed mostly as currently planned irrespective of rail service expansion into the area. We make this assumption based on a couple of factors. First, the scope, timing, and prospective real estate values are, at this time, highly speculative under any scenario; adding land use-transit interaction uncertainties would only complicate matters. Thus, in our Monte Carlo analysis we hold projections of land use variables constant across scenarios, and focus only on the land value impacts of transit.

Second, the current South Works redevelopment plan already resembles a land use pattern which might be expected to result from the presence of urban rail on our proposed alignment (see Figure 5-7). Based on the high-level details made public by the development team and our own judgment, we expect relatively high density residential development along the realigned U.S. 41 corridor (along which we propose to align the CTA line and stations); clustered commercial development along the proposed "Market Common" and "The Slip" (in close proximity to our two proposed stations); and a generally faster pace of development in the western segment of the redevelopment site due in part to proximity to existing Metra stations (as close as one-quarter mile from the site's western boundary, e.g., Market Common, U.S. 41, and the Ore Wall). The results would be high-density, mixed-use land use patterns in these districts, which should also deliver faster than parcels to the interior and eastern edges of the site – consistent with our qualitative expectations of land development patterns resulting from the hypothetical new transit station alignment.

Figure 5-7. Map of Proposed South Works Development Districts

Source: CLD, 2010

We make a number of additional simplifying assumptions to narrow our focus to direct land value impacts and value capture as a local transit financing strategy. Since we cannot distinguish between taxes on land and improvements, we again use the property tax as a proxy for LVT. We also isolate the impacts of CTA rail accessibility on the 369 acres at the South Works site, ignoring possible property value effects on existing, settled communities in South Chicago and on remaining South Works acreage not currently included in redevelopment proposals. In terms of administration, we assume the CTA either requests from Cook County a “fair share” of property taxes generated from existing rates and procedures (i.e., similar to Scenario 1) or that CTA becomes a tax jurisdiction assessing taxes as a fair share of value created (i.e., similar to Scenario 2, above) over a specified period of time, which for our purposes will be 40 years (i.e., the accounting life of CTA stations; see CTA, 2011b), from 2016 to 2055. Furthermore, and consistent with the previous scenario analyses, we assume existing taxing agencies are revenue-maximizing, subject to constraint; ignore first-order effects of the value capture tax on property (e.g., capitalization into land value); and assume negligible impacts on property values elsewhere in the CMA.

We simulate average property values for typical single-family and multi-family dwellings under scenarios with and without CTA rail accessibility. To do this, we use the parameters of the hedonic price models to forecast property values, tax transfer rates, and other variables critical to determining the “fair share” of property value and, hence, property tax created by the CTA line for our homogenous dwelling units. For improvements, neighborhood, and transportation variables, we apply location-specific values whenever possible. For many neighborhood factors, however, it makes sense to use values from a comparable developed area of the City. In these cases, we apply averages from Hyde Park, a relatively affluent, waterfront district just north of South Works. For multi-family properties, we simulate value as if all multi-family properties were two-family, two-story dwellings (which account for about 80% of properties we analyzed in the CMA), and divide this value by two for a crude unit-based multi-family dwelling estimate. We also assume that about two-thirds of residential units will be multi-family, roughly consistent with city-wide averages of properties within a half mile of CTA stations. The scale of proposed development at South Works may require a much greater share of multi-family units. Appendix 8.5 presents detailed land use and development assumptions.

After establishing base values for single- and multi-family dwelling units, we speculate on the relative location of those units based on public details of South Works redevelopment plans, our judgment informed by the spatial characteristics of the proposed site, and the Chicago real estate market. We also hypothesize an approximate balance of residential (and commercial) real estate in each of five developer-proposed districts (see Figure 5-7). This produces, for each district: generic unit-based property values,[37] a speculative quantity of property development, the percentage of property located at different distances from the hypothetical CTA stations, and implementation timelines (see Table 5-7).

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[37] Unit-based generic values are derived using our best OLS hedonic price estimates and a mix of location specific variable inputs. Again, we do this in order to simulate values based on our hedonic price parameters while avoiding the need to create a spatial weights matrix.

Table 5-7. South Works Development Assumptions

		Generic Unit Values (OLS, 2016 $)		Share of Properties by Class Type and CTA Station Proximity			Pace of Completion	
		No CTA	**With CTA Line & Station Effects**	**< ¼ Mile**	**¼ - ½ Mile**	**Share of total Development**	**Lower Bound**	**Upper Bound**
Single-Family	Market Common	310,650	312,658	81.8%	18.2%	7.8%	2016	2018
	US 41	307,299	298,407	79.5%	20.5%	23.4%	2016	2021
	Ore Wall	302,613	304,333	49.1%	50.9%	9.7%	2016	2030
	The Slip	300,834	296,537	12.7%	87.3%	14.0%	2025	2040
	Central Park	300,350	295,382	52.4%	47.6%	18.2%	2030	2050
	Lakefront	300,350	303,616	44.7%	55.3%	26.9%	2040	2060
Multi-Family	Market Common	206,312	217,708	81.8%	18.2%	7.8%	2016	2018
	US 41	207,622	210,731	79.5%	20.5%	23.4%	2016	2021
	Ore Wall	209,391	220,298	49.1%	50.9%	9.7%	2016	2030
	The Slip	209,980	216,530	12.7%	87.3%	14.0%	2025	2040
	Central Park	210,141	216,630	52.4%	47.6%	18.2%	2030	2050
	Lakefront	210,141	221,853	44.7%	55.3%	26.9%	2040	2060
Commercial	Market Common	7,586,313	10,039,874	81.8%	18.2%	43.8%	2016	2018
	US 41	9,133,636	12,065,317	79.5%	20.5%	2.4%	2016	2021
	Ore Wall	10,036,764	12,934,101	49.1%	50.9%	2.4%	2016	2028
	The Slip	10,354,876	12,954,608	12.7%	87.3%	29.0%	2023	2038
	Central Park	10,443,333	13,494,588	52.4%	47.6%	11.2%	2028	2048
	Lakefront	10,443,333	13,410,483	44.7%	55.3%	11.2%	2038	2058

Note: (1) We assume 2016 dollars are roughly equivalent to 2006 values based on FHFA-reported decreases in value for 2004-2011 and our forecasted mean annual property value appreciation rate (2.8%), which is based on broader 20-year FHFA-reported market trends in the CMA. (2) Estimates of residential units delivered range from 5,000 to 13,575, but shares of total development are constant across zones. (3) District definitions, "Share of Properties by Class Type," and "Pace of Completion" are based on a combination of publicly-available information and our own judgment of likely trends. See Appendix 8.5 for more details.

To account for the uncertainty of future market conditions, we apply a random variable to model three particularly critical variables: year-over-year appreciation of real estate market value, the quantity of development, and the pace/timing of development. For annual market value appreciation, we calculate a twenty year average from Office of Federal Housing and Enterprise Oversight (FHFA) data as a base inflation factor (2.8%), but allow this figure to vary between one standard deviation above and below in any given year (6.1% in either direction due to recent high volatility). The quantity of residential development varies at random between the City's original plans for about 5,000 units to the developer's current plans for about 13,575. Each of the developer's five proposed districts is assigned a range of potential delivery dates. The ranges are based on qualitative judgment (i.e., those closer to existing and projected transportation infrastructure are developed first), and values vary randomly within each range. Finally, the sets of random numbers generated for each iteration are applied consistently across each of the three variables. We do this to approximately simulate a real development market, such that a higher random variable for any given iteration and year will lead to higher property value appreciation, greater quantity of development, and a faster pace of delivery. Appendix 8.5 provides details.

Table 5-8. Monte Carlo Simulations: Revenues Available to CTA for Hypothetical Rail Expansion

			Calculations (2016 $)	
			Total Present Value Over 40-Year Period	**Average Annualized Cash Flow (Nominal)**
Tax Transfer (Spatial Error)	With CTA Line Effect	Mean	11,498,975	287,474
		Standard Deviation	2,266,174	N/A
		10th Percentile	8,740,369	218,509
		90th Percentile	14,421,358	360,534
	No CTA Line Effect	Mean	43,949,322	1,098,733
		Standard Deviation	8,660,636	N/A
		10th Percentile	32,920,884	823,022
		90th Percentile	55,281,096	1,382,027
CTA as Tax Authority (OLS)	With CTA Line Effect	Mean	32,765,757	819,144
		Standard Deviation	4,839,237	N/A
		10th Percentile	26,828,787	670,720
		90th Percentile	38,972,825	974,321
	No CTA Line Effect	Mean	170,628,834	4,265,721
		Standard Deviation	23,149,554	N/A
		10th Percentile	139,171,285	3,479,282
		90th Percentile	200,108,415	5,002,710
CTA as Tax Authority With Commercial (OLS)	With CTA Line Effect	Mean	333,625,640	8,340,641
		Standard Deviation	48,401,741	N/A
		10th Percentile	273,205,946	6,830,149
		90th Percentile	398,998,294	9,974,957
	No CTA Line Effect	Mean	362,760,153	9,069,004
		Standard Deviation	53,821,035	N/A
		10th Percentile	295,599,678	7,389,992
		90th Percentile	431,570,154	10,789,254

We calculate the present value of potential revenues for CTA over a 40-year period using three different methods: (1) a fair share of simulated residential tax revenues based on average tax transfer rates at three different tiers (following the model of Scenario 1 and using our spatial error model coefficients for impedance); (2) a CTA levy that would allow the full recovery of residential property value created by transit access over the study period (following the model of Scenario 2 and using OLS parameters to simulate property value); and (3) identical to the previous scenario, except including commercial property values using our best OLS model estimates. We include the third estimate because of the large amount of forecast commercial development (permitted for up to 17.5 million square feet) and our understanding that much of that development will take place near our hypothetical CTA station at 82nd Street. Finally, we include both an estimate assuming CTA rail line proximity negative effects and an estimate without line effects. We do this for two reasons. First, since this is a new construction project, it might be possible to mitigate negative externalities by, say, aligning the rail right-of-way through the median of Highway 41. Second, we hope to inform policy debates about the trade-offs of underground versus above-ground line construction (see Table 5-8).

Our third calculation is methodologically problematic, but usefully illustrative, with appropriate caveats. Obviously, using the OLS estimates ignores issues related to spatial error (also the case in developing our generic property value created estimates for the second calculation). We are also aware that our hedonic price estimates for commercial properties are significant at only the 10% level, and that most of the observations used for the hedonic price model are actually located in suburban areas. We also recognize the weakness of converting the commercial square foot number into equivalent generic "units" (in this case about 191 homogenous units based on an approximate 91,000 square-foot average size of commercial properties in our study). Nevertheless, the commercial estimates allow at least an order-of-magnitude estimate of impact, which can be refined in future research.

In the first calculation, our analysis suggests that CTA could plausibly claim from Cook County a transfer of about $11.5 million (present value in 2016)[38] of property taxes generated over the 40-year study. We estimate above-ground station construction costs at about $30 million per station (in 2016 dollars[39]), for a total of $60 million; residential tax transfers could cover about 18.6% of construction costs. A decision to underground this segment of the line could allow CTA to claim up to $43.9 million. Assuming per-station construction costs equivalent to the $85 million Howard Station (probably a high estimate even if we assume no inflation to 2016 $), CTA still captures from residential properties only about a quarter of station construction costs (and incurs the additional costs for tunneling and underground line construction).

In the second calculation, we find that CTA stations will create about $32.8 million in residential market property value, based on the simulated market value of properties in the year of delivery, discounted back to 2016. This scenario would recover 54.6% of station construction costs from residential properties alone. Much like Scenario 2, the revenues generated using this approach are substantially higher due in large part to the fact that the requested levy is based on recovery of market value added due to the existence of the CTA infrastructure (station and line) rather than a fair share of the fixed amount of total property tax. Unlike Scenario 2, however, cash flows could be much more uneven, as properties will slowly come on line over time, and CTA

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[38] For all calculations in this hypothetical analysis, we apply a 6% discount rate. If we use the OFHEO 20-year average year-over-year appreciation in housing costs as a proxy for inflation (2.8%) and the 30-year Treasury Bond as a proxy for non-inflationary discount factors (~3.2%), this seems reasonable.

[39] PB's (2003) conservative cost estimate of $18 million is inflated to 2012 dollars at a rate of 4%.

could not likely request its fair share of value added until that value has actually been created (as is the case for all calculations in this hypothetical scenario). If CTA could eliminate negative line effects, the agency could justifiably raise about $170.6 million (NPV, 2016$) in taxes over forty years. This would probably be about enough to cover underground station construction costs (again, however, additional line costs would be incurred with the underground option).

Our third calculation illustrates the potentially critical role of commercial property in fully recovering capital costs of transit infrastructure improvements via value capture methods. While the calculation may not be robust, the results are profound. We simulate the property taxes generated by residential and commercial properties using our OLS parameters both with and without the CTA stations, while subtracting the latter from the former. Over the 40-year period, we estimate that CTA could possibly claim a share of those revenues generated amounting to about $333.6 million with CTA line effects and about $362.8 without line effects. The reason for the small difference between these two calculations is the fact that our models do not indicate any negative effects on commercial property values due to proximity to urban rail lines.

Several factors contribute to this high estimate for commercial properties. First, the developer plans to build a massive amount of commercial space in this small area. Second, we assume that the majority of this commercial development will be located within a short walking distance from the CTA stations, particularly in the Market Common district. Furthermore, we do not include any potential local property tax exemptions or other types of local financial assistance for large-scale commercial development (we are unaware of any broad-based programs comparable to residential property tax exemptions), so that commercial properties are assessed at about 75% of actual market value (i.e., the 25% commercial assessment rate multiplied by 3 to reflect the State Equalizer). Again, however, these results should be viewed with caution due to our relatively poor hedonic price models for commercial properties. If we were to apply our best spatial error model, the walk impedance value coefficient on commercial properties would reduce by one-half and, in fact, would not be significant (see Table 4-2). Our sample size is small, and commercial properties are diverse in size and purpose. The commercial property effects in the CMA clearly require further research.

Given our low confidence in the commercial property estimates, we focus our analysis on value capture from residential properties. Our calculations suggest that CTA could potentially cover, using taxes from residential property values, about 18.6-54.6% of construction costs of two new light rail stations within the South Works redevelopment area given sufficient time and authority to collect a fair share of property value creation. Undergrounding the line through the study area could lead to higher property values, however, the additional overall costs (including undergrounding the right-of-way) would not likely be justified based on the residential property value effects alone. Perhaps, it would be best to focus on at-grade light rail and mitigating potentially negative property impacts with smart alignment, better technology, and other noise abatement programs.

Actual implementation of the financing instrument would still face numerous challenges. In particular, the availability of revenue streams is highly sensitive to the pace and timing of development, potentially increasing borrowing costs. If we assume that CTA can only rightly claim its fair share of property taxes once a residential unit is delivered, then revenues levels would ramp-up over time. Thus, actual cash flows will be much smaller in earlier years and larger in later years (Table 5-8 provides annualized estimates of revenue streams). Since we assume CTA stations are operational by the first year of our study period (2016), the need for funds does not match the availability of cash flows. Any capital debt instruments tied to value capture would need to be flexible enough (and perhaps long enough) to account for this reality.

Furthermore, we only consider the capital costs of station construction. Even if CTA implemented the less costly above-ground light rail option, the Agency would incur numerous additional costs to activate this new line, including procurement of right-of-way from CSX and/or other regional rail infrastructure owners (via purchase or lease), rolling stock, track upgrades and maintenance, operating subsidies in the (likely) event that user fees are insufficient to cover new operations costs, other network operation and management changes, etc. Of course, CTA could also be granted authority to collect property tax increments from other properties near the new stations and to construct other stations between South Works and the Red Line along the right-of-way.

We make numerous simplifying assumptions which require further analysis. We ignore the effects of proximity to the CTA line, which could offset much of the residential property value gains. Local tax district competition, land/property capitalization of CTA taxes, negative property value impacts elsewhere in the CMA, and inadequate resources for other public services due to diversion of tax money to CTA are all possible, if not probable. Nevertheless, given the scope and nature of redevelopment plans for the South Works site, and given the existing and presumably underutilized rail rights-of-way, our analysis suggests the potential for positive synergies between transit investment and land value appreciation, with the latter providing some revenues to fund the former.

6. Conclusions

CTA and other transit agencies throughout the United States face a daunting funding challenge that could exacerbate in the coming years. A combination of insufficient demand (or perhaps over-supply), poor coordination with land use planning and development, inefficient pricing elsewhere in the transportation system (especially roads), and a variety of other factors make it nearly impossible for transit agencies to fund capital maintenance and rehabilitation, let alone expansion. The Federal Government and the States have been subsidizing these capital investments for years. The current economic and fiscal climate makes it unrealistic to think that these sources alone can meet funding needs. At the same time, taxpayers who do not directly benefit from transit investment are being asked to foot part of the bill, posing equity problems.

Land value capture offers a potentially viable approach for financing at least some share of transit capital needs in a fair manner, consistent with fiscal federalist principles. Our review of the empirical evidence suggests that a well-planned mass transit investment can improve accessibility and that some of these benefits are capitalized into higher land values for properties near station ingress/egress points. Since these positive externalities could be considered windfall gains for property owners, it seems reasonable to ask these beneficiaries to contribute a “fair share” of those gains to cover construction and ongoing maintenance and rehabilitation costs, which is ultimately in their financial interests.

Our theoretical view of local tax options suggests that LVT is a reasonably effective means of financing public transportation capital improvements by levying taxes on the portion of property value created by transit stations. This approach is mostly consistent with the *fiscal equivalence* condition, as value capture attempts to assign costs directly to beneficiaries. Since this type of financial instrument does not, however, directly influence the use of the infrastructure, land value capture imperfectly fulfills the *efficiency* criterion in supplementing current financing regimes. Value capture helps indirectly internalize certain *externalities* (e.g., positive externalities accruing to property owners as property value increments, perhaps reducing automobile congestion), but has limited value for others, such as congestion in the transit system. In theory, LVT can improve horizontal *equity*, at least in terms of assigning costs. As our implementation scenarios show, however, the type of administrative methods adopted carry trade-offs between *administrative ease*, *efficiency*, and vertical *equity*.

For Chicago, justification exists to partly finance CTA capital programs from value capture techniques. Previous context-specific research provides evidence of land value appreciation due to the presence and/or construction of new CTA infrastructure. Our hedonic pricing models, although cross-sectional at a moment in time, concur with prior evidence that CTA stations ‘bring value” to proximate properties, even after controlling for a broad range of neighborhood conditions and relative transportation levels of service to opportunities across the Chicago metropolitan area. The various specifications offer some insights. For example, the model approach (i.e., spatial error) apparently matters more for single family than multi-family homes in terms of estimated effect of station proximity. Also, distinguishing between regional transit accessibility and local accessibility (station walk distance) suggests interesting differences in the commercial versus residential property markets. Commercial property values do relate to regional transit accessibility levels, but station proximity does not matter. For residential properties, station proximity has an additional property value benefit, beyond transit’s regional accessibility. This difference should be viewed with some caution, since our commercial properties sample is small and not obviously representative, but it suggests that the residential property market might value transit’s fixed station assets distinctly.

Our calculations suggest a land rent gradient around CTA transit stations and imply that CTA stations add about $4 billion in residential property value to the City of Chicago (roughly 3.5% of the estimated $115 billion total value). Capturing this value raises a range of institutional challenges, which we illustrate through different implementation scenarios. First, we considered the possibility that CTA receive transfers from existing local tax agencies on the percentage of additional property tax revenues attributable to rail transit value added. Under this scenario, CTA could justifiably claim $20-$54 million per year. Second, we considered the possibility that CTA become a local tax agency and levy a tax so as to capture its “market” value added over time through property taxes. Our analysis suggests that CTA could theoretically argue for a levy (in nominal terms) of about $135 million per year under a 30-year amortization schedule or $100 million per year under a 40-year amortization. However, the magnitude of these new taxes would surely prompt heavy opposition from affected residents. For single-family homes within a quarter mile of stations, this estimated CTA levy would constitute a tax rate of approximately the same magnitude as the combined Cook County and the City of Chicago “home rule” tax rates. For our third scenario, we relax assumptions on what constitutes a “fair share,” estimating a needs-based tax levy to recover CTA’s annual capital maintenance program costs (estimated at

$360 million). We find that this scenario not only begins to violate principles of fiscal federalism, it would substantially increase taxes, including practically doubling total local property taxes for some properties close to CTA stations. We deem it difficult to justify capturing much more than 25% of annual costs solely from residential property values.

We provide these estimates to illustrate an order of magnitude. Nonetheless, they are based on unrealistic assumptions. For example, Cook County, the City of Chicago, or the various local tax agencies therein would not likely be interested (or financially able) in participating in a zero-sum game for property tax revenues (e.g., Scenario 1). Thus, financing CTA infrastructure via taxes on existing properties would likely require tax rate increases within a hypothetical CTA tax jurisdiction (e.g., Scenario 2). Even if these increases were politically viable, they would likely be capitalized into property value, thus triggering a rebalancing of other local tax agencies' revenue-maximizing rates. In addition, care must be taken to ensuring no "double taxation," since municipalities already contribute sales taxes, direct subsidies, and other in-kind services (e.g., policing in Chicago) to CTA (most of these transfers are for CTA operations rather than infrastructure).

A clear, transparent, and reasonably fair implementation strategy is critical to deriving the theoretical benefits of land value capture. A simple tax would be preferable; but, since the benefits of CTA station proximity decline exponentially with distance, a variable rate is more efficient and equitable. A reasonable compromise between *efficiency* and/or *equity* and *administrative ease*, might employ tax "tiers," as in Scenarios 2 and 3, rather than property-specific tax transfer rates. CTA's taxing objectives should also be legally feasible and politically defensible; recovering shares of property taxes generated (i.e., Scenario 1) or, over time, property value added (i.e., Scenario 2) more likely meets this criteria.

Nonetheless, changing the tax approach for existing properties due to existing transit infrastructures may be a political non-starter. Linking system expansion to land development might hold greater near-term promise. Towards that end, we applied our hedonic price model estimates to analyze a hypothetical expansion of CTA services to a large, underutilized former industrial site in South Chicago. Enjoying a prime location along Lake Michigan and in close proximity to highway and commuter rail services, the South Works site is primed for large-scale redevelopment in the near future. We considered a scenario whereby CTA negotiates track rights to underutilized freight rail right-of-way to link the South Works site to the larger urban rail network. Assuming all new development to be within one-quarter mile of two hypothetical CTA stations, we use Monte Carlo-based simulations which suggest that value capture methods could reasonably generate $11.5 to $32.8 million (in present values). We estimate that these revenues would be sufficient to cover 18.6% to 54.6% of the two station's construction costs. Mitigating the negative property value effects of proximity to CTA at-grade lines would increase the revenue raised to $43.9 to $170.6 million, although the cost of mitigation (say, undergrounding the lines and station) might outweigh the financial benefits. These estimates exclude potential commercial property value added, as our models do not provide statistically reliable evidence of station proximity effects for such properties.

We essentially propose land value capture strategies to fund CTA capital investments in a manner analogous to a large, long-term TIF or SAD financing program. The precedent exists:

Chicago already has numerous TIF districts supporting transportation initiatives. We provide further empirical evidence justifying such financing techniques, based on station proximity alone. Regional accessibility (for both autos and transit) is also positively associated with property values, suggesting a broader possible justification for pursuing value-based mechanisms to finance transportation infrastructure and services. Capitalizing on these possibilities may be increasingly critical as transportation's ongoing fiscal crisis across metropolitan USA threatens to only get worse.

7. References

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8. Appendices

8.1. Overview of Studied Geographic Objects in the Chicago Metropolitan Area

Table 8-1 presents the geographic objects of the Chicago Metro Area studied in this paper.

Table 8-1 Statistics of Studied Geographic Objects in the Chicago Metro Area

Spatial Objects	Data Scope	Count	Length (Mile)	Area (Acre)					Data Source
				Min	Max	Sum	Mean	S.D.	
Spatial Units									
Census Block Group (in 2000)	Cook County	4,241	--	0.077	14,503.74	609,161.26	143.64	397.69	ESRI TIGER 2000 Census
Census Tract (in 2000)	Cook County	1,343	--	9.657	19,552.14	615,066.03	457.98	929.85	ESRI TIGER 2000 Census
TAZ (in 2000)	Chicago Metro	3,153	--	0.072	4,806.80	646,853.68	205.15	184.13	Chicago Metropolitan Agency for Planning
Environmental Amenities									
Park	City of Chicago	576	--	0.002	991.38	6,961.95	12.11	56.79	City of Chicago GIS Data
Forest	City of Chicago	19	--	4.943	552.24	3,202.24	168.54	154.49	City of Chicago GIS Data
Cemetery	City of Chicago	24	--	1.163	322.16	1,616.67	67.36	82.39	City of Chicago GIS Data
Public School	City of Chicago	540	--	--	--	--	--	--	Illinois State Board of Education
	Cook County	1,123	--	--	--	--	--	--	Illinois State Board of Education
Incentive Districts									
TIF for Residential Use	City of Chicago	13	--	3.832	328.97	834.84	64.22	83.31	City of Chicago GIS Data
TIF for Mixed-use	City of Chicago	100	--	2.670	1,947.87	22,373.37	223.73	302.01	City of Chicago GIS Data
TIF for Commercial Use	City of Chicago	4	--	20.480	255.43	559.25	139.81	83.11	City of Chicago GIS Data
TIF for Industrial Use	City of Chicago	41	--	5.080	7,590.08	20,662.35	503.96	1,163.95	City of Chicago GIS Data
Transportation									
CTA Bus Stop (in 2004)	Chicago Metro	12,180	--	--	--	--	--	--	Chicago Transit Authority
CTA Rail Station (in 2004)	Chicago Metro	143	--	--	--	--	--	--	Chicago Transit Authority
CTA Rail Line (in 2004)	Chicago Metro	8	224.1	--	--	--	--	--	Chicago Transit Authority
Metra Commuter Rail Station	Chicago Metro	238	--	--	--	--	--	--	Chicago Transit Authority
Metra Commuter Rail Line	Chicago Metro	--	557.79	--	--	--	--	--	Chicago Transit Authority
Pace Bus Stop	Chicago Metro	9,572	--	--	--	--	--	--	Chicago Transit Authority
Expressway	Chicago Metro	--	410.44	--	--	--	--	--	Chicago Metropolitan Agency for Planning
Major Arterial	Chicago Metro	--	429.17	--	--	--	--	--	Chicago Metropolitan Agency for Planning

8.2. Variable Description

Property Characteristics/Improvements on the Parcel

Detailed residential property characteristics and sales transaction records data were provided by the Cook County Assessor’s Office, including single family and multi-family units, and vacant land. Each property is associated with a unique Property Identification Number (PIN) that Cook County Assessor’s Office uses to track parcels of real property. This database contains detailed property characteristics (such as building area, land lot size, building frame materials, and number of garages, etc), and property transaction records (including sales price and sales date). It also records street address of each property, which we used to locate properties in the road network provided by the ESRI TIGER database in ArcGIS, a geographic information system (GIS) software package. Among the 1,832,516 property records in the Cook County dataset that we obtained, we successfully geo-coded 1,485,334 (81.05%). For properties in the City of Chicago, the matching ratio was higher, around 91.05%.

In order to study the impact of transit accessibility on property values, we selected properties that were sold in 2004 to match with the available Chicago transit network data in 2004. The spatial distributions of our sample single family, multi family, and vacant land data are shown in Figure 8-1a-c. Detailed data descriptions are summarized in Appendix 8.3.

Besides residential properties, we are also interested in commercial properties. Since the Assessor’s Office does not track detailed commercial property information, we obtained commercial properties that were sold in 2003 to 2005 in Cook County from CoStar Group, a private real estate data provider. Figure 8-1d displays the distribution of the sample commercial properties, and Table 8-6 lists the descriptive statistics of the commercial data. Detailed structure characteristics include building area (in square feet), land lot size (in sq ft), number of floors, building materials, building classes[1], property location, property use types, and building frame materials, parking ratio, etc.

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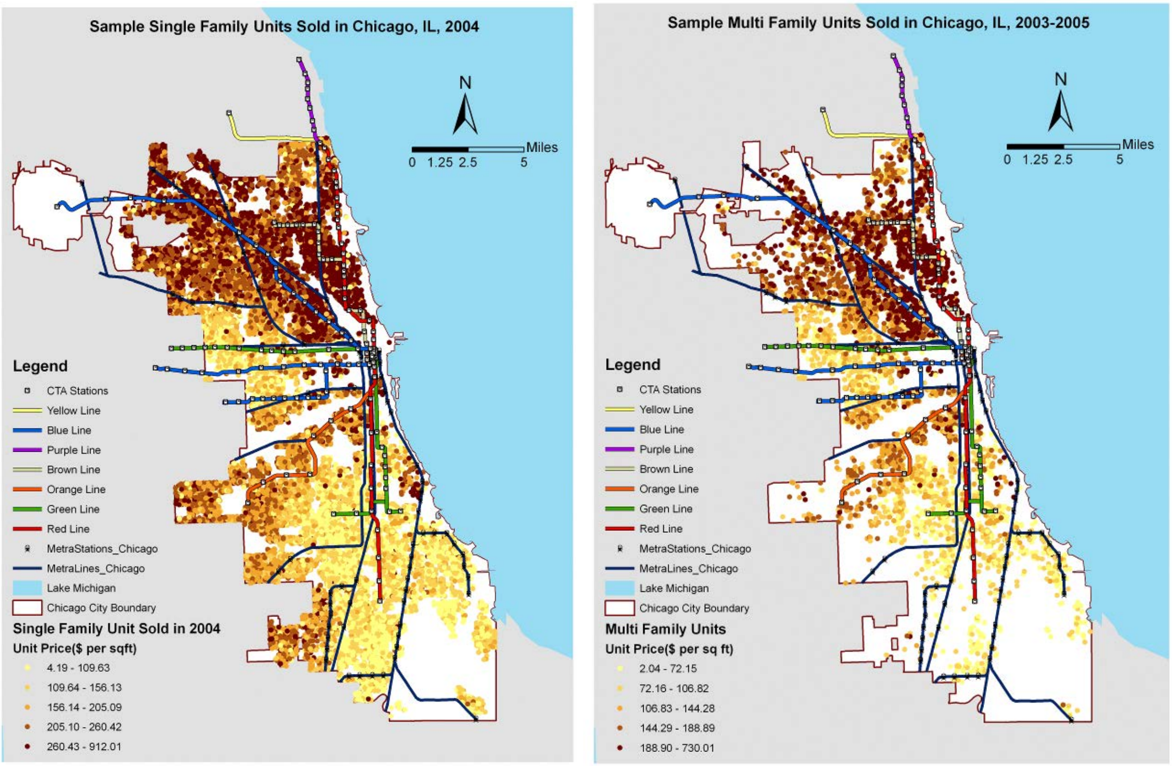
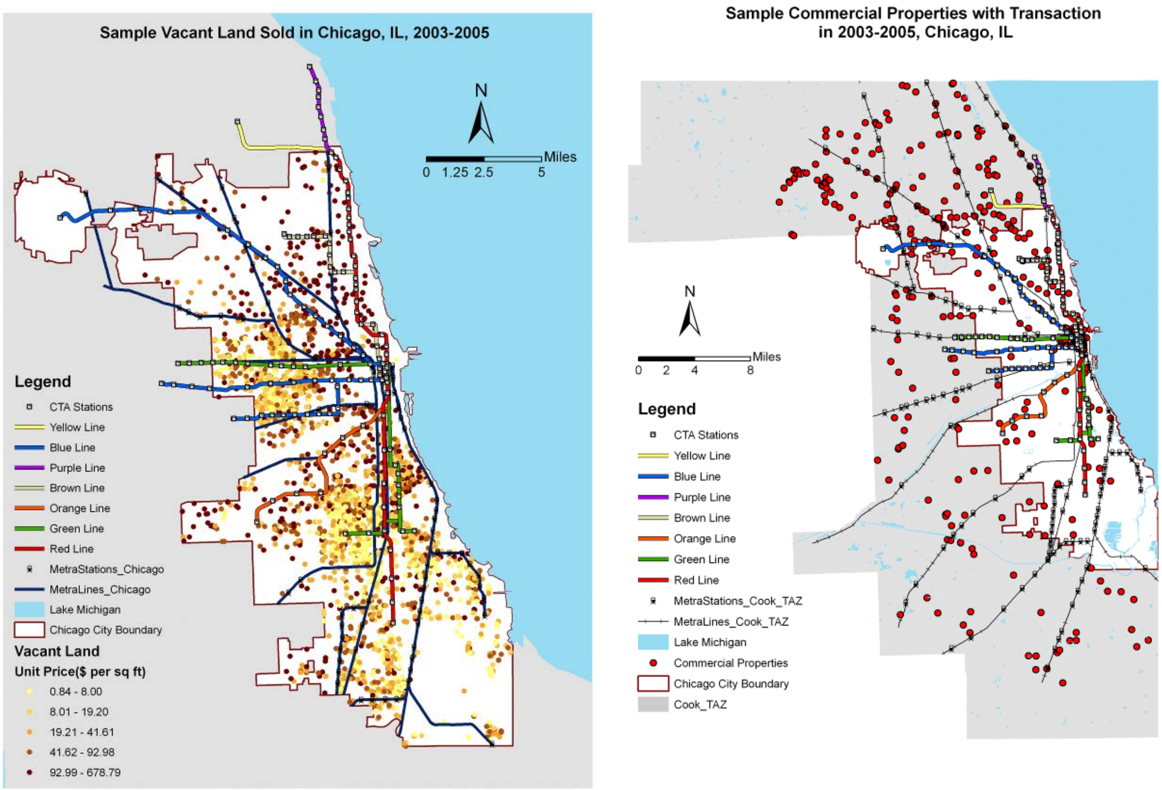
[1] The office building classes represent a combination of a subjective and objective quality rating of buildings that indicates the competitive ability of each building to attract similar types of tenants. CoStar groups office buildings into four classes – A, B, C, or F – with assignment depending on a variety of building characteristics, such as total rentable area, age, building finishes and materials, mechanical systems standards and efficiencies, developer, architect, building features, location/accessibility, property manager, design/tenant layout, and much more. Once assigned, a building's class reflects not only characteristics and attributes evaluated objectively, but also the subjective evaluations of finishes and amenities.



(a) Sample Single Family Units **(b) Sample Multi Family Units**

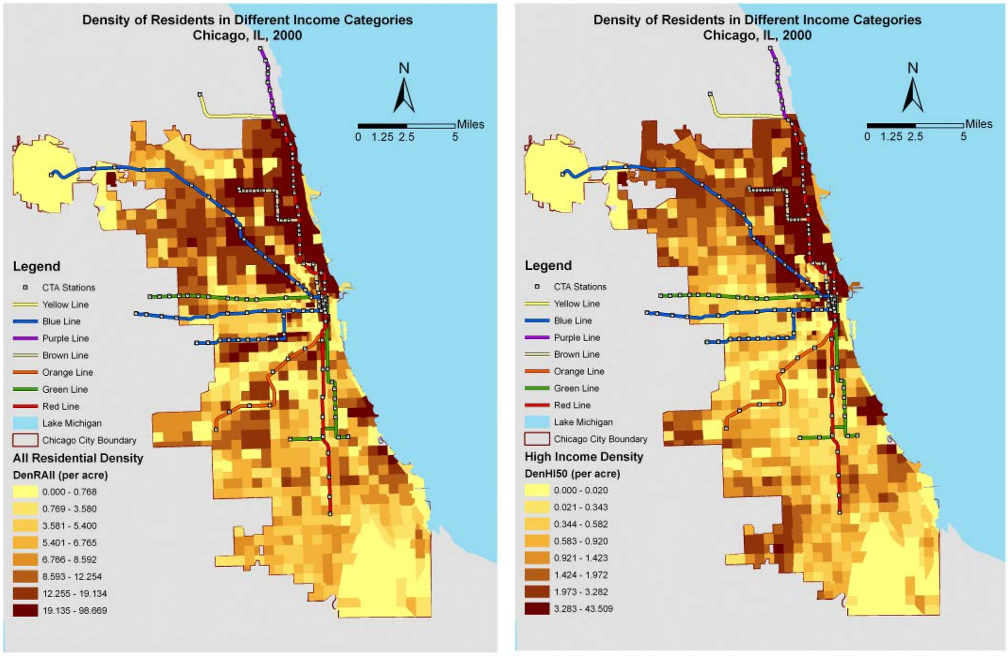


(c) Sample Vacant Land **(d) Sample Commercial Property**

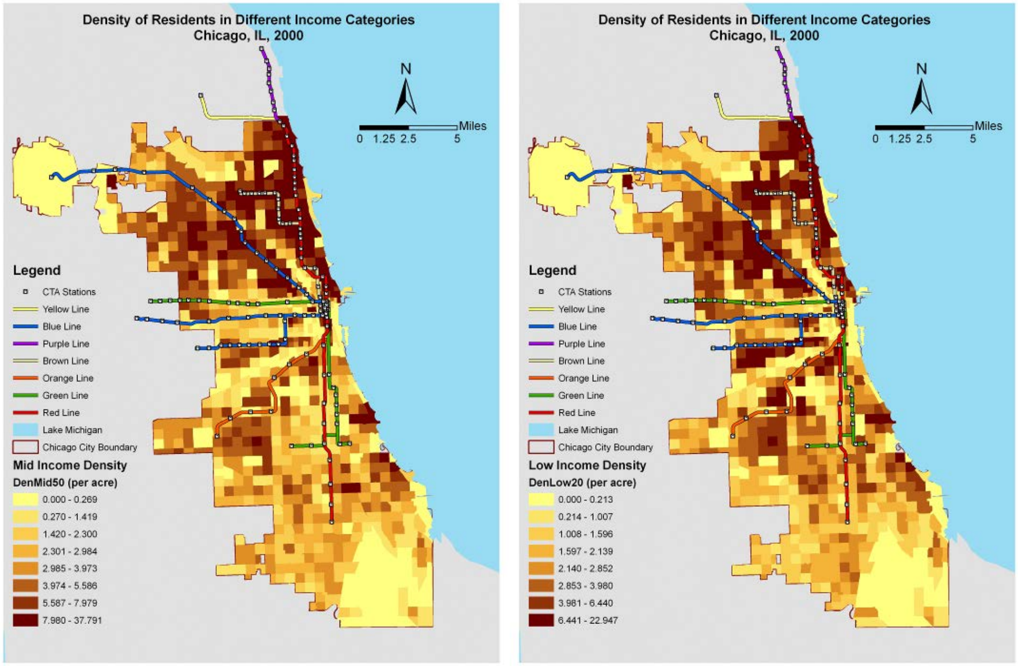
Figure 8-1 Sample properties sold in Chicago, IL, 2004

Neighborhood Socioeconomic Characteristics

Neighborhood socioeconomic characteristics data including population density (persons per acre), ratio of Hispanic people, and ratio of African American people are calculated at the census block group level (data source: MIT GIS Geolytics 2000 Census). We also calculated the density of residents in different income categories at the transportation analysis zone (see Figure 8-2) and the density of opportunities (such as retail, recreational, public administration and social service opportunities) (see Figure 8-3). The number of residents within different earning category was obtained from the Census Transportation Planning Package (CTPP) 2000 part 1, and the opportunities in different sector were obtained from CTPP 2000 part 2.



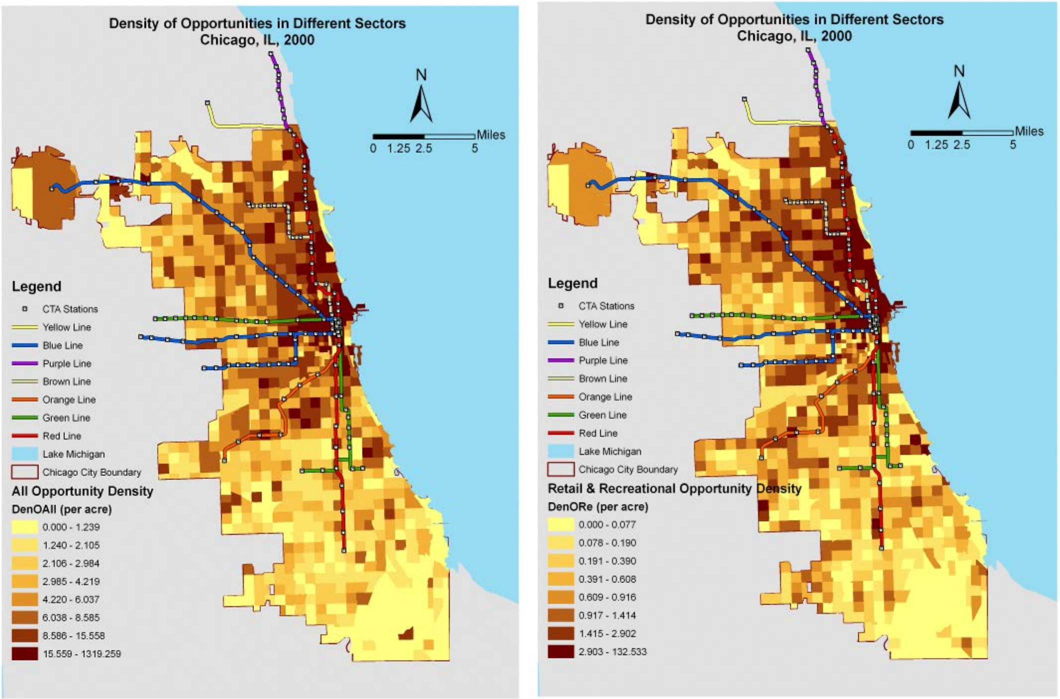
(a) All Residents Density **(b) Density of High Income (above 50 K) Residents**



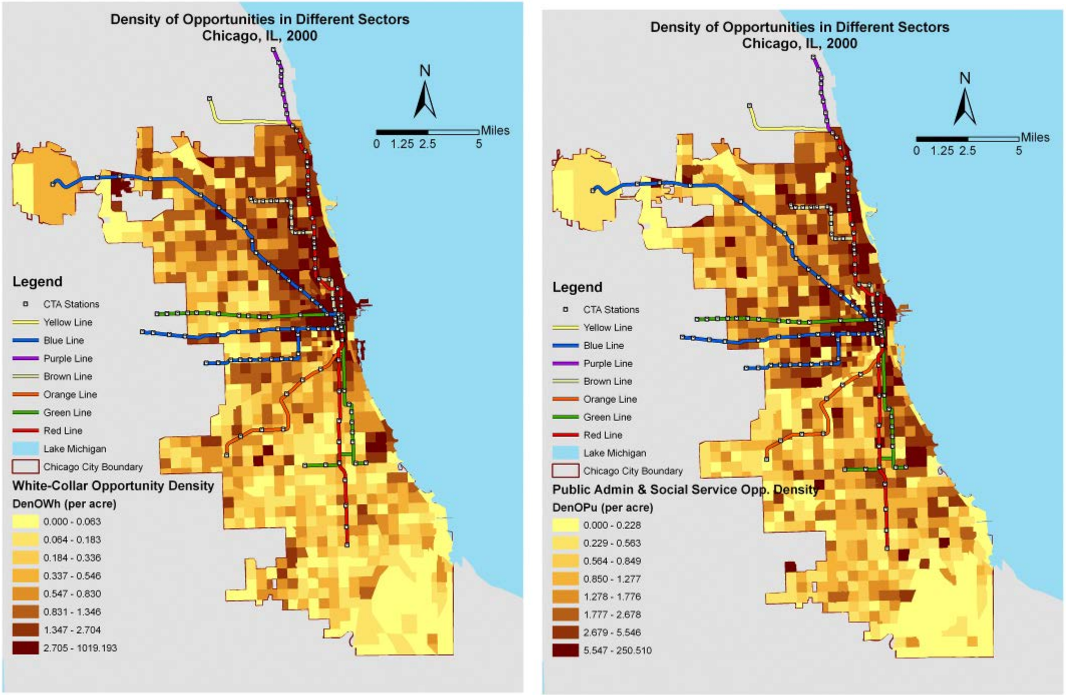
(c) Density of Middle Income (20-50 K) Residents (d) Density of Low Income (below 20 K) Residents

Figure 8-2 Density of Residents in Different Income-categories, Chicago, IL, 2000

Sources: data on residents in different income-categories obtained from CTPP 2000 Part 1.



(a) All Opportunity Density **(b) Retail & Recreational Opportunity Density**



(c) White-Collar Opportunity Density **(d) Public Admin & Social Services Opportunity Density**

Figure 8-3 Density of Opportunities in Different Sectors in Chicago, IL, 2000
Sources: data on opportunities in different sectors obtained from CTPP 2000 Part 2.

Opportunity Diversity Index (ODI)

In order to represent the level of land-use mix surrounding each property, we developed an Opportunity Diversity Index (ODI), following Rajamani et al (2003). The measure aims to capture the mix of uses relative to a perfect distribution of uses. Data for preparing the ODI were obtained from CTPP part 1 and part 2. Equation 8.1 shows the calculation of the ODI, whose value ranges from zero to one. A value of zero means that there is a single type of opportunity in the analysis unit (in this case in TAZ), and a value of one indicates a perfect mixing among the eight types of opportunities (residential, retail, information industry, finance, professional & management, educational & social services, and public administration) that we identified.

$$ODI = 1 - \left[\frac{\left|\frac{W}{T} - \frac{1}{8}\right| + \left|\frac{R}{T} - \frac{1}{8}\right| + \left|\frac{I}{T} - \frac{1}{8}\right| + \left|\frac{F}{T} - \frac{1}{8}\right| + \left|\frac{M}{T} - \frac{1}{8}\right| + \left|\frac{E}{T} - \frac{1}{8}\right| + \left|\frac{A}{T} - \frac{1}{8}\right| + \left|\frac{P}{T} - \frac{1}{8}\right|}{\frac{14}{8}} \right] \qquad \text{[Eq. 8.1]}$$

Where:

ODI= opportunity diversity index
W=number of workers residing in the TAZ
R = number of retail opportunities in the TAZ
I = number of information industry opportunities in the TAZ
F = number of finance, insurance, real estate and rental and leasing opportunities in the TAZ
M = number of professional, scientific, management, administrative, and waste management service opportunities in the TAZ
E = number of educational, health and social services opportunities in the TAZ
A = number of arts, entertainment, recreation, accommodation and food service opportunities in the TAZ
P= number of public administration opportunities in the TAZ
T = W+R + I + F + M + E + A+P

Crime Data

We obtained the latest annual crime account data from the Chicago Police Department[2] , and calculated the crime density (annual crime account per acre) at the census tract level.

School Score

To evaluate the performance of schools in surrounding neighborhoods of each property, we obtained public school addresses in Cook County from the Illinois State Board of Education (ISBE)[3]. Using the same geo-coding methods described for locating the properties, we geo-

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[2] Retrieved March 25, 2009 from http://gis.chicagopolice.org
[3] Retrieved March 18, 2009 from http://www.isbe.state.il.us/research/xls/school_directory.xls

coded the 1253 public schools in the school year 2004-2005 in Cook County. Locations of the schools are shown in Figure 8-4.

We then calculated school performance scores based on two main tests:

- Illinois Standards Achievement Test (ISAT) - measures individual student achievement relative to the Illinois Learning Standards. The results provide one measure of student learning and school performance. This test is given in grades 3 through 8 and includes testing in reading, mathematics, and science.
- Prairie State Achievement Examination (PSAE) - measures individual student achievement relative to the Illinois Learning Standards. The results provide one measure of student learning and school performance. This test is given in grade 11 and includes testing in reading, mathematics, and science.

To keep the school performance consistent with the properties' sale year, we use ISAT/PSAE Performance Results from the school years of 2003-2004 to 2004-2005[4]. We use the same measurements as the ISBE to evaluate school performance—that is the percent of students meeting or exceeding standards as a general score to evaluate school performance, and average the percentages for all the grades of a particular school.

$$\text{School Score} = \text{AVG}\ (\text{Grade } 3 + \text{Grade } 5 + \text{Grade } 8 + \text{Grade } 11) \qquad [\text{Eq. } 8.2]$$

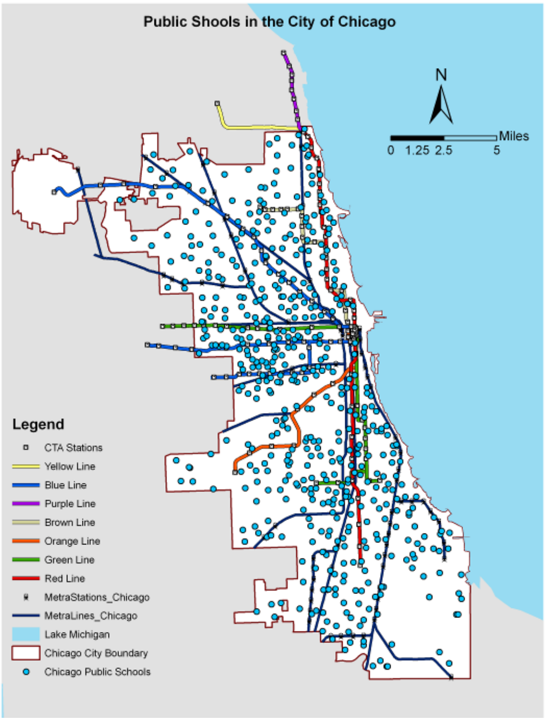

Figure 8-4 Locations of Public Schools in the City of Chicago

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[4] Retrieved March 18, 2009 from http://www.isbe.state.il.us/research/htmls/report_card.htm

Environmental Quality

GIS layers of parks, forests, cemetery, and Lake Michigan in the City of Chicago were obtained from the City of Chicago GIS online database[5]. Using ArcGIS, we calculated the distances of each property to the nearest parks and forests, to the nearest parks and forests that are larger than 10 acres, to the nearest parks and forest that are larger than 20 acres, to the nearest cemetery, and to the nearest point of Lake Michigan (again, see data descriptions in Appendix 8.3).

Transportation Accessibility

Local Transportation Accessibility. The Chicago transit network including the CTA stations and lines, the Metra stations and lines (Figure 8-5), and the highway network in 2004 were provided by the CTA. We calculated the distances of each property to its nearest CTA station, to its nearest CTA line, to its nearest Metra station, and to its nearest Metra line. We also calculated distances of each property to its nearest expressway, and major/minor arterials. We constructed several dummy variables based on these distance measures (see data descriptions in Appendix 8.3).

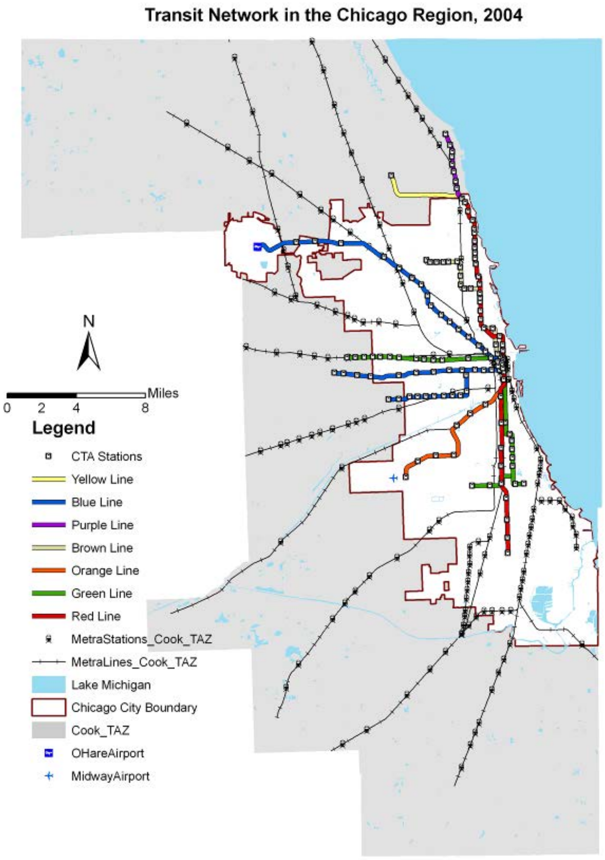

Figure 8-5 Transit Network in the Chicago Region

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[5] Retrieved April 22, 2009 from http://egov.cityofchicago.org/city/

Based on the walk impedance function (Figure 8-6) calibrated by Warade (2007), we calculated the walk impedance index (Eq. 8.3) for each property to its nearest CTA station. The impedance function weights the value of opportunities based on estimated travel times, with more distant opportunities weighted lower (reflecting the relative disutility of longer trips, all else equal). The weight is derived from empirical evidence on reported walking origins and destinations. Warade (2007) calibrated the gamma shaped impedance function based on the observed trip travel times of commuting trips in the Chicago region, based on the CTPP 2000 data. Using this impedance function, we estimated the walk impedance index for all properties in our study area. In Eq. 8.3, *x* is walking time to the nearest transit station from each property. We used the nearest distance of each property divided by 3 miles per hour[6] (or 0.05 mile per minute) to approximate the walking time from each property to its nearest transit station.

$$f(x) = \frac{a}{1 + (a-1)\cdot \exp(b \cdot x)}; \qquad \text{[Eq. 8.3]}$$

Where:
a = 1.357 and b = 0.118
x = walking time (distance to the nearest transit station/0.05 mile per minute)

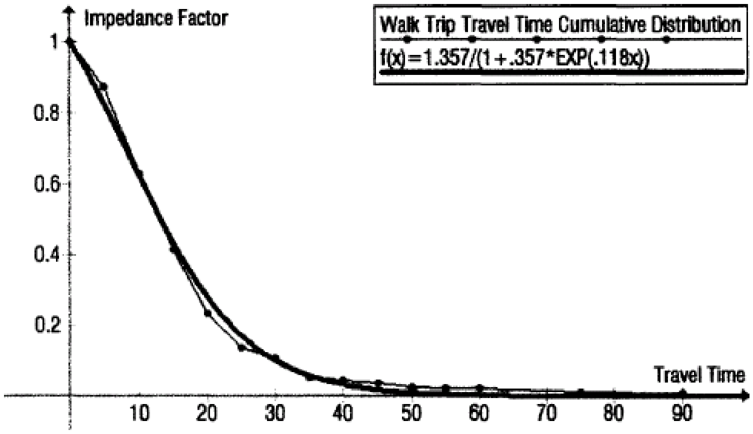


Figure 8-6 Walk Impedance Function for the Chicago Metropolitan Area
Source: Warade, 2007.

Regional Transportation Accessibility. We obtained a Chicago road and transit network model developed by CATS, and processed by Murga (2008). This model enables estimation of the transit travel[7] matrix (3153 by 3153), and the auto travel time matrix (3153 by 3153) for the peak hours in the Chicago metro region. With the data on number of opportunities in different industry sectors and residents in different income categories (obtained from CTPP 2000 part 1 and part 2[8]), and adopting the accessibility models calibrated by Warade (2007) for Chicago, we calculated transit and auto accessibility to opportunities and to residents (Eq. 8.4 and 8.5) (see descriptive statistics in Appendix 8.3). Figure 8-7 shows the transit and auto impedance functions calibrated by Warade (2007) and Figure 8-8 and Figure 8-9 show some of the transit and auto accessibility estimates.

[6] We assume the average walking speed is 3 miles per hour.
[7] The origins and destinations for both transit and auto travel times are calculated for the TAZ centroid.
[8] Retrieved March 5, 2009 http://www.fhwa.dot.gov/ctpp/

$$AQ_{i,c} = \sum_{j} B_{j,c} f(T_{ij}) \qquad \text{[Eq 8.4]}$$

$$AI_{i,c} = \frac{\sum_{j \in R} B_{j,c} f(T_{ij})}{\sum_{j \in R} B_{j,c}} \qquad \text{[Eq. 8.5]}$$

Where

R = set of locations within a given region (in this case the Chicago Metropolitan Area)
i = origin location
j = destination location
c = opportunity category
$AQ_{i,c}$ = accessibility to opportunity category c, at location i
$AI_{i,c}$ = accessibility index to opportunity category c, at location i
$B_{j,c}$ = number of opportunities in category c, at location j
T_{ij} = travel time from i to j
$f(T_{ij})$ = impedance function, which is of the form

$$f(x) = \frac{a}{1 + (a-1) \cdot \exp(b \cdot x)};$$

- in the Automobile Accessibility Model, a = 1.130 and b = 0.077;
- in the Public Transit Accessibility Model, a = 1.027 and b = 0.083;
x= travel time by mode (transit or auto)

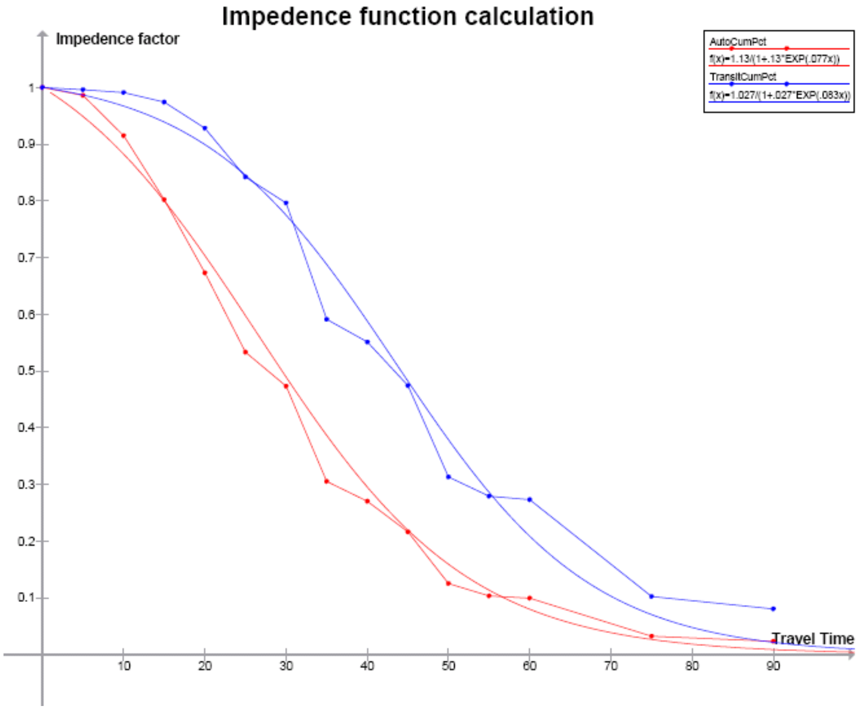
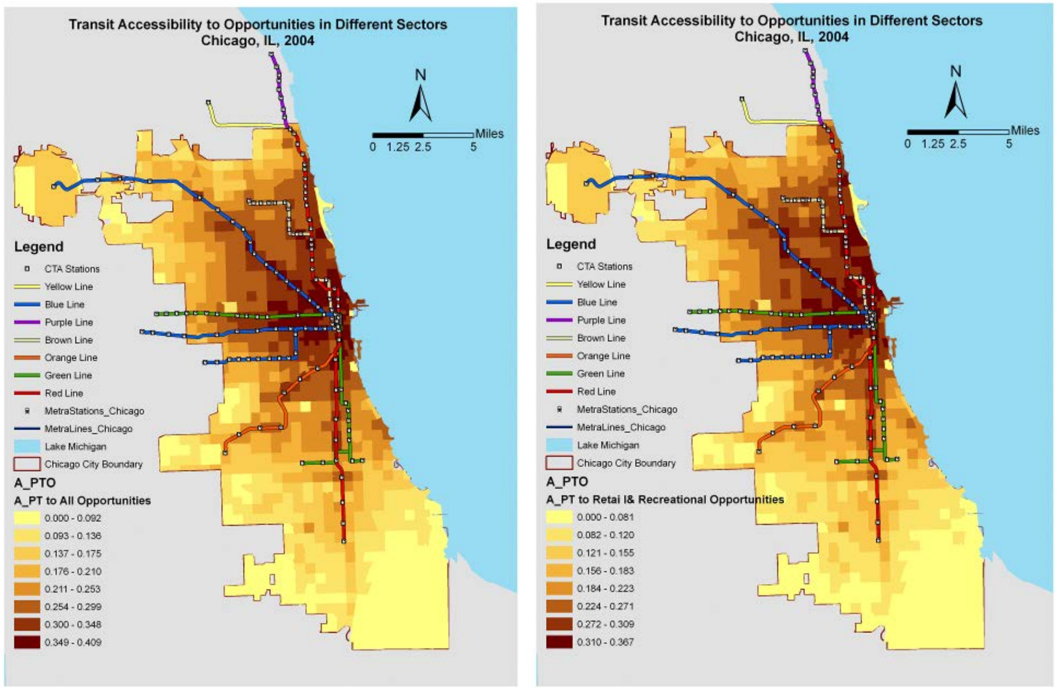
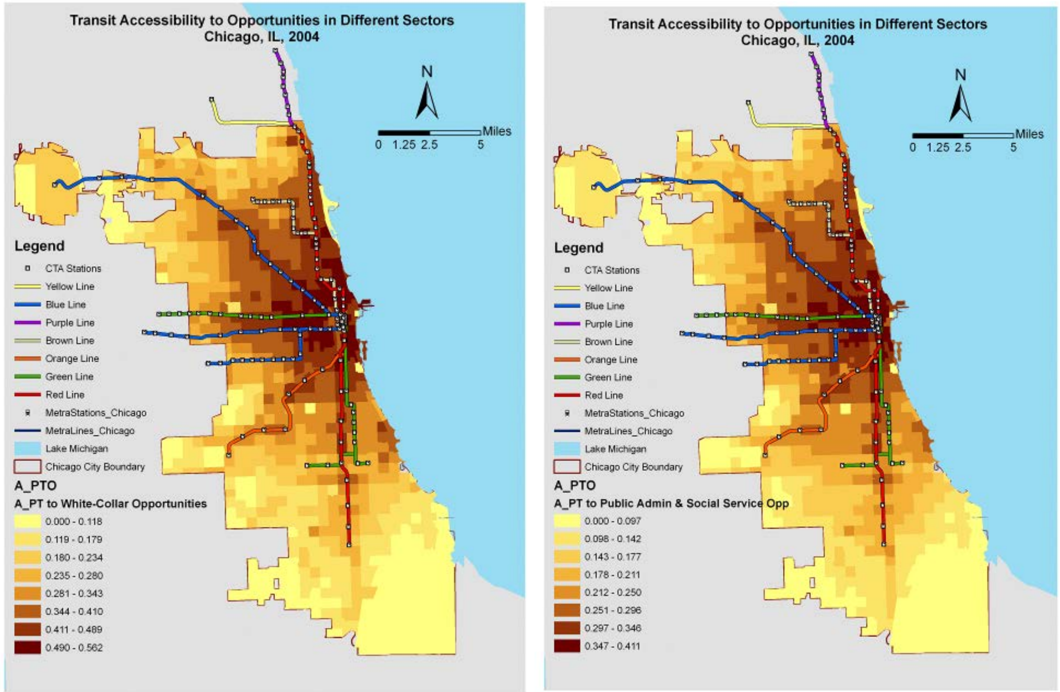


Figure 8-7 Transit/Auto impedance function for the Chicago Metropolitan Area. Source: Warade, 2007

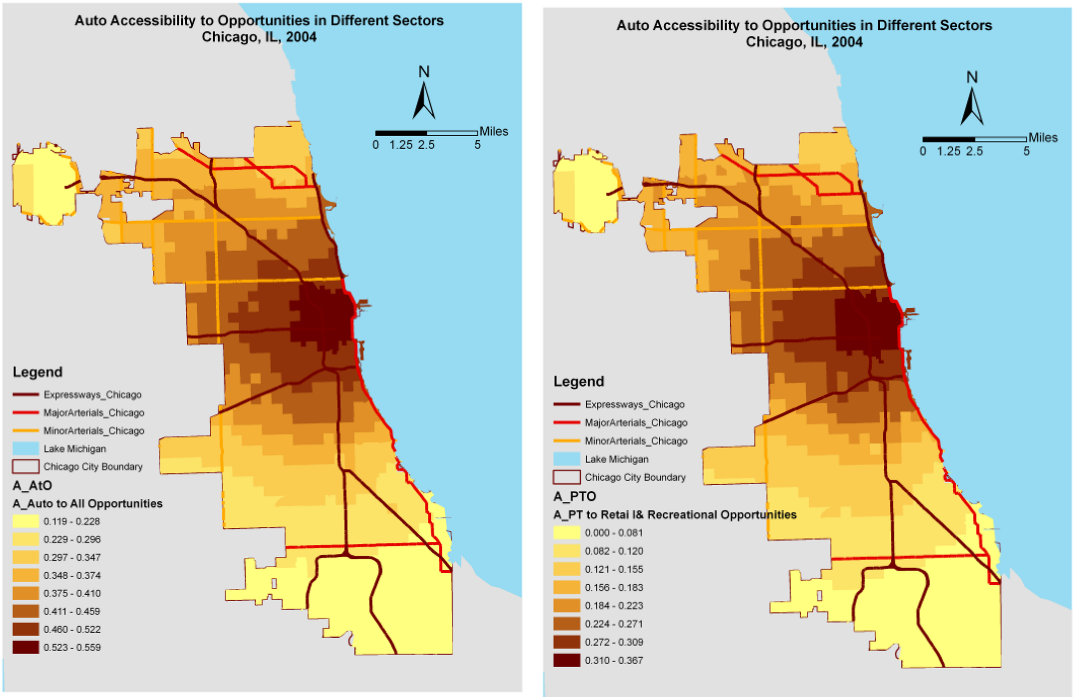


(a) Transit Accessibility to All Opportunities (b) Transit Accessibility to Retail & Recreational Opp.

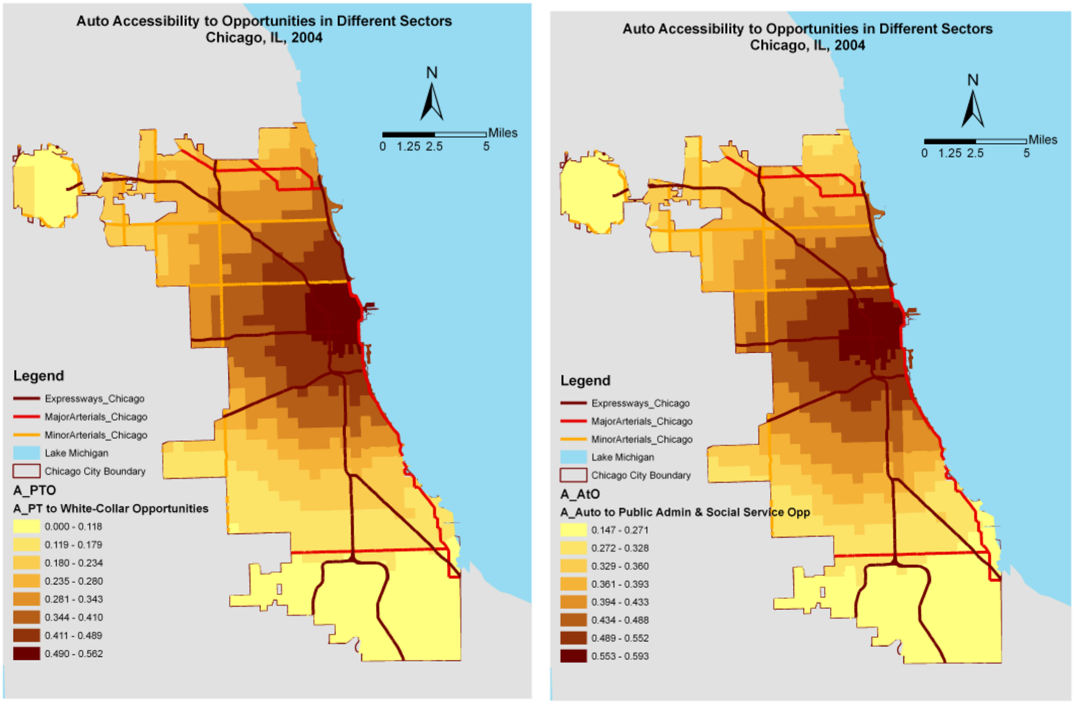


(c) Transit Accessibility to White-Collar Opp. (d) Transit Accessibility to Public Admin & Social Service Opp.

Figure 8-8 Transit Accessibility to Opportunities in Different Sectors in Chicago, IL, 2004
Sources: data on opportunities in different sectors obtained from CTPP 2000 Part 2; the Chicago transit network model calibrated by Murga (2008); the transit network impedance function calibrated by Warade (2007); and the transit accessibility indices calculated and mapped by the authors.



(a) Auto Accessibility to All Opportunities **(b) Auto Accessibility to Retail & Recreational Opportunities**



(c) Auto Accessibility to White-Collar Opp. (d) Auto Accessibility to Public Admin & Social Service Opp.

Figure 8-9 Auto accessibility to opportunities in different sectors in Chicago, IL, 2004
Sources: data on opportunities in different sectors obtained from CTPP 2000 Part 2; the Chicago highway and streets model calibrated by Murga (2008); the auto network impedance function calibrated by Warade (2007); and the auto accessibility indices calculated and mapped by the authors.

Factor Analysis for Regional Accessibility. The Variance Inflation Factor (VIF) and tolerance measures of the degree of multi-collinearity in our preliminary models suggest that the regional accessibility variables (such as transit or auto accessibility to different opportunities and to residents of different income levels) are highly correlated. To reduce multi-collinearity among the regional accessibility variables, we employ Principal Component Analysis (PCA) in an exploratory fashion to ultimately reduce the number of accessibility variables within our regression models while maximizing the amount of information retained in the models (Gorsuch, 1983, p4).

We conducted PCA on the regional accessibility values calculated at the Transportation Analysis Zone (TAZ) level. By applying the default rule of extracting only those components whose eigenvalues are greater than 1.0, we extract two components (with 97.058% cumulative variance explained by Factor 1 and Factor 2). Component loadings for different accessibility variables can be found in Table 8-2. Component 1 is the weighted sum of transit and auto accessibility to different opportunities (such as manufacturing, retail, information industry, financial industry, educational and social service opportunities) and to residents of different annual income levels (ranging from less than $20,000 to more than $75,000). Component 2 essentially represents the auto “peaks” and transit “valleys” – those zones with high auto accessibility and low transit accessibility (to both opportunities and to residents).

While PCA allows us to reduce the number of accessibility variables in our analysis to two, methodological problems arise when reincorporating the components as variables into regression models (see Ben-Akiva et al., 1999). A basic problem is that any errors from the PCA are carried into the subsequent regression models. Instead, based on the findings from the exploratory PCA, we calculated indices for transit and auto accessibility to the aggregate number of opportunities (in the categories as mentioned above) and to the aggregate number of residents:

$$AI_{i,c} = \frac{\sum_{j\in R} B_{j,c}\, f(T_{ij})}{\sum_{j\in R} B_{j,c}} \qquad \text{[Eq. 8.6]}$$

Where

R = set of locations within a given region (in this case the Chicago Metropolitan Area)
i = origin location
j = destination location
c = opportunity category (combination of the 12 sub-categories, including construction opportunities; manufacturing opportunities; wholesale trade opportunities; transportation & warehousing opportunities; retail trade opportunities; arts & entertainment opportunities; information industry opportunities; financial industry opportunities; professional & management opportunities; educational & social service opportunities; other service opportunities; public administration opportunities;)
$AQ_{i,c}$ = accessibility to opportunity category c, at location i
$AI_{i,c}$ = accessibility index to opportunity category c, at location i
Bj,c = number of the total opportunities in category c , at location j
T_{ij} = travel time from i to j
$f(T_{ij})$ = impedance function, which is of the form

$$f(x) = \frac{a}{1 + (a-1) \cdot \exp(b \cdot x)};$$

- in Automobile Accessibility Model, a = 1.130 and b = 0.077;
- in Public Transit Accessibility Model, a = 1.027 and b = 0.083;

x= travel time by mode (transit or auto)

We use these accessibility indices in our regression models presented in Section 8.4.

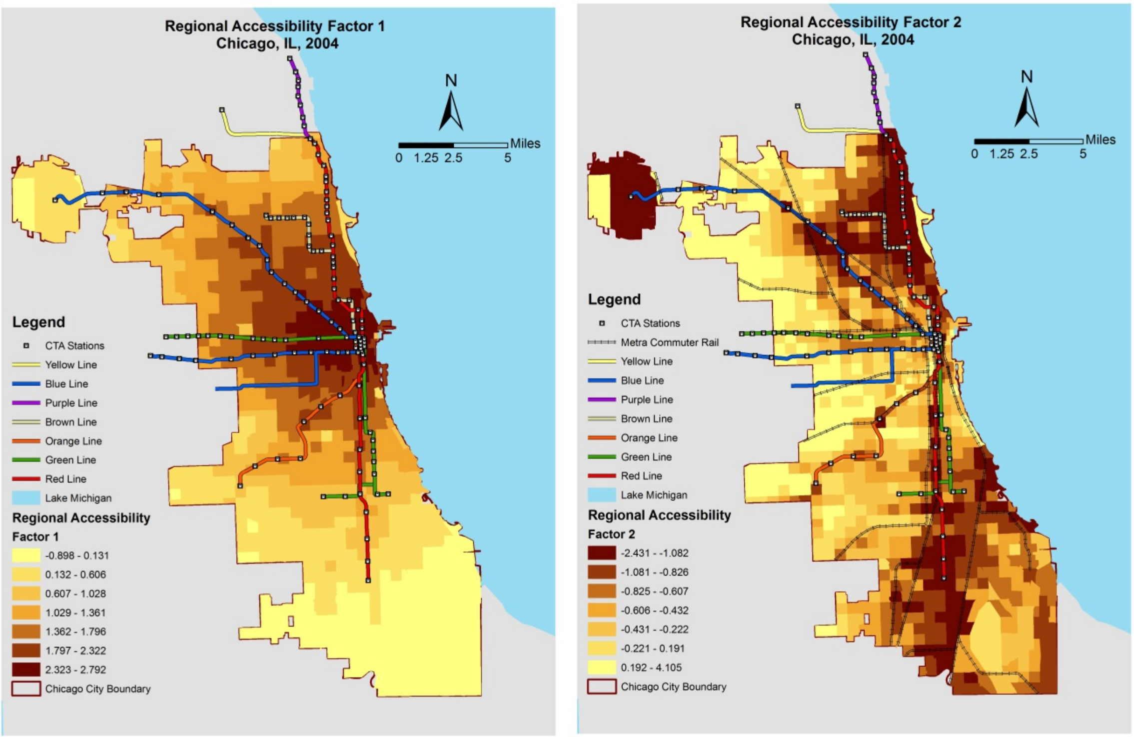


Figure 8-10 Two Main Extracted Factors of Regional Accessibility in Chicago, IL, 2004
Sources: data on opportunities in different sectors obtained from CTPP 2000 Part 2; the Chicago transit network, highway and streets model calibrated by Murga (2008); the transit and auto network impedance function calibrated by Warade (2007); and the transit and auto accessibility indices calculated and mapped by the authors.

Table 8-2 Statistics of Regional Accessibility Indices and Factor Loadings

Variable		Factor Loadings*		Statistics of Accessibility Indices				
Abbreviations	**Descriptions**	**Factor 1**	**Factor 2**	**Min**	**Max**	**Range**	**Mean**	**S.D.**
A_PToCST	Transit accessibility to construction opportunities	0.958	-0.282	0.000	0.374	0.374	0.069	0.101
A_PToMAF	Transit accessibility to manufacturing opportunities	0.959	-0.263	0.000	0.258	0.258	0.049	0.071
A_PToWHL	Transit accessibility to wholesale trade opportunities	0.959	-0.268	0.000	0.295	0.295	0.053	0.078
A_PToTRN	Transit accessibility to transportation & warehousing opportunities	0.955	-0.276	0.000	0.365	0.365	0.065	0.096
A_PToRET	Transit accessibility to retail trade opportunities	0.955	-0.291	0.000	0.305	0.305	0.057	0.083
A_PToART	Transit accessibility to arts & entertainment opportunities	0.951	-0.303	0.000	0.451	0.451	0.079	0.119
A_PToINF	Transit accessibility to information industry opportunities	0.949	-0.298	0.000	0.509	0.509	0.091	0.137
A_PToFIN	Transit accessibility to financial industry opportunities	0.947	-0.292	0.000	0.578	0.578	0.106	0.156
A_PToMNG	Transit accessibility to professional & management opportunities	0.948	-0.296	0.000	0.565	0.565	0.103	0.153
A_PToEDU	Transit accessibility to educational & social service opportunities	0.947	-0.309	0.000	0.394	0.394	0.070	0.102
A_PToOTH	Transit accessibility to other service opportunities	0.953	-0.301	0.000	0.395	0.395	0.074	0.108
A_PToPUB	Transit accessibility to public administration opportunities	0.943	-0.292	0.000	0.566	0.566	0.104	0.154
A_AToCST	Auto accessibility to construction opportunities	0.931	0.36	0.037	0.532	0.495	0.258	0.115
A_AToMAF	Auto accessibility to manufacturing opportunities	0.77	0.597	0.036	0.461	0.425	0.269	0.110
A_AToWHL	Auto accessibility to wholesale trade opportunities	0.791	0.568	0.031	0.468	0.437	0.264	0.113
A_AToTRN	Auto accessibility to transportation & warehousing opportunities	0.851	0.434	0.036	0.513	0.477	0.257	0.111
A_AToRET	Auto accessibility to retail trade opportunities	0.905	0.419	0.044	0.484	0.441	0.263	0.098
A_AToART	Auto accessibility to arts & entertainment opportunities	0.972	0.215	0.039	0.581	0.542	0.251	0.127
A_AToINF	Auto accessibility to information industry opportunities	0.95	0.237	0.027	0.611	0.584	0.237	0.141
A_AToFIN	Auto accessibility to financial industry opportunities	0.975	0.132	0.031	0.668	0.637	0.234	0.148
A_AToMNG	Auto accessibility to professional & management opportunities	0.965	0.175	0.026	0.655	0.629	0.230	0.148
A_AToEDU	Auto accessibility to educational & social service opportunities	0.965	0.2	0.048	0.578	0.529	0.266	0.122
A_AToOTH	Auto accessibility to other service opportunities	0.965	0.252	0.043	0.563	0.519	0.260	0.120
A_AToPUB	Auto accessibility to public administration opportunities	0.957	0.072	0.045	0.702	0.658	0.255	0.162
A_PTr20k	Transit accessibility to residents with annual earnings less than $19,999	0.948	-0.29	0.000	0.347	0.347	0.062	0.088
A_PTr30k	Transit accessibility to residents with annual earnings between $20,000 and $29,999	0.946	-0.288	0.000	0.336	0.336	0.061	0.085
A_PTr50k	Transit accessibility to residents with annual earnings between $30,000 and $49,999	0.942	-0.299	0.000	0.322	0.322	0.057	0.081
A_PTr75k	Transit accessibility to residents with annual earnings between $50,000 and $74,999	0.938	-0.304	0.000	0.306	0.306	0.053	0.076
A_PTrTop	Transit accessibility to residents with annual earnings between $75,000 or more	0.929	-0.302	0.000	0.355	0.355	0.057	0.088
A_ATr20k	Auto accessibility to residents with annual earnings less than $19,999	0.936	0.271	0.056	0.550	0.494	0.282	0.116
A_ATr30k	Auto accessibility to residents with annual earnings between $20,000 and $29,999	0.928	0.297	0.057	0.542	0.485	0.284	0.114
A_ATr50k	Auto accessibility to residents with annual earnings between $30,000 and $49,999	0.927	0.312	0.055	0.516	0.461	0.278	0.104
A_ATr75k	Auto accessibility to residents with annual earnings between $50,000 and $74,999	0.914	0.364	0.050	0.483	0.433	0.271	0.095
A_ATrTop	Auto accessibility to residents with annual earnings between $75,000 or more	0.851	0.375	0.029	0.487	0.459	0.249	0.118

* Extraction Method: Principal Component Analysis.

8.3. Descriptive Statistics: Single Family Homes, Multi-Family Homes, Vacant Land, and Commercial Properties

Table 8-3 Variable Descriptive Statistics for Single Family Homes

Variables	Description	Mean	S.D.	Min	Max
Sale_Am	Property sales amount (in $2004)	263,888	204,032	11,119	1,988,000
Property Attributes					
BSqFt	Building area (square feet)	1,335	575	400	6,825
LSqFt	Land lot size (square feet)	3,932	1,469	355	29,006
Mid_Stry	1.5 to 1.9 stories	0.148	0.355	0	1
Two_Stry	Two stories	0.235	0.424	0	1
Tre_Stry	Three stories	0.035	0.185	0	1
Mult_Lvl	Multi-level	0.025	0.156	0	1
Frm_Mas	Frame/Masonry	0.094	0.292	0	1
Mas	Masonry	0.542	0.498	0	1
Stucco	Stucco	0.015	0.122	0	1
Two_FBth	Two full baths	0.207	0.405	0	1
Tre_FBth	Three or more baths	0.044	0.206	0	1
One_HBth	One or more half bath	0.290	0.454	0	1
Bsmt_APT	Basement: full/partial apartment	0.000	0.019	0	1
Bsmt_Lvg	Basement: full/partial recreation room	0.257	0.437	0	1
Bsmt_Unf	Basement: full/partial unfinished	0.535	0.499	0	1
Bsmt_Crl	Basement: crawl	0.019	0.138	0	1
Atti_APT	Attic: full/partial apartment	0.000	0.019	0	1
Atti_Liv	Attic: full/partial living room	0.173	0.378	0	1
Atti_Unf	Attic: full/partial unfinished	0.249	0.433	0	1
A_C	Central air conditioning	0.287	0.453	0	1
One_Fire	One fireplace	0.102	0.303	0	1
Two_Fire	Two or more fireplaces	0.027	0.163	0	1
Grge1	Garage for 1 or 1.5 car (attached/detached)	0.265	0.441	0	1
Grge2	Garage for 2 or 2.5 cars (attached/detached)	0.482	0.500	0	1
Grge3	Garage for 3 or more cars (attached/detached)	0.007	0.082	0	1
Age	Building age	67.969	30.933	1	155
Row_Hse	Row house or town house	0.078	0.268	0	1
Neighborhood Socioeconomics & Amenities					
PFAll_E	Distance to the nearest park or forest is not greater than 1/8 mile	0.248	0.432	0	1
CmtyMi	Distance to the nearest cemetery (mile)	2.513	1.684	0.006	8.399
LakeMich	Distance to Lake Michigan is within 1 mile	0.057	0.231	0	1
SCHScore	School score (average % passing qualified level in Grades 3, 8, 11) of the nearest schoc	48.923	14.029	6	99.761
HISRATIO	Ratio of Hispanic people in 2000 (in census block group)	23.399	26.598	0	97.940

Table 8-3 (Continued)

Variables	Description	Mean	S.D.	Min	Max
AARATIO	Ratio of African American people in 2000 (in census block group)	33.873	42.637	0	100
CRIMEDEN	Crime density (latest annual count per acre, in census tract)	2.886	2.273	0.143	22.986
DenLow20	Density of residents (persons per acre) with low income (annual earnings<=20K in 1999, in TAZ)	3.282	2.268	0	22.947
DenMid35	Density of residents (persons per acre) with middle income (annual earnings >20K, <=35K in 1999, in TAZ)	2.831	1.708	0	18.851
DenHI35	Density of residents (persons per acre) with high income (annual earnings > 35K in 1999, in TAZ)	3.591	3.621	0	62.348
DenOAll	Density of all opportunities (in TAZ, 1999)	4.395	4.775	0	92.014
ODI	Opportunity diversity index (in TAZ, 1999)	0.209	0.101	0	0.760
TIF_Res	In the TIF district for residential use	0.000	0.021	0	1
TIF_Mix	In the TIF district for mixed use	0.070	0.256	0	1
TIF_Com	In the TIF district for commercial use	0.002	0.043	0	1
TIF_Ind	In the TIF district for industrial use	0.014	0.116	0	1
Transportation & Accessibility					
BStp_18	Within 0.125 mile distance to the CTA bus stop	0.558	0.497	0	1
CTA_Q_Im	Walk impedance measure to the nearest CTA station(=1 while within a quarter mile boundary & continuous further away)	0.292	0.307	0	1
CTAL_G18	Distance to the nearest CTA line (above-ground) is within 1/8 mile	0.023	0.149	0	1
CTAL_G1814	Distance to the nearest CTA line (above-ground) is beyond 1/8 mile & within 1/4 mile	0.031	0.174	0	1
CTAL_G1412	Distance to the nearest CTA line (above-ground) is beyond 1/4 mile & within 1/2 mile	0.067	0.251	0	1
CTAL_L18	Distance to the nearest CTA line (elevated) is within 1/8 mile	0.022	0.146	0	1
CTAL_L1814	Distance to the nearest CTA line (elevated) is beyond 1/8 mile & within 1/4 mile	0.029	0.167	0	1
CTAL_L1412	Distance to the nearest CTA line (elevated) is beyond 1/4 mile & within 1/2 mile	0.057	0.232	0	1
Mtra_18	Distance to the nearest Metra station is within 1/8 mile	0.010	0.102	0	1
Mtra_1814	Distance to the nearest Metra station is beyond 1/8 mile & within 1/4 mile	0.044	0.205	0	1
Mtra_1412	Distance to the nearest Metra station is beyond 1/4 mile & within 1/2 mile	0.127	0.333	0	1
Mtra_12t1	Distance to the nearest Metra station is beyond 1/2 mile & within 1 mile	0.272	0.445	0	1
Mtra_1t2	Distance to the nearest Metra station is beyond 1 mile & within 2 mile	0.359	0.480	0	1
Mtra_2t3	Distance to the nearest Metra station is beyond 2 mile & within 3 mile	0.137	0.343	0	1
MtraL_18	Distance to the nearest Metra line is within 1/8 mile	0.084	0.277	0	1
MtraL1814	Distance to the nearest Metra line is beyond 1/8 mile & within 1/4 mile	0.112	0.315	0	1
MtraL1412	Distance to the nearest Metra line is beyond 1/4 mile & within 1/2 mile	0.176	0.381	0	1
ExpHalfM	Distance to the nearest expressway is within one half mile	0.185	0.389	0	1
ArtHalfM	Distance to the nearest major arterial is within one half mile	0.094	0.292	0	1
Mi_2CBD	Distance to the center of the central business district (CBD) (in mile)	8.740	2.918	0.858	16.639
AI_Atopp12	Auto accessibility index to aggregated opportunities	0.336	0.084	0.119	0.551
AI_Ptopp12	Public transit accessibility index to aggregated opportunities	0.180	0.079	0.000	0.398
Number of Observations	14,263				

Table 8-4 Variable Descriptive Statistics for Multi-Family Homes

Variables	Description	Mean	S.D.	Min	Max
Sale_Amt	Property sales amount (in $2004)	401,448	176,300	58,000	1,325,000
Property Attributes					
Bsqft	Building area (square feet)	2,729	1,133	920	11,142
Lsqft	Land lot size (square feet)	3,680	954	1,001	12,318
Mid_Stry	1.5 to 1.9 stories	0.046	0.210	0	1
Two_Stry	Two stories	0.798	0.401	0	1
Tre_Stry	Three stories	0.146	0.353	0	1
Tre_Apt	Three apartments in the building	0.230	0.421	0	1
Four_Apt	Four apartments in the building	0.063	0.244	0	1
Five_Apt	Five apartments in the building	0.005	0.072	0	1
Six_Apt	Six apartments in the building	0.027	0.161	0	1
Frm_Mas	Frame/Masonry	0.050	0.218	0	1
Mas	Masonry	0.639	0.480	0	1
Stucco	Stucco	0.005	0.072	0	1
Two_Fbth	Two full baths	0.631	0.483	0	1
Tre_Fbth	Three full baths	0.258	0.438	0	1
Fr_Fbth	Four full baths	0.070	0.255	0	1
Fv_Fbth	Five full baths	0.005	0.072	0	1
Six_Fbth	Six full baths	0.029	0.169	0	1
Svn_Fbth	Seven or more full baths	0.000	0.022	0	1
One_Hbth	One half bath	0.053	0.224	0	1
Two_Hbth	Two half bath	0.018	0.131	0	1
Tre_Hbth	Three half bath	0.008	0.089	0	1
Fr_Hbth	Four or more half bath	0.002	0.043	0	1
Bsmt_Apt	Basement: full/partial apartment	0.114	0.318	0	1
Bsmt_Lvg	Basement: full/partial recreation room	0.119	0.324	0	1
Bsmt_Unf	Basement: full/partial unfinished	0.560	0.497	0	1
Bsmt_Crl	Basement: crawl	0.026	0.158	0	1
Attic_Apt	Attic: full/partial apartment	0.049	0.215	0	1
Attic_Lvg	Attic: full/partial living room	0.054	0.225	0	1
Attic_Unf	Attic: full/partial unfinished	0.115	0.319	0	1
A_C	Central air conditioning	0.074	0.262	0	1
One_Fire	One fireplace	0.022	0.148	0	1
Two_Fire	Two or more fireplaces	0.025	0.155	0	1
Grge1	Garage for 1 or 1.5 car (attached/detached)	0.161	0.368	0	1
Grge2	Garage for 2 or 2.5 cars (attached/detached)	0.512	0.500	0	1
Grge3	Garage for 3 or more cars (attached/detached)	0.029	0.168	0	1
Age	Building age	93.497	21.159	1	143
Neighborhood Socioeconomics & Amenities					
Pfall_Q	Distance to the nearest park or forest is not greater than 1/4 mile	0.660	0.474	0	1
Cmtymi	Distance to the nearest cemetery (mile)	2.762	1.931	0.007	7.950
Lakemich	Distance to Lake Michigan is within 1 mile	0.071	0.258	0	1
Schscore	School score (average percent of passing the qualified level in Grades 3, 8, 11) of the nearest school	47.470	13.025	6.620	97.010
Hisratio	Ratio of Hispanic people in 2000 (in census block group)	34.692	30.677	0	97.810
Aaratio	Ratio of African American people in 2000 (in census block group)	26.155	38.948	0	100
Crimeden	Crime density (latest annual count per acre, in census tract)	4.077	2.571	0.140	16.810
Denlow20	Density of residents (persons per acre) with low income (annual earnings<=20K in 1999, in TAZ)	5.212	2.880	0.060	17.740
Denmid35	Density of residents (persons per acre) with middle income (annual earnings >20K, <=35K in 1999, in TAZ)	4.152	1.977	0.080	18.850

Table 8-4 (Continued)

Variables	Description	Mean	S.D.	Min	Max
Denhi35	Density of residents (persons per acre) with high income (annual earnings > 35K in 1999, in TAZ)	4.687	4.523	0.020	47.230
Denoall	Density of all opportunities (in TAZ, 1999)	6.204	4.592	0.340	92.010
Odi	Opportunity diversity index (in TAZ, 1999)	0.220	0.084	0.020	0.750
Tif_Res	In the TIF district for residential use	0.000	0.022	0	1
Tif_Mix	In the TIF district for mixed use	0.117	0.322	0	1
Tif_Com	In the TIF district for commercial use	0.002	0.043	0	1
Tif_Ind	In the TIF district for industrial use	0.016	0.126	0	1
Transportation & Accessibility					
Bstp_18	Within 0.125 mile distance to the CTA bus stops	0.674	0.469	0	1
Cta_Q_Im	Walk impedance measure to the nearest CTA station (=1 while within a quarter mile boundary & continuous further away)	0.487	0.311	0.000	1
Ctal_G18	Distance to the nearest CTA line (above ground) is within 1/8 mile	0.030	0.170	0	1
Ctal_G1814	Distance to the nearest CTA line (above ground) is beyond 1/8 mile & within 1/4 mile	0.055	0.229	0	1
Ctal_L18	Distance to the nearest CTA line (elevated) is within 1/8 mile	0.052	0.222	0	1
Ctal_L1814	Distance to the nearest CTA line (elevated) is beyond 1/8 mile & within 1/4 mile	0.064	0.246	0	1
Mtra_18	Distance to the nearest Metra station is within 1/8 mile	0.005	0.069	0	1
Mtra_1814	Distance to the nearest Metra station is beyond 1/8 mile & within 1/4 mile	0.028	0.166	0	1
Mtra_1412	Distance to the nearest Metra station is beyond 1/4 mile & within 1/2 mile	0.107	0.309	0	1
Mtra_12T1	Distance to the nearest Metra station is beyond 1/2 mile & within 1 mile	0.283	0.450	0	1
Mtra_1T2	Distance to the nearest Metra station is beyond 1 mile & within 2 mile	0.437	0.496	0	1
Mtra_2T3	Distance to the nearest Metra station is beyond 2 mile & within 3 mile	0.087	0.282	0	1
Mtral_18	Distance to the nearest Metra line is within 1/8 mile	0.081	0.273	0	1
Mtral1814	Distance to the nearest Metra line is beyond 1/8 mile & within 1/4 mile	0.154	0.361	0	1
Mtral1412	Distance to the nearest Metra line is beyond 1/4 mile & within 1/2 mile	0.245	0.430	0	1
Exphalfm	Distance to the nearest expressway is within one half mile	0.212	0.409	0	1
Arthalfm	Distance to the nearest major arterial is within one half mile	0.078	0.268	0	1
Mi_2Cbd	Distance to the center of the central business district (in mile)	6.524	2.275	1.808	16.616
Ai_Atopp12	Auto accessibility index to aggregated opportunities	0.396	0.065	0.132	0.537
Ai_Ptopp12	Public transit accessibility index to aggregated opportunities	0.245	0.066	0.011	0.385
No. of Obs.	2,112*				

*Note: The observations of multi-family homes (MFHs) listed here are filtered by the authors from the 2004 MFH sales (including partial and complete building transactions), whose sales-to-assessed value ratio, more specifically the ratio of their 2004 sales value to their 2006 (which is the most closed to 2004 and available) assessed value, is between 9 and 11. We observed that, from the records of all MFHs sold in 2004, the ratio [2004 Market Transaction Value/ 2006 (or 07 or 08) Assessed Building Value] with value 10 is most frequently repeated, which fits the Cook County Assessor's assessment that estimated market value of a building equals to 10 times of the assessed building value. We believe that, with a sales-to-assessed value ratio ranging between 9 and 11, the sold MFH should be a whole building instead of a partial MFH building.

Table 8-5 Variable Descriptive Statistics for Vacant Land

Variables	Description	Mean	S.D.	Min	Max
S_04p	Land sales amount (in $2004)	209,958	293,523	9,832	1,998,632
Land Attributes					
LSqFt	Land lot size (square feet)	4,544	6,277	135	88,226
Neighborhood Socioeconomics & Amenities					
PFAll_E	Distance to the nearest park or forest is not greater than 1/8 mile	0.672	0.469	0	1
CmtyMi	Distance to the nearest cemetery (mile)	3.474	1.850	0.020	8.340
LakeMich	Distance to Lake Michigan is within 1 mile	0.093	0.290	0	1
SCHScore	School score (average percent of passing the qualified level in Grades 3, 8, 11) of the nearest school	43.067	13.595	6.625	99.761
HISRATIO	Ratio of Hispanic people in 2000 (in census block group)	15.974	27.283	0	97.940
AARATIO	Ratio of African American people in 2000 (in census block group)	70.868	40.424	0	100
CRIMEDEN	Crime density (latest annual count per acre, in census tract)	4.763	2.931	0.022	16.816
DenLow20	Density of residents (persons per acre) with low income (annual earnings<=20K in 1999, in TAZ)	3.079	2.247	0	17.745
DenMid35	Density of residents (persons per acre) with middle income (annual earnings >20k, <=35K in 1999, in TAZ)	2.151	1.532	0	18.851
DenHI35	Density of residents (persons per acre) with high income (annual earnings > 35K in 1999, in TAZ)	2.020	2.622	0	47.234
DenOAll	Density of all opportunities (in TAZ, 1999)	5.222	24.218	0.039	743.388
ODI	Opportunity diversity index (in TAZ, 1999)	0.240	0.102	0	0.760
TIF_Res	In the TIF district for residential use	0.010	0.100	0	1
TIF_Mix	In the TIF district for mixed use	0.390	0.488	0	1
TIF_Com	In the TIF district for commercial use	0.003	0.057	0	1
TIF_Ind	In the TIF district for industrial use	0.073	0.261	0	1
Z_BusCom	Zoning is restricted to business and commercial use	0.002	0.049	0	1
Z_Manuf	Zoning is restricted to manufacturing use	0.104	0.306	0	1
Z_Res	Zoning is restricted to residential use	0.672	0.469	0	1
MinLot25	Zoning minimum lot size restricts that land lot size is between 2,500 and 5,000 square feet	0.384	0.486	0	1
MinLot5k	Zoning minimum lot size restricts that land lot size is no less than 5,000 square feet	0.105	0.306	0	1
Far2	Zoning requires that FAR is between 2 and 3	0.229	0.420	0	1
Far3_5	Zoning requires that FAR is between 3 and 5	0.052	0.222	0	1

Table 8-5 (Continued)

Variables	Description	Mean	S.D.	Min	Max
Transportation & Accessibility					
BStp_18	Within 0.125 mile distance to the CTA bus stop	0.727	0.446	0	1
CTA_Q_Im	Walk impedance measure to the nearest CTA station(=1 while within a quarter mile boundary & continuous further away)	0.468	0.330	0	1
CTAL_G18	Distance to the nearest CTA line (above-ground) is within 1/8 mile	0.053	0.225	0	1
CTAL_G1814	Distance to the nearest CTA line (above-ground) is beyond 1/8 mile & within 1/4 mile	0.052	0.222	0	1
CTAL_G1412	Distance to the nearest CTA line (above-ground) is beyond 1/4 mile & within 1/2 mile	0.067	0.250	0	1
CTAL_L18	Distance to the nearest CTA line (elevated) is within 1/8 mile	0.063	0.244	0	1
CTAL_L1814	Distance to the nearest CTA line (elevated) is beyond 1/8 mile & within 1/4 mile	0.073	0.261	0	1
CTAL_L1412	Distance to the nearest CTA line (elevated) is beyond 1/4 mile & within 1/2 mile	0.119	0.324	0	1
Mtra_18	Distance to the nearest Metra station is within 1/8 mile	0.016	0.126	0	1
Mtra_1814	Distance to the nearest Metra station is beyond 1/8 mile & within 1/4 mile	0.058	0.233	0	1
Mtra_1412	Distance to the nearest Metra station is beyond 1/4 mile & within 1/2 mile	0.113	0.317	0	1
Mtra_12t1	Distance to the nearest Metra station is beyond 1/2 mile & within 1 mile	0.209	0.406	0	1
Mtra_1t2	Distance to the nearest Metra station is beyond 1 mile & within 2 mile	0.372	0.483	0	1
Mtra_2t3	Distance to the nearest Metra station is beyond 2 mile & within 3 mile	0.144	0.351	0	1
MtraL_18	Distance to the nearest Metra line is within 1/8 mile	0.138	0.345	0	1
MtraL1814	Distance to the nearest Metra line is beyond 1/8 mile & within 1/4 mile	0.154	0.361	0	1
MtraL1412	Distance to the nearest Metra line is beyond 1/4 mile & within 1/2 mile	0.205	0.404	0	1
ExpHalfM	Distance to the nearest expressway is within one half mile	0.293	0.455	0	1
ArtHalfM	Distance to the nearest major arterial is within one half mile	0.076	0.264	0	1
Mi_2CBD	Distance to the center of the central business district (CBD) (in mile)	7.189	3.220	0.049	16.618
AI_Atopp12	Auto accessibility index to aggregated opportunities	0.362	0.097	0.119	0.551
AI_Ptopp12	Public transit accessibility index to aggregated opportunities	0.211	0.080	0.000	0.409
Number of Observations	3,344				

Table 8-6 Variable Descriptive Statistics for Commercial Properties

Variables	Description	Mean	S.D.	Min	Max
Price04	Property sales amount (in $2004)	13,900,000	60,300,000	127,174	840,000,000
Property Attributes					
BSqFt	Building area (square feet)	91,341	281,260	1,200	3,781,045
Two_Stry	Two stories (1=Yes, 0=No)	0.277	0.448	0	1
TrFr_Str	Three to four stories (1=Yes, 0=No)	0.243	0.429	0	1
Fv_Stry	Five and more stories (1=Yes, 0=No)	0.206	0.405	0	1
BdgCls_A	Building class* is A	0.084	0.277	0	1
BdgCls_B	Building class* is B	0.345	0.476	0	1
CNER	The property is located in block corner	0.332	0.471	0	1
RETAILUSE	Property type is retail	0.050	0.217	0	1
HOSTLUSE	Property type is hospitality	0.076	0.265	0	1
Mas	Building frame material is masonry	0.527	0.500	0	1
Metal	Building frame material is metal	0.008	0.088	0	1
RCncrt	Building frame material is reinforced concrete	0.094	0.292	0	1
Steel	Building frame material is steel	0.055	0.228	0	1
WoodF	Building frame material is wood	0.008	0.088	0	1
PkRatio	Parking ratio (# of parking spaces per 1,000 building sq ft)	2.987	2.612	0.021	25.000
Age	Age (Year Sale- Year Built)	37.554	25.327	-2	118
Neighborhood Socioeconomics & Amenities					
LakeMich	Distance to Lake Michigan is within one mile	0.117	0.322	0	1
HISRATIO	Ratio of Hispanic people in 2000 (in census block group)	13.333	17.847	0.000	90.456
AARATIO	Ratio of African American people in 2000 (in census BG)	12.716	24.830	0.000	99.678
POPDEN00	Population density in 2000 (persons per acre, census BG)	12.740	13.592	0.000	75.338
DenOAll	Density of all opportunities (in TAZ, 1999)	64.236	206.628	0.077	1,319.259
ODI	Opportunity diversity index (in TAZ, 1999)	0.399	0.161	0.033	0.791
Transportation & Accessibility					
Pace_Sp18	Within 0.125 mile distance to the PACE bus stop	0.347	0.477	0	1
CTA_Q_Im	Walk impedance to the nearest CTA station(=1 while within a quarter mile boundary & continuous further away)	0.304	0.399	0	1
Mtra_18	Distance to the nearest Metra station is within 1/8 mile	0.042	0.200	0	1
Mtra_1814	Distance to the nearest Metra station is beyond 1/8 mile & within 1/4 mile	0.070	0.256	0	1
Mtra_1412	Distance to the nearest Metra station is beyond 1/4 mile & within 1/2 mile	0.128	0.334	0	1
ExpHalfM	Distance to the nearest expressway is within 1 half mile	0.405	0.491	0	1
ArtHalfM	Distance to the nearest major arterial is within 1 half mile	0.191	0.393	0	1
Mi_2CBD	Distance to the center of the CBD (in mile)	12.493	7.254	0.056	24.452
AI_Atopp12	Auto accessibility index to aggregated opportunities	0.319	0.128	0.080	0.556
AI_Ptopp12	Public transit accessibility index to aggregated opportunities	0.127	0.139	0.000	0.399
No. of Obs.	383				

*The office building classes represent a combination of a subjective and objective quality rating of buildings that indicates the competitive ability of each building to attract similar types of tenants. CoStar groups office buildings into four classes. The options are Class A, B, C, or F, with assignment depending on a variety of building characteristics, such as total rentable area, age, building finishes and materials, mechanical systems standards and efficiencies, developer, architect, building features, location/accessibility, property manager, design/tenant layout, and much more. Once assigned, a building's class reflects not only characteristics and attributes evaluated objectively, but also the subjective evaluations of finishes and amenities.

8.4. Model Estimation Results: Single Family Homes, Multi-Family Homes, Vacant Land, and Commercial Properties

Table 8-7 Robust OLS Regression Models for Single Family Homes (LN [Sale amount in $2004])

Variables	Robust OLS Model 1				Robust OLS Model 2				Robust OLS Model 3				Robust OLS Model 4			
	Coef.	Std. Err.	t		Coef.	Std. Err.	t		Coef.	Std. Err.	t		Coef.	Std. Err.	t	
CONSTANT	8.404	0.156	53.880	*	8.847	0.150	58.930	*	7.655	0.152	50.510	*	7.670	0.151	50.840	*
Property Attributes																
LN_BSQFT	0.447	0.017	26.560	*	0.391	0.016	24.080	*	0.399	0.016	24.700	*	0.393	0.016	24.310	*
LN_LSQFT	0.065	0.014	4.640	*	0.152	0.014	11.130	*	0.132	0.014	9.660	*	0.145	0.014	10.560	*
MID_STRY	-0.040	0.014	-2.890	*	-0.035	0.013	-2.690	*	-0.047	0.013	-3.670	*	-0.045	0.013	-3.490	*
TWO_STRY	-0.020	0.010	-1.920	***	-0.016	0.010	-1.640		-0.018	0.010	-1.770	***	-0.017	0.010	-1.730	***
TRE_STRY	0.103	0.032	3.190	*	0.061	0.030	2.000	**	0.060	0.030	1.990	**	0.054	0.030	1.790	***
MULT_LVL	0.016	0.021	0.790		0.052	0.021	2.540	**	0.049	0.020	2.420	**	0.046	0.020	2.260	**
FRM_MAS	0.036	0.013	2.910	*	0.033	0.012	2.770	*	0.034	0.012	2.900	*	0.039	0.012	3.350	*
MAS	0.079	0.009	9.000	*	0.060	0.008	7.020	*	0.064	0.008	7.610	*	0.069	0.008	8.170	*
STUCCO	0.019	0.026	0.700		0.032	0.025	1.270		0.035	0.026	1.350		0.038	0.026	1.460	
TWO_FBTH	0.039	0.010	4.000	*	0.031	0.009	3.330	*	0.036	0.009	3.870	*	0.033	0.009	3.540	*
TRE_FBTH	0.140	0.023	6.220	*	0.113	0.021	5.340	*	0.137	0.022	6.310	*	0.129	0.022	5.990	*
ONE_HBTH	0.014	0.008	1.750	***	0.015	0.007	2.030	**	0.016	0.007	2.110	**	0.015	0.007	2.050	**
BSMT_APT	-0.178	0.126	-1.420		-0.222	0.079	-2.820	*	-0.188	0.082	-2.290	**	-0.181	0.080	-2.270	**
BSMT_LVG	-0.056	0.012	-4.550	*	-0.041	0.012	-3.490	*	-0.027	0.012	-2.300	**	-0.031	0.012	-2.650	*
BSMT_UNF	-0.061	0.011	-5.610	*	-0.040	0.010	-3.780	*	-0.031	0.010	-2.970	*	-0.035	0.010	-3.360	*
BSMT_CRL	-0.251	0.024	-10.620	*	-0.242	0.023	-10.720	*	-0.199	0.021	-9.280	*	-0.202	0.022	-9.380	*
ATTI_APT	0.007	0.047	0.150		0.030	0.041	0.740		0.021	0.052	0.400		0.016	0.048	0.340	
ATTI_LIV	-0.037	0.014	-2.730	*	-0.033	0.013	-2.530	**	-0.038	0.013	-2.960	*	-0.037	0.013	-2.920	*
ATTI_UNF	-0.002	0.008	-0.250		0.004	0.007	0.570		0.005	0.007	0.660		0.005	0.007	0.700	
A_C	0.046	0.007	6.440	*	0.033	0.007	4.830	*	0.031	0.007	4.500	*	0.029	0.007	4.340	*
ONE_FIRE	0.071	0.012	5.960	*	0.063	0.011	5.570	*	0.066	0.011	5.770	*	0.063	0.011	5.580	*
TWO_FIRE	0.090	0.027	3.310	*	0.063	0.026	2.450	**	0.074	0.026	2.870	*	0.070	0.026	2.730	*
GRGE1	0.052	0.009	5.870	*	0.051	0.008	5.970	*	0.041	0.008	4.900	*	0.043	0.008	5.110	*
GRGE2	0.064	0.008	7.580	*	0.063	0.008	7.850	*	0.060	0.008	7.500	*	0.060	0.008	7.500	*
GRGE3	0.029	0.055	0.520		0.037	0.052	0.700		0.036	0.054	0.670		0.034	0.053	0.640	
AGE	0.000	0.000	-1.120		-0.001	0.000	-4.050	*	-0.001	0.000	-3.800	*	-0.001	0.000	-4.360	*
ROW_HSE	-0.181	0.020	-9.220	*	-0.150	0.018	-8.120	*	-0.143	0.019	-7.720	*	-0.145	0.018	-7.910	*
Neighborhood Socioeconomics & Amenities																
PFALL_E	0.041	0.007	5.480	*	0.020	0.007	2.800	*	0.026	0.007	3.660	*	0.023	0.007	3.320	*
CMTYMI	-0.036	0.003	-14.070	*	-0.040	0.002	-17.370	*	-0.041	0.002	-17.740	*	-0.038	0.002	-16.600	*
LAKEMICH	-0.023	0.020	-1.150		0.001	0.018	0.040		0.049	0.019	2.630	*	0.057	0.019	3.030	*
SCHSCORE	0.001	0.000	3.190	*	0.001	0.000	6.010	*	0.001	0.000	4.250	*	0.001	0.000	4.300	*
HISRATIO	-0.003	0.000	-13.840	*	-0.004	0.000	-22.120	*	-0.003	0.000	-14.790	*	-0.003	0.000	-16.330	*
AARATIO	-0.008	0.000	-59.370	*	-0.008	0.000	-62.000	*	-0.007	0.000	-46.610	*	-0.007	0.000	-48.050	*
CRIMEDEN	-0.007	0.003	-2.710	*	-0.018	0.002	-7.330	*	-0.023	0.003	-9.250	*	-0.023	0.002	-9.260	*
DENLOW20	-0.005	0.003	-1.630		-0.007	0.003	-2.310	**	-0.006	0.003	-2.200	**	-0.005	0.003	-1.810	***
DENMID35	0.021	0.005	4.710	*	0.014	0.004	3.390	*	0.009	0.004	2.110	**	0.002	0.004	0.460	
DENHI35	0.017	0.002	8.270	*	0.013	0.002	7.630	*	0.019	0.002	10.640	*	0.017	0.002	10.230	*
DENOALL	0.011	0.001	8.310	*	0.007	0.001	6.360	*	0.007	0.001	6.090	*	0.006	0.001	5.590	*

Table 8-7 (Continued)

Variables	Robust OLS Model 1				Robust OLS Model 2				Robust OLS Model 3				Robust OLS Model 4			
	Coef.	Std. Err.	t		Coef.	Std. Err.	t		Coef.	Std. Err.	t		Coef.	Std. Err.	t	
ODI	0.112	0.042	2.630	*	-0.015	0.039	-0.380		0.050	0.039	1.260		0.000	0.039	-0.010	
TIF_RES	0.333	0.117	2.840	*	0.391	0.070	5.550	*	0.378	0.070	5.410	*	0.400	0.065	6.120	*
TIF_MIX	0.004	0.017	0.210		-0.054	0.017	-3.110	*	-0.067	0.017	-3.900	*	-0.067	0.017	-3.860	*
TIF_COM	0.212	0.065	3.280	*	0.132	0.062	2.130	**	0.049	0.063	0.780		0.081	0.062	1.300	
TIF_IND	-0.004	0.031	-0.130		-0.063	0.031	-2.060	**	-0.088	0.030	-2.900	*	-0.086	0.030	-2.880	*
Transportation & Accessibility																
BSTP_18	0.001	0.006	0.140		-0.010	0.006	-1.770	***	-0.013	0.006	-2.240	**	-0.016	0.006	-2.720	*
CTA_Q_IM	0.401	0.020	19.920	*	0.161	0.020	8.080	*	0.190	0.020	9.630	*	0.095	0.022	4.250	*
CTAL_G18	-0.167	0.025	-6.790	*	-0.106	0.025	-4.250	*	-0.133	0.025	-5.340	*	-0.124	0.025	-4.950	*
CTAL_G1814	-0.110	0.020	-5.360	*	-0.060	0.020	-2.940	*	-0.091	0.020	-4.520	*	-0.081	0.020	-4.010	*
CTAL_G1412	-0.059	0.015	-3.950	*	-0.036	0.015	-2.480	**	-0.053	0.015	-3.610	*	-0.044	0.015	-2.980	*
CTAL_L18	-0.083	0.029	-2.850	*	0.013	0.029	0.460		0.005	0.029	0.190		0.036	0.029	1.230	
CTAL_L1814	-0.052	0.024	-2.190	**	0.030	0.023	1.310		0.028	0.023	1.200		0.057	0.023	2.430	**
CTAL_L1412	-0.012	0.018	-0.700		0.016	0.017	0.980		0.018	0.017	1.080		0.035	0.017	2.050	**
MTRA_18	0.231	0.043	5.360	*	0.333	0.043	7.740	*	0.263	0.042	6.250	*	0.259	0.042	6.170	*
MTRA_1814	0.341	0.028	12.320	*	0.434	0.027	16.200	*	0.359	0.027	13.390	*	0.350	0.027	13.090	*
MTRA_1412	0.317	0.022	14.470	*	0.381	0.021	17.780	*	0.301	0.022	13.960	*	0.295	0.022	13.710	*
MTRA_12T1	0.293	0.018	15.940	*	0.328	0.018	18.190	*	0.255	0.018	13.940	*	0.258	0.018	14.120	*
MTRA_1T2	0.232	0.018	13.280	*	0.242	0.017	14.000	*	0.190	0.018	10.770	*	0.199	0.018	11.290	*
MTRA_2T3	0.101	0.017	5.960	*	0.122	0.017	7.210	*	0.121	0.017	7.030	*	0.130	0.017	7.530	*
MTRAL_18	-0.015	0.015	-0.980		-0.068	0.015	-4.570	*	-0.056	0.015	-3.790	*	-0.071	0.015	-4.800	*
MTRAL1814	0.018	0.013	1.320		-0.039	0.013	-3.000	*	-0.033	0.013	-2.520	**	-0.049	0.013	-3.770	*
MTRAL1412	0.031	0.011	2.930	*	-0.005	0.010	-0.470		-0.001	0.010	-0.080		-0.005	0.010	-0.520	
EXPHALFM	-0.053	0.010	-5.030	*	-0.033	0.010	-3.280	*	-0.043	0.010	-4.320	*	-0.042	0.010	-4.200	*
ARTHALFM	0.011	0.013	0.860		0.035	0.012	2.950	*	0.051	0.012	4.370	*	0.050	0.012	4.300	*
MI_2CBD	--	--	--		-0.063	0.002	-29.850	*	--	--	--		--	--	--	
AI_ATOPP12	--	--	--		--	--	--		2.113	0.062	34.070	*	1.571	0.081	19.370	*
AI_PTOPP12	--	--	--		--	--	--		--	--	--		1.020	0.111	9.210	*
Diagnostics for Spatial Dependence																
Test		***Statistic***	***p-value***			***Statistic***	***p-value***			***Statistic***	***p-value***			***Statistic***	***p-value***	
LM-Lag		612.18	0.00			364.38	0.00			343.92	0.00			324.26	0.00	
LM-Error		3836.44	0.00			2209.36	0.00			1809.27	0.00			1696.72	0.00	
Robust LM-Lag		83.16	0.00			58.65	0.00			69.48	0.00			66.32	0.00	
Robust LM-Error		3307.41	0.00			1903.62	0.00			1534.84	0.00			1438.79	0.00	
Summary Statistics																
Observation No.		14,263				14,263				14,263				14,263		
R-squared		0.7029				0.7253				0.7291				0.7308		
Adj R-squared		0.7016				0.7241				0.7279				0.7296		
Log Likelihood		-5475.33				-4916.06				-4816.35				-4772.11		
Akaike info		11076.70				9960.11				9760.70				9674.21		

* Significant< 1%; ** Significant < 5%; ***Significant < 10%

Table 8-8 Spatial Error Models for Single Family Homes (LN [Sale amount in $2004])

Variables	Spatial Error Model 1				Spatial Error Model 2				Spatial Error Model 3				Spatial Error Model 4			
	Coef.	Std. Err.	z-value		Coef.	Std. Err.	z-value		Coef.	Std. Err.	z-value		Coef.	Std. Err.	z-value	
LAMBDA	0.639	0.012	53.470	*	0.539	0.014	37.839	*	0.524	0.015	35.881	*	0.513	0.015	34.583	*
CONSTANT	8.776	0.136	64.721	*	9.398	0.136	69.058	*	8.053	0.135	59.821	*	8.100	0.135	60.205	*
Property Attributes																
LN_BSQFT	0.341	0.014	24.377	*	0.333	0.014	23.980	*	0.339	0.014	24.422	*	0.338	0.014	24.361	*
LN_LSQFT	0.122	0.012	9.793	*	0.147	0.012	11.948	*	0.140	0.012	11.390	*	0.143	0.012	11.686	*
MID_STRY	-0.043	0.013	-3.307	*	-0.040	0.013	-3.132	*	-0.044	0.013	-3.421	*	-0.044	0.013	-3.404	*
TWO_STRY	-0.037	0.010	-3.641	*	-0.035	0.010	-3.432	*	-0.034	0.010	-3.390	*	-0.035	0.010	-3.435	*
TRE_STRY	0.045	0.025	1.821	***	0.029	0.025	1.171		0.031	0.024	1.271		0.029	0.024	1.166	
MULT_LVL	0.034	0.020	1.747	***	0.042	0.020	2.158	**	0.042	0.020	2.172	**	0.041	0.020	2.075	**
FRM_MAS	0.016	0.011	1.439		0.020	0.011	1.782	***	0.020	0.011	1.825	***	0.023	0.011	2.011	**
MAS	0.048	0.008	6.010	*	0.047	0.008	6.022	*	0.049	0.008	6.258	*	0.051	0.008	6.477	*
STUCCO	0.024	0.023	1.039		0.027	0.023	1.156		0.029	0.023	1.237		0.029	0.023	1.255	
TWO_FBTH	0.044	0.008	5.125	*	0.040	0.008	4.684	*	0.041	0.008	4.826	*	0.040	0.008	4.731	*
TRE_FBTH	0.135	0.018	7.485	*	0.124	0.018	6.869	*	0.131	0.018	7.310	*	0.129	0.018	7.192	*
ONE_HBTH	0.021	0.007	2.836	*	0.020	0.007	2.781	*	0.020	0.007	2.745	*	0.020	0.007	2.736	*
BSMT_APT	-0.204	0.144	-1.411		-0.214	0.145	-1.477		-0.208	0.145	-1.432		-0.205	0.145	-1.411	
BSMT_LVG	-0.022	0.011	-2.030	**	-0.023	0.011	-2.118	**	-0.018	0.011	-1.720	***	-0.020	0.011	-1.863	***
BSMT_UNF	-0.020	0.009	-2.110	**	-0.020	0.009	-2.103	**	-0.017	0.009	-1.844	***	-0.019	0.009	-2.015	**
BSMT_CRL	-0.156	0.023	-6.903	*	-0.163	0.022	-7.298	*	-0.154	0.022	-6.870	*	-0.154	0.022	-6.912	*
ATTI_APT	-0.023	0.147	-0.155		-0.011	0.146	-0.076		-0.008	0.146	-0.052		-0.010	0.146	-0.068	
ATTI_LIV	-0.043	0.012	-3.444	*	-0.041	0.012	-3.320	*	-0.042	0.012	-3.449	*	-0.042	0.012	-3.389	*
ATTI_UNF	-0.002	0.007	-0.255		0.000	0.007	-0.055		0.000	0.007	-0.017		0.000	0.007	0.031	
A_C	0.028	0.008	3.708	*	0.027	0.008	3.514	*	0.026	0.008	3.442	*	0.026	0.008	3.414	*
ONE_FIRE	0.037	0.011	3.423	*	0.037	0.011	3.457	*	0.039	0.011	3.714	*	0.039	0.011	3.703	*
TWO_FIRE	0.025	0.020	1.244		0.019	0.020	0.957		0.026	0.020	1.311		0.025	0.020	1.279	
GRGE1	0.034	0.008	4.328	*	0.036	0.008	4.603	*	0.034	0.008	4.258	*	0.034	0.008	4.331	*
GRGE2	0.049	0.007	6.729	*	0.051	0.007	7.015	*	0.049	0.007	6.838	*	0.049	0.007	6.854	*
GRGE3	-0.015	0.035	-0.425		-0.010	0.034	-0.294		-0.006	0.034	-0.176		-0.008	0.034	-0.225	
AGE	0.000	0.000	-2.751	*	-0.001	0.000	-3.986	*	-0.001	0.000	-3.813	*	-0.001	0.000	-4.078	*
ROW_HSE	-0.196	0.017	-11.491	*	-0.186	0.017	-11.034	*	-0.181	0.017	-10.774	*	-0.183	0.017	-10.891	*
Neighborhood Socioeconomics & Amenities																
PFALL_E	0.036	0.008	4.495	*	0.026	0.008	3.385	*	0.029	0.008	3.742	*	0.028	0.008	3.635	*
CMTYMI	-0.042	0.005	-8.118	*	-0.048	0.004	-11.657	*	-0.047	0.004	-11.617	*	-0.044	0.004	-11.103	*
LAKEMICH	0.052	0.029	1.761	***	0.036	0.025	1.412		0.083	0.025	3.322	*	0.082	0.025	3.344	*
SCHSCORE	0.001	0.000	1.729	***	0.001	0.000	3.163	*	0.001	0.000	2.320	**	0.001	0.000	2.431	**
HISRATIO	-0.003	0.000	-7.623	*	-0.004	0.000	-13.143	*	-0.003	0.000	-9.474	*	-0.003	0.000	-10.222	*
AARATIO	-0.008	0.000	-31.520	*	-0.008	0.000	-37.768	*	-0.007	0.000	-30.874	*	-0.007	0.000	-31.821	*
CRIMEDEN	-0.003	0.003	-0.997		-0.013	0.003	-4.420	*	-0.016	0.003	-5.417	*	-0.016	0.003	-5.548	*
DENLOW20	-0.004	0.005	-0.960		-0.006	0.004	-1.407		-0.007	0.004	-1.572		-0.006	0.004	-1.427	
DENMID35	0.003	0.007	0.445		0.003	0.006	0.484		-0.001	0.006	-0.126		-0.005	0.006	-0.826	
DENHI35	0.020	0.003	7.370	*	0.015	0.002	6.089	*	0.020	0.002	8.513	*	0.018	0.002	7.931	*
DENOALL	0.008	0.002	5.168	*	0.005	0.001	3.897	*	0.006	0.001	4.152	*	0.005	0.001	3.859	*

Table 8-8 (Continued)

Variables	Spatial Error Model 1				Spatial Error Model 2				Spatial Error Model 3				Spatial Error Model 4			
	Coef.	Std. Err.	z-value		Coef.	Std. Err.	z-value		Coef.	Std. Err.	z-value		Coef.	Std. Err.	z-value	
ODI	0.081	0.061	1.333		-0.016	0.056	-0.294		0.017	0.055	0.302		-0.024	0.055	-0.444	
TIF_RES	0.164	0.137	1.195		0.222	0.136	1.630		0.219	0.136	1.613		0.233	0.136	1.718	***
TIF_MIX	-0.027	0.016	-1.718	***	-0.046	0.015	-3.096	*	-0.050	0.015	-3.347	*	-0.050	0.015	-3.380	*
TIF_COM	0.061	0.069	0.881		0.056	0.068	0.816		0.033	0.068	0.479		0.042	0.068	0.611	
TIF_IND	-0.024	0.027	-0.905		-0.044	0.026	-1.668	***	-0.054	0.026	-2.038	**	-0.054	0.026	-2.041	**
Transportation & Accessibility																
BSTP_18	-0.004	0.007	-0.655		-0.009	0.006	-1.333		-0.010	0.006	-1.547		-0.011	0.006	-1.711	***
CTA_Q_IM	0.494	0.034	14.394	*	0.195	0.033	5.972	*	0.229	0.031	7.373	*	0.150	0.034	4.441	*
CTAL_G18	-0.192	0.034	-5.658	*	-0.129	0.031	-4.112	*	-0.157	0.031	-5.100	*	-0.150	0.030	-4.908	*
CTAL_G1814	-0.125	0.029	-4.288	*	-0.073	0.027	-2.718	*	-0.099	0.026	-3.751	*	-0.093	0.026	-3.546	*
CTAL_G1412	-0.055	0.021	-2.585	*	-0.037	0.020	-1.868	***	-0.051	0.019	-2.619	*	-0.048	0.019	-2.487	**
CTAL_L18	-0.081	0.035	-2.314	**	-0.013	0.032	-0.406		-0.020	0.032	-0.612		-0.002	0.032	-0.061	
CTAL_L1814	-0.056	0.030	-1.845	***	0.004	0.028	0.161		0.003	0.027	0.107		0.019	0.027	0.703	
CTAL_L1412	-0.014	0.022	-0.647		0.001	0.020	0.062		0.004	0.020	0.209		0.012	0.020	0.628	
MTRA_18	0.231	0.049	4.752	*	0.307	0.045	6.884	*	0.248	0.044	5.639	*	0.241	0.044	5.537	*
MTRA_1814	0.330	0.039	8.408	*	0.401	0.035	11.551	*	0.337	0.034	9.917	*	0.330	0.034	9.806	*
MTRA_1412	0.295	0.035	8.463	*	0.349	0.030	11.501	*	0.285	0.030	9.584	*	0.281	0.029	9.582	*
MTRA_12T1	0.277	0.031	8.814	*	0.306	0.027	11.388	*	0.245	0.026	9.294	*	0.246	0.026	9.489	*
MTRA_1T2	0.228	0.030	7.537	*	0.234	0.026	9.003	*	0.187	0.025	7.333	*	0.193	0.025	7.702	*
MTRA_2T3	0.126	0.029	4.411	*	0.128	0.025	5.068	*	0.120	0.025	4.871	*	0.126	0.024	5.162	*
MTRAL_18	-0.013	0.021	-0.606		-0.053	0.019	-2.802	*	-0.046	0.018	-2.519	**	-0.059	0.018	-3.215	*
MTRAL1814	0.000	0.018	0.025		-0.036	0.016	-2.225	**	-0.031	0.016	-1.923	***	-0.043	0.016	-2.697	*
MTRAL1412	0.021	0.014	1.508		-0.002	0.013	-0.122		0.000	0.013	0.014		-0.004	0.013	-0.300	
EXPHALFM	-0.038	0.016	-2.330	**	-0.027	0.014	-1.906	***	-0.036	0.014	-2.517	**	-0.036	0.014	-2.545	**
ARTHALFM	-0.001	0.022	-0.023		0.030	0.019	1.601		0.050	0.019	2.677	*	0.049	0.018	2.682	*
MI_2CBD	--	--	--		-0.066	0.003	-20.378	*	--	--	--		--	--	--	
AI_ATOPP12	--	--	--		--	--	--		2.228	0.101	22.144	*	1.694	0.138	12.315	*
AI_PTOPP12	--	--	--		--	--	--		--	--	--		0.924	0.167	5.525	*
Summary Statistics																
Observation No.		14,263				14,263				14,263				14,263		
R-squared		0.7503				0.7533				0.7538				0.7541		
Adj R-squared		--				--				--				--		
Log Likelihood		-4489.55				-4316.76				-4290.74				-4275.78		
Akaike info criterion		9105.11				8761.52				8709.48				8681.56		

* Significant< 1%; ** Significant < 5%; ***Significant < 10%

Table 8-9 Robust OLS Regression Models for Multi-Family Homes (LN [Sale amount in $2004])

	Robust OLS Model 1				**Robust OLS Model 2**				**Robust OLS Model 3**				**Robust OLS Model 4**			
Variable	Coef.	Std. Err.	t		Coef.	Std. Err.	t		Coef.	Std. Err.	t		Coef.	Std. Err	t	
CONSTANT	9.601	0.266	36.140	*	9.617	0.229	41.910	*	8.513	0.231	36.930	*	8.542	0.229	37.250	*
Property Attributes																
LN_BSQFT	0.266	0.026	10.410	*	0.266	0.023	11.750	*	0.275	0.022	12.320	*	0.273	0.022	12.320	*
LN_LSQFT	0.089	0.024	3.690	*	0.177	0.022	8.070	*	0.156	0.021	7.380	*	0.158	0.021	7.500	*
MID_STRY	0.091	0.058	1.560		0.055	0.053	1.050		0.027	0.050	0.530		0.027	0.050	0.530	
TWO_STRY	0.149	0.054	2.770	*	0.097	0.050	1.950	***	0.075	0.046	1.620		0.074	0.047	1.580	
TRE_STRY	0.206	0.060	3.410	*	0.148	0.056	2.660	*	0.128	0.052	2.460	**	0.128	0.052	2.450	**
TRE_APT	-0.001	0.023	-0.060		0.009	0.022	0.400		0.016	0.020	0.810		0.017	0.020	0.840	
FOUR_APT	0.012	0.046	0.260		0.002	0.042	0.050		0.002	0.041	0.040		0.003	0.040	0.070	
FIVE_APT	-0.034	0.123	-0.280		0.031	0.092	0.340		0.002	0.075	0.020		0.011	0.080	0.130	
SIX_APT	-0.031	0.062	-0.500		-0.075	0.056	-1.340		-0.073	0.054	-1.340		-0.075	0.054	-1.370	
FRM_MAS	0.009	0.021	0.440		0.003	0.018	0.170		0.003	0.018	0.170		0.004	0.018	0.230	
MAS	0.051	0.012	4.300	*	0.037	0.011	3.450	*	0.044	0.010	4.250	*	0.045	0.010	4.320	*
STUCCO	0.126	0.055	2.290	**	0.069	0.055	1.260		0.074	0.051	1.440		0.070	0.052	1.360	
TWO_FBTH	-0.010	0.062	-0.160		0.004	0.054	0.060		0.002	0.054	0.040		0.006	0.053	0.120	
TRE_FBTH	0.000	0.065	0.000		0.004	0.058	0.070		-0.004	0.057	-0.060		0.000	0.056	0.000	
FR_FBTH	-0.005	0.075	-0.070		0.006	0.066	0.090		0.006	0.065	0.100		0.008	0.064	0.130	
FV_FBTH	0.081	0.125	0.650		0.011	0.100	0.110		0.064	0.091	0.710		0.058	0.092	0.630	
SIX_FBTH	0.118	0.083	1.420		0.120	0.074	1.630		0.122	0.072	1.700	***	0.126	0.071	1.780	***
SVN_FBTH	0.437	0.102	4.280	*	0.534	0.092	5.790	*	0.488	0.091	5.360	*	0.496	0.090	5.500	*
ONE_HBTH	0.020	0.017	1.180		0.021	0.015	1.340		0.022	0.016	1.370		0.021	0.016	1.310	
TWO_HBTH	0.013	0.028	0.450		0.038	0.024	1.560		0.025	0.025	1.000		0.031	0.024	1.250	
TRE_HBTH	-0.057	0.062	-0.930		-0.083	0.056	-1.480		-0.094	0.050	-1.880	***	-0.097	0.050	-1.930	***
FR_HBTH	-0.041	0.053	-0.780		-0.129	0.056	-2.290	**	-0.122	0.058	-2.080	**	-0.136	0.065	-2.110	**
BSMT_APT	0.035	0.021	1.640		0.024	0.020	1.200		0.028	0.019	1.450		0.027	0.019	1.390	
BSMT_LVG	0.027	0.017	1.620		0.025	0.016	1.560		0.025	0.015	1.670	***	0.025	0.015	1.650	***
BSMT_UNF	0.030	0.013	2.270	**	0.029	0.012	2.440	**	0.035	0.012	3.060	*	0.034	0.012	2.950	*
BSMT_CRL	-0.042	0.026	-1.580		-0.045	0.024	-1.840	***	-0.044	0.023	-1.900	***	-0.043	0.023	-1.870	***
ATTIC_APT	0.009	0.029	0.300		0.015	0.026	0.570		0.013	0.026	0.500		0.014	0.026	0.520	
ATTIC_LVG	0.000	0.025	0.000		0.008	0.023	0.330		0.017	0.023	0.720		0.019	0.023	0.840	
ATTIC_UNF	-0.012	0.016	-0.780		-0.008	0.014	-0.530		0.004	0.014	0.260		0.003	0.014	0.240	
A_C	0.035	0.018	1.920	***	0.003	0.017	0.150		0.014	0.017	0.840		0.012	0.017	0.690	
ONE_FIRE	-0.026	0.030	-0.880		-0.018	0.030	-0.590		-0.002	0.030	-0.050		-0.003	0.030	-0.100	
TWO_FIRE	-0.028	0.025	-1.100		-0.035	0.024	-1.450		-0.022	0.024	-0.940		-0.024	0.024	-1.030	
GRGE1	0.005	0.013	0.390		0.015	0.012	1.260		0.014	0.012	1.190		0.014	0.012	1.230	
GRGE2	-0.007	0.011	-0.630		0.003	0.010	0.270		0.003	0.010	0.320		0.004	0.010	0.390	
GRGE3	0.039	0.023	1.710	***	0.054	0.021	2.600	*	0.077	0.020	3.900	*	0.077	0.020	3.890	*
AGE	-0.001	0.000	-1.720	***	-0.002	0.000	-6.140	*	-0.001	0.000	-4.400	*	-0.001	0.000	-4.740	*
Neighborhood Socioeconomics & Amenities																
PFALL_Q	0.026	0.009	2.860	*	-0.001	0.009	-0.120		0.001	0.008	0.090		-0.001	0.008	-0.100	
CMTYMI	-0.036	0.004	-9.740	*	-0.056	0.003	-18.590	*	-0.062	0.003	-21.120	*	-0.059	0.003	-19.310	*
LAKEMICH	-0.129	0.027	-4.760	*	-0.053	0.026	-2.080	**	-0.020	0.025	-0.770		-0.018	0.026	-0.700	
SCHSCORE	0.000	0.000	0.980		0.001	0.000	1.880	***	0.001	0.000	1.890	***	0.001	0.000	1.940	***
HISRATIO	-0.002	0.000	-5.320	*	-0.002	0.000	-7.790	*	-0.002	0.000	-6.270	*	-0.002	0.000	-6.650	*
AARATIO	-0.006	0.000	-21.610	*	-0.006	0.000	-22.510	*	-0.005	0.000	-18.270	*	-0.005	0.000	-18.500	*
CRIMEDEN	0.011	0.003	3.950	*	0.003	0.003	1.130		-0.001	0.003	-0.320		-0.001	0.003	-0.450	

Table 8-9 (Continued)

	Robust OLS Model 1				**Robust OLS Model 2**				**Robust OLS Model 3**				**Robust OLS Model 4**			
Variable	Coef.	Std. Err.	t		Coef.	Std. Err.	t		Coef.	Std. Err.	t		Coef.	Std. Err	t	
DENLOW20	-0.016	0.003	-4.800	*	-0.011	0.003	-3.600	*	-0.008	0.003	-2.560	*	-0.007	0.003	-2.110	**
DENMID35	0.016	0.007	2.420	**	0.008	0.006	1.290		0.001	0.006	0.180		-0.001	0.006	-0.170	
DENHI35	0.025	0.002	10.070	*	0.020	0.002	9.070	*	0.023	0.002	10.160	*	0.022	0.002	10.090	*
DENOALL	0.003	0.001	2.190	**	0.000	0.001	-0.060		0.000	0.001	0.250		0.000	0.001	0.230	
ODI	0.229	0.075	3.050	*	0.171	0.065	2.630	*	0.170	0.070	2.410	**	0.159	0.070	2.280	**
TIF_RES	0.100	0.038	2.650	*	0.196	0.035	5.580	*	0.160	0.034	4.660	*	0.169	0.035	4.890	*
TIF_MIX	0.042	0.016	2.540	**	0.024	0.016	1.560		0.008	0.015	0.500		0.008	0.015	0.530	
TIF_COM	0.070	0.052	1.340		0.068	0.050	1.360		-0.007	0.055	-0.130		0.006	0.056	0.110	
TIF_IND	-0.014	0.050	-0.280		-0.083	0.045	-1.840	***	-0.085	0.042	-2.020	**	-0.087	0.042	-2.080	**
Transportation & Accessibility																
BSTP_18	0.010	0.008	1.170		0.003	0.008	0.440		0.004	0.008	0.560		0.004	0.008	0.470	
CTA_Q_IM	0.197	0.021	9.350	*	0.089	0.019	4.650	*	0.113	0.018	6.130	*	0.091	0.020	4.540	*
CTAL_G18	-0.078	0.029	-2.740	*	-0.057	0.028	-1.990	**	-0.072	0.026	-2.710	*	-0.077	0.027	-2.890	*
CTAL_G1814	-0.013	0.018	-0.740		-0.008	0.017	-0.470		-0.021	0.017	-1.280		-0.025	0.017	-1.520	
CTAL_L18	-0.023	0.025	-0.910		0.006	0.024	0.240		-0.006	0.023	-0.240		-0.002	0.023	-0.090	
CTAL_L1814	-0.002	0.020	-0.120		0.027	0.019	1.400		0.019	0.019	1.000		0.023	0.019	1.230	
MTRA_18	0.292	0.064	4.540	*	0.351	0.058	6.020	*	0.305	0.059	5.150	*	0.306	0.060	5.140	*
MTRA_1814	0.220	0.038	5.750	*	0.298	0.033	8.960	*	0.210	0.032	6.480	*	0.207	0.032	6.400	*
MTRA_1412	0.243	0.026	9.270	*	0.286	0.025	11.430	*	0.207	0.025	8.390	*	0.206	0.025	8.410	*
MTRA_12T1	0.263	0.023	11.590	*	0.280	0.021	13.120	*	0.211	0.022	9.780	*	0.212	0.022	9.860	*
MTRA_1T2	0.247	0.021	11.510	*	0.252	0.020	12.490	*	0.195	0.021	9.440	*	0.197	0.021	9.570	*
MTRA_2T3	0.064	0.022	2.850	*	0.088	0.022	4.080	*	0.083	0.022	3.670	*	0.084	0.022	3.750	*
MTRAL_18	-0.043	0.018	-2.340	**	-0.057	0.017	-3.340	*	-0.035	0.016	-2.170	**	-0.038	0.016	-2.380	**
MTRAL1814	-0.014	0.014	-0.980		-0.040	0.013	-2.980	*	-0.022	0.013	-1.750	***	-0.028	0.013	-2.160	**
MTRAL1412	0.000	0.011	0.010		-0.012	0.011	-1.110		-0.006	0.010	-0.540		-0.009	0.011	-0.850	
EXPHALFM	-0.038	0.014	-2.820	*	-0.038	0.012	-3.160	*	-0.050	0.012	-4.270	*	-0.050	0.012	-4.280	*
ARTHALFM	-0.033	0.019	-1.710	***	-0.012	0.017	-0.750		0.035	0.016	2.140	**	0.033	0.016	2.040	**
MI_2CBD	--	--	--		-0.056	0.003	-18.310	*	--	--	--		--	--	--	
AI_ATOPP12	--	--	--		--	--	--		2.073	0.096	21.610	*	1.805	0.126	14.310	*
AI_PTOPP12	--	--	--		--	--	--		--	--	--		0.387	0.138	2.800	*
Diagnostics for Spatial Dependence																
Test		***Statistic***	***p-value***			***Statistic***	***p-value***			***Statistic***	***p-value***			***Statistic***	***p-value***	
LM-Lag		33.76	0.00			15.15	0.00			9.23	0.00			9.00	0.00	
LM-Error		499.67	0.00			348.73	0.00			298.15	0.00			286.35	0.00	
Robust LM-Lag		22.84	0.00			9.57	0.00			5.36	0.02			5.26	0.02	
Robust LM-Error		488.75	0.00			343.15	0.00			294.28	0.00			282.60	0.00	
Summary Statistics																
Observation No.		2,112				2,112				2,112				2,112		
R-squared		0.8242				0.8516				0.8590				0.8596		
Adj. R-squared		0.8182				0.8465				0.8542				0.8547		
Log Likelihood		614.86				794.03				848.23				852.34		
Akaike info criterion		-1089.72				-1446.05				-1554.45				-1560.68		

* Significant< 1%; ** Significant < 5%; ***Significant < 10%

Table 8-10 Spatial Error Models for Multi-Family Homes (LN [Sale amount in $2004])

Variables	Spatial Error Model 1				Spatial Error Model 2				Spatial Error Model 3				Spatial Error Model 4			
	Coef.	Std. Err.	z-value		Coef.	Std. Err.	z-value		Coef.	Std. Err.	z-value		Coef.	Std. Err.	z-value	
LAMBDA	0.526	0.020	26.284	*	0.457	0.022	20.624	*	0.429	0.023	18.706	*	0.427	0.023	18.534	*
CONSTANT	9.530	0.197	48.365	*	9.838	0.190	51.736	*	8.647	0.193	44.717	*	8.659	0.194	44.680	*
Property Attributes																
LN_BSQFT	0.261	0.019	13.837	*	0.262	0.018	14.402	*	0.267	0.018	14.805	*	0.267	0.018	14.803	*
LN_LSQFT	0.117	0.019	6.258	*	0.161	0.018	8.844	*	0.152	0.018	8.488	*	0.152	0.018	8.514	*
MID_STRY	0.013	0.041	0.326		0.009	0.039	0.217		0.001	0.039	0.036		0.001	0.039	0.033	
TWO_STRY	0.055	0.037	1.488		0.038	0.036	1.076		0.035	0.035	0.994		0.035	0.035	0.981	
TRE_STRY	0.104	0.041	2.531	**	0.082	0.040	2.078	**	0.081	0.039	2.058	**	0.081	0.039	2.051	**
TRE_APT	0.009	0.017	0.511		0.013	0.017	0.764		0.018	0.016	1.074		0.018	0.016	1.075	
FOUR_APT	-0.026	0.028	-0.943		-0.028	0.027	-1.028		-0.028	0.027	-1.037		-0.027	0.027	-1.014	
FIVE_APT	-0.048	0.082	-0.583		0.032	0.080	0.404		0.018	0.079	0.229		0.020	0.079	0.251	
SIX_APT	-0.008	0.047	-0.166		-0.039	0.046	-0.855		-0.043	0.045	-0.957		-0.044	0.045	-0.977	
FRM_MAS	0.002	0.016	0.126		-0.002	0.016	-0.097		-0.002	0.016	-0.114		-0.002	0.016	-0.106	
MAS	0.050	0.009	5.279	*	0.044	0.009	4.765	*	0.046	0.009	5.044	*	0.046	0.009	5.051	*
STUCCO	0.047	0.047	1.000		0.029	0.045	0.634		0.034	0.045	0.752		0.033	0.045	0.729	
TWO_FBTH	0.010	0.043	0.229		0.017	0.042	0.414		0.015	0.041	0.359		0.016	0.041	0.383	
TRE_FBTH	0.022	0.046	0.473		0.024	0.044	0.543		0.017	0.044	0.377		0.018	0.044	0.399	
FR_FBTH	0.065	0.051	1.275		0.067	0.049	1.360		0.062	0.048	1.285		0.062	0.049	1.285	
FV_FBTH	0.142	0.094	1.509		0.063	0.091	0.693		0.088	0.090	0.981		0.087	0.090	0.966	
SIX_FBTH	0.107	0.061	1.748	***	0.115	0.059	1.944	***	0.117	0.059	1.985	**	0.118	0.059	2.006	**
SVN_FBTH	0.414	0.153	2.700	*	0.459	0.151	3.044	*	0.452	0.150	3.007	*	0.460	0.151	3.053	*
ONE_HBTH	0.027	0.015	1.817	***	0.024	0.015	1.623		0.023	0.015	1.610		0.023	0.015	1.581	
TWO_HBTH	0.015	0.027	0.553		0.025	0.026	0.980		0.023	0.026	0.910		0.024	0.026	0.947	
TRE_HBTH	0.007	0.040	0.168		-0.019	0.038	-0.491		-0.028	0.038	-0.741		-0.029	0.038	-0.774	
FR_HBTH	-0.084	0.088	-0.962		-0.124	0.084	-1.482		-0.126	0.083	-1.526		-0.129	0.083	-1.559	
BSMT_APT	0.018	0.015	1.198		0.018	0.015	1.204		0.021	0.015	1.459		0.021	0.015	1.432	
BSMT_LVG	0.024	0.014	1.752	***	0.023	0.013	1.712	***	0.024	0.013	1.811	***	0.024	0.013	1.805	***
BSMT_UNF	0.035	0.010	3.358	*	0.035	0.010	3.485	*	0.038	0.010	3.830	*	0.038	0.010	3.782	*
BSMT_CRL	-0.025	0.023	-1.101		-0.027	0.022	-1.230		-0.026	0.022	-1.198		-0.026	0.022	-1.204	
ATTIC_APT	0.011	0.023	0.496		0.012	0.022	0.532		0.011	0.022	0.500		0.011	0.022	0.505	
ATTIC_LVG	0.007	0.018	0.374		0.007	0.017	0.387		0.009	0.017	0.540		0.010	0.017	0.579	
ATTIC_UNF	-0.001	0.012	-0.055		0.002	0.012	0.155		0.005	0.012	0.395		0.004	0.012	0.388	
A_C	0.019	0.014	1.318		0.005	0.014	0.397		0.012	0.013	0.889		0.011	0.013	0.830	
ONE_FIRE	0.001	0.024	0.060		0.001	0.023	0.049		0.009	0.023	0.410		0.009	0.023	0.384	
TOW_FIRE	-0.028	0.022	-1.274		-0.035	0.021	-1.620		-0.028	0.021	-1.312		-0.028	0.021	-1.327	
GRGE1	0.012	0.011	1.055		0.013	0.011	1.203		0.013	0.011	1.196		0.013	0.011	1.206	
GRGE2	-0.008	0.008	-0.998		-0.005	0.008	-0.569		-0.004	0.008	-0.489		-0.004	0.008	-0.464	
GRGE3	0.051	0.023	2.254	**	0.053	0.022	2.455	**	0.067	0.022	3.115	*	0.067	0.022	3.128	*
AGE	-0.001	0.000	-3.068	*	-0.001	0.000	-6.044	*	-0.001	0.000	-4.876	*	-0.001	0.000	-4.977	*
Neighborhood Socioeconomics & Amenities																
PFALL_Q	0.015	0.009	1.636		-0.003	0.009	-0.385		0.000	0.009	0.033		0.000	0.009	-0.043	
CMTYMI	-0.038	0.004	-8.662	*	-0.057	0.004	-13.947	*	-0.062	0.004	-15.608	*	-0.061	0.004	-14.721	*
LAKEMICH	-0.094	0.025	-3.780	*	-0.047	0.023	-2.056	**	-0.010	0.022	-0.429		-0.009	0.022	-0.418	
SCHSCORE	0.000	0.000	0.721		0.001	0.000	1.728	***	0.001	0.000	1.469		0.001	0.000	1.480	
HISRATIO	-0.002	0.000	-4.863	*	-0.002	0.000	-7.505	*	-0.002	0.000	-5.963	*	-0.002	0.000	-6.056	*
AARATIO	-0.006	0.000	-21.074	*	-0.006	0.000	-22.254	*	-0.005	0.000	-18.385	*	-0.005	0.000	-18.434	*

Table 8-10 (Continued)

Variables	Spatial Error Model 1				Spatial Error Model 2				Spatial Error Model 3				Spatial Error Model 4			
	Coef.	Std. Err.	z-value		Coef.	Std. Err.	z-value		Coef.	Std. Err.	z-value		Coef.	Std. Err.	z-value	
CRIMEDEN	0.010	0.003	3.200	*	0.002	0.003	0.797		-0.001	0.003	-0.282		-0.001	0.003	-0.325	
DENLOW20	-0.007	0.004	-1.778	***	-0.006	0.003	-1.863	***	-0.004	0.003	-1.251		-0.004	0.003	-1.159	
DENMID35	0.006	0.006	1.038		0.003	0.006	0.612		-0.002	0.005	-0.379		-0.003	0.005	-0.482	
DENHI35	0.026	0.002	10.643	*	0.020	0.002	8.953	*	0.023	0.002	11.008	*	0.023	0.002	10.747	*
DENOALL	-0.001	0.001	-0.781		-0.003	0.001	-2.089	**	-0.002	0.001	-1.529		-0.002	0.001	-1.542	
ODI	0.293	0.071	4.114	*	0.196	0.067	2.935	*	0.190	0.065	2.909	*	0.183	0.065	2.796	*
TIF_RES	0.074	0.154	0.482		0.117	0.149	0.785		0.111	0.148	0.754		0.114	0.148	0.774	
TIF_MIX	0.025	0.015	1.607		0.010	0.014	0.663		0.000	0.014	-0.006		0.000	0.014	0.018	
TIF_COM	0.080	0.078	1.027		0.083	0.075	1.106		0.054	0.074	0.732		0.056	0.074	0.754	
TIF_IND	-0.038	0.030	-1.279		-0.073	0.029	-2.514	**	-0.072	0.028	-2.527	**	-0.072	0.028	-2.543	**
Transportation & Accessibility																
BSTP_18	-0.006	0.008	-0.788		-0.007	0.008	-0.926		-0.006	0.007	-0.799		-0.006	0.007	-0.811	
CTA_Q_IM	0.228	0.028	8.208	*	0.072	0.027	2.716	*	0.095	0.025	3.799	*	0.084	0.027	3.112	*
CTAL_G18	-0.082	0.027	-3.075	*	-0.049	0.025	-1.941	***	-0.064	0.025	-2.589	*	-0.065	0.025	-2.642	*
CTAL_G1814	-0.030	0.020	-1.501		-0.015	0.019	-0.825		-0.025	0.018	-1.376		-0.026	0.018	-1.439	
CTAL_L18	-0.019	0.025	-0.747		0.011	0.023	0.452		0.006	0.023	0.270		0.008	0.023	0.334	
CTAL_L1814	0.002	0.021	0.075		0.031	0.020	1.582		0.027	0.019	1.422		0.029	0.019	1.504	
MTRA_18	0.243	0.072	3.401	*	0.306	0.067	4.588	*	0.253	0.065	3.890	*	0.252	0.065	3.878	*
MTRA_1814	0.169	0.041	4.139	*	0.255	0.037	6.831	*	0.181	0.036	5.051	*	0.179	0.036	4.988	*
MTRA_1412	0.235	0.034	6.959	*	0.283	0.030	9.347	*	0.209	0.029	7.200	*	0.208	0.029	7.174	*
MTRA_12T1	0.240	0.030	7.984	*	0.262	0.027	9.834	*	0.197	0.026	7.691	*	0.197	0.026	7.705	*
MTRA_1T2	0.228	0.030	7.719	*	0.234	0.026	8.972	*	0.180	0.025	7.149	*	0.180	0.025	7.185	*
MTRA_2T3	0.078	0.031	2.539	**	0.095	0.028	3.453	*	0.082	0.027	3.088	*	0.083	0.027	3.112	*
MTRAL_18	-0.028	0.020	-1.402		-0.044	0.019	-2.355	**	-0.029	0.018	-1.582		-0.030	0.018	-1.658	***
MTRAL1814	-0.018	0.016	-1.124		-0.038	0.015	-2.564	**	-0.025	0.014	-1.758	***	-0.027	0.014	-1.888	***
MTRAL1412	0.001	0.013	0.106		-0.010	0.012	-0.881		-0.004	0.011	-0.327		-0.005	0.011	-0.430	
EXPHALFM	-0.031	0.015	-2.090	**	-0.031	0.014	-2.250	**	-0.037	0.013	-2.817	*	-0.037	0.013	-2.835	*
ARTHALFM	-0.062	0.024	-2.580	*	-0.030	0.021	-1.376		0.015	0.021	0.709		0.014	0.021	0.692	
MI_2CBD	--	--	--		-0.057	0.004	-15.788	*	--	--	--		--	--	--	
AI_ATOPP12	--	--	--		--	--	--		2.110	0.116	18.231	*	1.989	0.165	12.074	*
AI_PTOPP12	--	--	--		--	--	--		--	--	--		0.177	0.171	1.033	
Summary Statistics																
Observation No.		2,112				2,112				2,112				2,112		
R-squared		0.8682				0.8788				0.8815				0.8815		
Adj. R-squared		--				--				--				--		
Log Likelihood		835.13				947.77				979.60				980.13		
Akaike info criterion		-1530.26				-1753.55				-1817.21				-1816.26		

* Significant< 1%; ** Significant < 5%; ***Significant < 10%

Table 8-11 Robust OLS Regression Models for Vacant Land (LN [Sale amount in $2004])

	Robust OLS Model 1				Robust OLS Model 2				Robust OLS Model 3				Robust OLS Model 4			
Variable	Coef.	Std. Err.	t		Coef.	Std. Err	t		Coef.	Std. Err.	t		Coef.	Std. Err.	t	
CONSTANT	10.554	0.336	31.450	*	11.303	0.348	32.460	*	10.092	0.346	29.200	*	10.130	0.352	28.770	*
Land Attributes																
LN_LSQFT	0.172	0.031	5.500	*	0.185	0.031	5.920	*	0.187	0.031	5.980	*	0.187	0.031	5.970	*
Neighborhood Socioeconomics & Amenities																
PFALL_Q	0.013	0.040	0.320		-0.029	0.040	-0.720		-0.026	0.040	-0.630		-0.027	0.040	-0.660	
CMTYMI	-0.070	0.012	-6.070	*	-0.085	0.012	-7.360	*	-0.099	0.012	-8.260	*	-0.097	0.012	-7.960	*
LAKEMICH	0.218	0.082	2.650	*	0.158	0.081	1.940	***	0.223	0.082	2.730	*	0.223	0.082	2.740	*
SCHSCORE	0.001	0.001	0.950		0.001	0.001	0.690		0.001	0.001	0.670		0.001	0.001	0.660	
HISRATIO	-0.006	0.001	-4.040	*	-0.006	0.001	-4.740	*	-0.006	0.001	-4.130	*	-0.006	0.001	-4.170	*
AARATIO	-0.014	0.001	-14.660	*	-0.014	0.001	-15.320	*	-0.013	0.001	-14.420	*	-0.013	0.001	-14.350	*
CRIMEDEN	-0.001	0.009	-0.080		-0.007	0.009	-0.790		-0.009	0.009	-1.010		-0.009	0.009	-1.000	
DENLOW20	-0.016	0.016	-1.010		-0.019	0.016	-1.160		-0.017	0.016	-1.080		-0.017	0.016	-1.060	
DENMID35	0.104	0.028	3.750	*	0.095	0.028	3.440	*	0.088	0.028	3.180	*	0.087	0.028	3.140	*
DENHI35	0.025	0.011	2.230	**	0.020	0.010	1.910	***	0.021	0.010	2.050	**	0.021	0.010	1.960	**
DENOALL	-0.003	0.002	-1.730	***	-0.003	0.002	-2.000	**	-0.003	0.002	-1.940	***	-0.003	0.002	-1.940	***
ODI	0.885	0.225	3.940	*	0.528	0.226	2.340	**	0.543	0.225	2.410	**	0.528	0.226	2.340	**
TIF_RES	0.085	0.217	0.390		0.061	0.216	0.280		0.058	0.216	0.270		0.061	0.216	0.280	
TIF_MIX	0.051	0.046	1.100		0.038	0.046	0.820		0.033	0.046	0.710		0.034	0.046	0.740	
TIF_COM	0.421	0.268	1.570		0.415	0.281	1.470		0.323	0.282	1.150		0.341	0.284	1.200	
TIF_IND	0.146	0.080	1.810	***	0.067	0.080	0.830		0.056	0.081	0.690		0.059	0.081	0.730	
Z_BUSCOM	0.784	0.581	1.350		0.721	0.578	1.250		0.718	0.575	1.250		0.726	0.576	1.260	
Z_MANUF	0.046	0.082	0.560		0.073	0.081	0.910		0.062	0.081	0.770		0.062	0.081	0.760	
Z_RES	-0.097	0.055	-1.770	***	-0.141	0.055	-2.550	**	-0.131	0.055	-2.390	**	-0.130	0.055	-2.370	**
MINLOT25	-0.163	0.057	-2.850	*	-0.145	0.057	-2.570	*	-0.159	0.056	-2.810	*	-0.160	0.057	-2.830	*
MINLOT5K	0.156	0.080	1.960	**	0.267	0.081	3.280	*	0.240	0.080	2.990	*	0.240	0.080	2.990	*
FAR2	0.299	0.060	5.030	*	0.239	0.060	4.010	*	0.254	0.060	4.260	*	0.254	0.060	4.260	*
FAR3_5	0.540	0.101	5.340	*	0.431	0.100	4.310	*	0.447	0.100	4.460	*	0.446	0.100	4.450	*
Transportation & Accessibility																
BSTP_18	0.071	0.043	1.650	***	0.046	0.043	1.080		0.047	0.043	1.110		0.046	0.043	1.060	
CTA_Q_IM	0.241	0.113	2.140	**	-0.112	0.125	-0.900		-0.077	0.123	-0.620		-0.103	0.132	-0.780	
CTAL_G18	0.186	0.105	1.780	***	0.283	0.106	2.680	*	0.259	0.105	2.460	**	0.252	0.105	2.390	**
CTAL_G1814	0.179	0.100	1.780	***	0.236	0.099	2.370	**	0.225	0.100	2.250	**	0.219	0.100	2.190	**
CTAL_G1412	0.135	0.082	1.640		0.167	0.082	2.050	**	0.160	0.082	1.950	***	0.158	0.082	1.930	***
CTAL_L18	-0.078	0.108	-0.720		0.089	0.110	0.810		0.067	0.109	0.620		0.076	0.110	0.690	
CTAL_L1814	0.089	0.099	0.900		0.225	0.101	2.240	**	0.214	0.101	2.120	**	0.225	0.103	2.190	**
CTAL_L1412	-0.156	0.073	-2.140	**	-0.084	0.073	-1.150		-0.092	0.073	-1.270		-0.084	0.074	-1.140	

Table 8-11 (Continued)

	Robust OLS Model 1				Robust OLS Model 2				Robust OLS Model 3				Robust OLS Model 4			
Variable	Coef.	Std. Err.	t		Coef.	Std. Err	t		Coef.	Std. Err.	t		Coef.	Std. Err.	t	
MTRA_18	0.193	0.177	1.090		0.375	0.179	2.100	**	0.318	0.177	1.800	***	0.308	0.177	1.740	***
MTRA_1814	0.254	0.122	2.080	**	0.446	0.125	3.580	*	0.396	0.123	3.220	*	0.390	0.123	3.170	*
MTRA_1412	0.146	0.102	1.440		0.293	0.103	2.830	*	0.249	0.102	2.440	**	0.245	0.102	2.400	**
MTRA_12T1	0.281	0.083	3.390	*	0.380	0.084	4.520	*	0.337	0.083	4.050	*	0.331	0.084	3.950	*
MTRA_1T2	0.277	0.078	3.540	*	0.354	0.078	4.530	*	0.317	0.078	4.070	*	0.319	0.078	4.090	*
MTRA_2T3	-0.115	0.084	-1.360		-0.040	0.085	-0.470		-0.043	0.085	-0.500		-0.041	0.085	-0.470	
MTRAL_18	0.055	0.065	0.850		-0.003	0.065	-0.050		-0.001	0.065	-0.020		-0.007	0.065	-0.110	
MTRAL1814	0.046	0.060	0.780		-0.020	0.060	-0.340		-0.020	0.060	-0.340		-0.025	0.061	-0.410	
MTRAL1412	0.103	0.053	1.920	***	0.055	0.054	1.030		0.051	0.054	0.950		0.047	0.054	0.870	
EXPHALFM	-0.076	0.052	-1.470		-0.081	0.051	-1.590		-0.078	0.051	-1.540		-0.079	0.051	-1.550	
ARTHALFM	-0.081	0.085	-0.960		-0.020	0.085	-0.240		0.001	0.085	0.010		0.006	0.085	0.070	
MI_2CBD	--	--	--		-0.063	0.010	-6.000	*	--	--	--		--	--	--	
AI_ATOPP12	--	--	--		--	--	--		2.086	0.348	5.990	*	1.804	0.533	3.380	*
AI_PTOPP12	--	--	--		--	--	--		--	--	--		0.425	0.640	0.660	
Diagnostics for Spatial Dependence																
Test		***Statistic***	***p-value***			***Statistic***	***p-value***			***Statistic***	***p-value***			***Statistic***	***p-value***	
LM-Lag		12.62	0.00			11.77	0.00			14.81	0.00			14.57	0.00	
LM-Error		196.97	0.00			178.47	0.00			180.51	0.00			179.90	0.00	
Robust LM-Lag		0.04	0.84			0.07	0.80			0.44	0.51			0.40	0.53	
Robust LM-Error		184.40	0.00			166.76	0.00			166.14	0.00			165.73	0.00	
Summary Statistics																
Observation No.		3,344				3,344				3,344				3,344		
R-squared		0.3209				0.3283				0.3280				0.3281		
Adj. R-squared										0.3191				0.3189		
Log Likelihood		-4775.44				-4757.15				-4757.75				-4757.55		
Akaike info criterion		9638.88				9604.29				9605.50				9607.10		

* Significant< 1%; ** Significant < 5%; ***Significant < 10%

Table 8-12 Spatial Error Models for Vacant Land (LN [Sale amount in $2004])

Variables	Spatial Error Model 1				Spatial Error Model 2				Spatial Error Model 3				Spatial Error Model 4			
	Coef.	Std. Err.	z-value		Coef.	Std. Err.	z-value		Coef.	Std. Err.	z-value		Coef.	Std. Err.	z-value	
LAMBDA	0.344	0.023	15.149	*	0.330	0.023	14.327	*	0.331	0.023	14.402	*	0.331	0.023	14.394	*
CONSTANT	10.617	0.341	31.171	*	11.345	0.375	30.252	*	10.164	0.352	28.838	*	10.175	0.360	28.272	*
Land Attributes																
LN_LSQFT	0.191	0.032	6.070	*	0.196	0.031	6.226	*	0.197	0.031	6.266	*	0.197	0.031	6.261	*
Neighborhood Socioeconomics & Amenities																
PFALL_Q	0.004	0.046	0.095		-0.026	0.046	-0.575		-0.024	0.046	-0.528		-0.024	0.046	-0.532	
CMTYMI	-0.078	0.016	-4.988	*	-0.093	0.016	-5.925	*	-0.106	0.017	-6.394	*	-0.105	0.017	-6.234	*
LAKEMICH	0.157	0.101	1.554		0.105	0.100	1.051		0.164	0.100	1.647	***	0.164	0.099	1.647	***
SCHSCORE	0.000	0.002	0.250		0.000	0.002	0.180		0.000	0.002	0.131		0.000	0.002	0.129	
HISRATIO	-0.006	0.002	-3.298	*	-0.007	0.002	-3.798	*	-0.006	0.002	-3.290	*	-0.006	0.002	-3.292	*
AARATIO	-0.015	0.001	-12.079	*	-0.015	0.001	-12.305	*	-0.014	0.001	-11.581	*	-0.014	0.001	-11.505	*
CRIMEDEN	0.007	0.010	0.651		0.001	0.010	0.096		-0.001	0.010	-0.065		-0.001	0.010	-0.063	
DENLOW20	-0.010	0.020	-0.520		-0.012	0.020	-0.622		-0.011	0.020	-0.567		-0.011	0.020	-0.564	
DENMID35	0.072	0.033	2.199	**	0.066	0.032	2.050	**	0.060	0.033	1.851	***	0.060	0.033	1.840	***
DENHI35	0.020	0.013	1.511		0.016	0.013	1.209		0.018	0.013	1.373		0.017	0.013	1.345	
DENOALL	0.000	0.001	-0.233		-0.001	0.001	-0.846		-0.001	0.001	-0.735		-0.001	0.001	-0.741	
ODI	0.623	0.251	2.484	**	0.344	0.256	1.341		0.352	0.256	1.377		0.348	0.258	1.350	
TIF_RES	-0.037	0.230	-0.160		-0.050	0.227	-0.221		-0.047	0.227	-0.206		-0.046	0.227	-0.201	
TIF_MIX	0.072	0.053	1.361		0.062	0.052	1.194		0.059	0.052	1.135		0.060	0.052	1.139	
TIF_COM	0.399	0.310	1.286		0.403	0.309	1.304		0.354	0.309	1.145		0.357	0.310	1.152	
TIF_IND	0.151	0.091	1.656	***	0.104	0.091	1.139		0.097	0.091	1.065		0.098	0.091	1.071	
Z_BUSCOM	0.410	0.402	1.020		0.338	0.401	0.844		0.336	0.401	0.837		0.337	0.401	0.840	
Z_MANUF	0.022	0.082	0.265		0.044	0.082	0.536		0.036	0.082	0.436		0.035	0.082	0.434	
Z_RES	-0.088	0.056	-1.584		-0.117	0.056	-2.109	**	-0.112	0.056	-2.016	**	-0.112	0.056	-2.014	**
MINLOT25	-0.160	0.060	-2.643	*	-0.147	0.060	-2.453	**	-0.157	0.060	-2.610	*	-0.157	0.060	-2.613	*
MINLOT5K	0.113	0.093	1.222		0.200	0.094	2.135	**	0.181	0.093	1.943	***	0.181	0.093	1.946	***
FAR2	0.223	0.061	3.630	*	0.189	0.062	3.065	*	0.198	0.061	3.231	*	0.198	0.061	3.230	*
FAR3_5	0.452	0.103	4.400	*	0.384	0.103	3.715	*	0.394	0.103	3.824	*	0.394	0.103	3.823	*
Transportation & Accessibility																
BSTP_18	0.058	0.045	1.305		0.043	0.045	0.962		0.044	0.045	0.975		0.043	0.045	0.964	
CTA_Q_IM	0.338	0.137	2.465	**	0.004	0.153	0.029		0.032	0.150	0.216		0.025	0.158	0.157	
CTAL_G18	0.129	0.128	1.012		0.202	0.127	1.585		0.183	0.127	1.440		0.181	0.127	1.421	
CTAL_G1814	0.116	0.121	0.956		0.166	0.120	1.380		0.152	0.120	1.270		0.151	0.120	1.257	
CTAL_G1412	-0.013	0.099	-0.129		0.016	0.098	0.167		0.007	0.098	0.071		0.007	0.098	0.069	
CTAL_L18	-0.110	0.124	-0.891		0.015	0.125	0.120		-0.001	0.124	-0.012		0.001	0.125	0.008	
CTAL_L1814	0.009	0.109	0.081		0.114	0.111	1.027		0.105	0.110	0.953		0.108	0.112	0.967	
CTAL_L1412	-0.147	0.084	-1.763	***	-0.100	0.084	-1.194		-0.105	0.083	-1.260		-0.103	0.084	-1.223	

Table 8-12 (Continued)

Variables	Spatial Error Model 1				Spatial Error Model 2				Spatial Error Model 3				Spatial Error Model 4			
	Coef.	Std. Err.	z-value		Coef.	Std. Err.	z-value		Coef.	Std. Err.	z-value		Coef.	Std. Err.	z-value	
MTRA_18	0.167	0.195	0.859		0.327	0.196	1.669	***	0.275	0.194	1.412		0.272	0.195	1.396	
MTRA_1814	0.270	0.144	1.877	***	0.423	0.146	2.896	*	0.375	0.144	2.606	*	0.374	0.144	2.587	*
MTRA_1412	0.187	0.125	1.503		0.304	0.126	2.424	**	0.260	0.124	2.097	**	0.259	0.124	2.080	**
MTRA_12T1	0.274	0.106	2.589	*	0.354	0.105	3.361	*	0.310	0.104	2.970	*	0.309	0.105	2.948	*
MTRA_1T2	0.280	0.100	2.798	*	0.343	0.099	3.454	*	0.305	0.099	3.098	*	0.306	0.099	3.103	*
MTRA_2T3	-0.101	0.109	-0.921		-0.039	0.108	-0.359		-0.043	0.108	-0.394		-0.042	0.108	-0.389	
MTRAL_18	0.068	0.080	0.850		0.020	0.080	0.250		0.021	0.080	0.268		0.020	0.080	0.247	
MTRAL1814	0.038	0.073	0.522		-0.013	0.073	-0.183		-0.012	0.073	-0.169		-0.014	0.073	-0.185	
MTRAL1412	0.087	0.062	1.407		0.051	0.062	0.821		0.048	0.062	0.775		0.047	0.062	0.759	
EXPHALFM	-0.016	0.063	-0.250		-0.021	0.062	-0.338		-0.018	0.062	-0.290		-0.018	0.062	-0.295	
ARTHALFM	-0.017	0.105	-0.161		0.035	0.104	0.334		0.058	0.105	0.550		0.059	0.105	0.559	
MI_2CBD	--	--	--		-0.060	0.013	-4.549	*	--	--	--		--	--	--	
AI_ATOPP12	--	--	--		--	--	--		2.044	0.445	4.591	*	1.958	0.701	2.791	*
AI_PTOPP12	--	--	--		--	--	--		--	--	--		0.130	0.814	0.160	
Summary Statistics																
Observation No.		3,344				3,344				3,344				3,344		
R-squared		0.3710				0.3736				0.3737				0.3737		
Adj. R-squared		--				--				--				--		
Log Likelihood		-4686.31				-4676.17				-4675.95				-4675.93		
Akaike info		9460.62				9442.33				9441.89				9443.87		

* Significant< 1%; ** Significant < 5%; ***Significant < 10%

Table 8-13 Robust OLS Regression Models for Commercial Properties (LN [Sale amount in $2004])

	Robust OLS Model 1				Robust OLS Model 2				Robust OLS Model 3				Robust OLS Model 4			
Variable	Coef.	Std. Err.	t		Coef.	Std. Err.	t		Coef.	Std. Err.	t		Coef.	Std. Err.	t	
CONSTANT	6.803	0.405	16.810	*	6.886	0.418	16.470	*	6.797	0.407	16.710	*	6.846	0.429	15.950	*
Property Attributes																
LN_BSQFT	0.763	0.043	17.600	*	0.766	0.044	17.560	*	0.766	0.043	17.640	*	0.766	0.043	17.660	*
TWO_STRY	-0.079	0.077	-1.020		-0.080	0.077	-1.040		-0.075	0.076	-0.980		-0.074	0.076	-0.970	
TRFR_STR	-0.035	0.098	-0.360		-0.036	0.098	-0.370		-0.041	0.098	-0.420		-0.041	0.098	-0.420	
FV_STRY	0.079	0.162	0.490		0.079	0.163	0.480		0.071	0.162	0.440		0.072	0.161	0.450	
BDGCLS_A	0.382	0.217	1.760	***	0.379	0.217	1.750	***	0.383	0.216	1.770	***	0.386	0.215	1.790	***
BDGCLS_B	0.083	0.071	1.170		0.082	0.071	1.160		0.072	0.070	1.020		0.071	0.071	1.000	
CNER	0.076	0.063	1.200		0.070	0.063	1.110		0.056	0.064	0.880		0.057	0.064	0.890	
RETAILUSE	0.557	0.135	4.120	*	0.548	0.136	4.040	*	0.515	0.132	3.890	*	0.513	0.133	3.850	*
HOSTLUSE	0.302	0.152	1.980	**	0.304	0.151	2.020	**	0.327	0.148	2.210	**	0.328	0.149	2.200	**
MAS	-0.166	0.070	-2.350	**	-0.169	0.070	-2.430	**	-0.171	0.070	-2.450	**	-0.169	0.069	-2.460	**
METAL	0.053	0.163	0.320		0.046	0.167	0.270		0.056	0.155	0.360		0.045	0.146	0.310	
RCNCRT	-0.087	0.113	-0.760		-0.078	0.114	-0.680		-0.081	0.113	-0.720		-0.083	0.114	-0.730	
STEEL	0.122	0.152	0.800		0.115	0.152	0.760		0.103	0.152	0.680		0.108	0.154	0.700	
WOODF	-0.575	0.488	-1.180		-0.581	0.491	-1.180		-0.572	0.472	-1.210		-0.570	0.464	-1.230	
PKRATIO	0.030	0.013	2.250	**	0.032	0.014	2.300	**	0.036	0.014	2.610	*	0.035	0.014	2.560	**
AGE	-0.004	0.002	-2.340	**	-0.005	0.002	-2.330	**	-0.005	0.002	-2.910	*	-0.005	0.002	-2.800	*
Neighborhood Socioeconomics & Amenities																
LAKEMICH	0.014	0.140	0.100		0.018	0.141	0.130		0.044	0.140	0.310		0.043	0.141	0.310	
HISRATIO	-0.007	0.002	-4.200	*	-0.007	0.002	-4.290	*	-0.007	0.002	-4.300	*	-0.007	0.002	-4.220	*
AARATIO	-0.005	0.001	-3.160	*	-0.005	0.001	-3.260	*	-0.005	0.001	-3.460	*	-0.005	0.001	-3.470	*
POPDEN00	0.003	0.003	0.970		0.003	0.003	0.830		0.001	0.003	0.340		0.001	0.003	0.330	
DENOALL	0.001	0.000	3.870	*	0.001	0.000	3.370	*	0.001	0.000	3.470	*	0.001	0.000	3.380	*
ODI	0.419	0.218	1.930	***	0.409	0.218	1.880	***	0.353	0.219	1.610		0.360	0.218	1.650	***
Transportation & Accessibility																
PACE_SP18	-0.011	0.067	-0.170		-0.012	0.066	-0.190		0.017	0.069	0.250		0.026	0.072	0.360	
CTA_Q_IM	0.531	0.121	4.400	*	0.476	0.138	3.450	*	0.296	0.165	1.800	***	0.295	0.166	1.770	***
MTRA_18	0.013	0.196	0.070		0.023	0.201	0.110		-0.009	0.196	-0.050		-0.022	0.206	-0.110	
MTRA_1814	-0.365	0.202	-1.810	***	-0.363	0.203	-1.790	***	-0.364	0.202	-1.800	***	-0.368	0.203	-1.810	***
MTRA_1412	-0.131	0.092	-1.420		-0.133	0.092	-1.440		-0.164	0.094	-1.740	***	-0.168	0.096	-1.740	***
EXPHALFM	-0.147	0.064	-2.300	**	-0.144	0.064	-2.250	**	-0.134	0.063	-2.120	**	-0.127	0.063	-2.030	**
ARTHALFM	0.044	0.076	0.580		0.041	0.076	0.540		0.038	0.076	0.500		0.034	0.076	0.450	
MI_2CBD	--	--	--		-0.006	0.008	-0.680		--	--	--		--	--	--	
AI_ATOPP12	--	--	--		--	--	--		--	--	--		-0.301	0.603	-0.500	
AI_PTOPP12	--	--	--		--	--	--		1.110	0.521	2.130	**	1.348	0.758	1.780	***

Table 8-13 (Continued)

	Robust OLS Model 1		Robust OLS Model 2		Robust OLS Model 3		Robust OLS Model 4	
Diagnostics for Spatial Dependence								
Test	***Statistic***	***p-value***	***Statistic***	***p-value***	***Statistic***	***p-value***	***Statistic***	***p-value***
LM-Lag	5.15	0.02	4.96	0.03	5.22	0.02	5.36	0.02
LM-Error	33.86	0.00	33.99	0.00	34.20	0.00	33.94	0.00
Robust LM-Lag	7.15	0.01	6.94	0.01	7.23	0.01	7.39	0.01
Robust LM-Error	35.86	0.00	35.96	0.00	36.22	0.00	35.97	0.00
Summary Statistics								
Observation No.	383		383		383		383	
R-squared	0.8711		0.8713		0.8726		0.8727	
Adj. R-squared	0.8605		0.8603		0.8618		0.8615	
Log Likelihood	-304.03		-303.77		-301.83		-301.68	
Akaike info criterion	668.07		669.54		665.65		667.35	

* Significant< 1%; ** Significant < 5%; ***Significant < 10%

Table 8-14 Spatial Error Models for Commercial Properties (LN [Sale amount in $2004])

	Spatial Error Model 1				Spatial Error Model 2				Spatial Error Model 3				Spatial Error Model 4			
Variable	Coef.	Std. Err.	z-value		Coef.	Std. Err.	z-value		Coef.	Std. Err.	z-value		Coef.	Std. Err.	z-value	
LAMBDA	0.612	0.034	18.007	*	0.611	0.034	17.948	*	0.607	0.034	17.630	*	0.606	0.034	17.606	*
CONSTANT	6.394	0.356	17.966	*	6.480	0.382	16.972	*	6.376	0.355	17.975	*	6.395	0.365	17.517	*
Property Attributes																
LN_BSQFT	0.790	0.036	21.652	*	0.791	0.037	21.666	*	0.791	0.036	21.767	*	0.792	0.036	21.724	*
TWO_STRY	-0.070	0.073	-0.969		-0.070	0.073	-0.959		-0.064	0.072	-0.880		-0.064	0.072	-0.878	
TRFR_STR	-0.038	0.085	-0.442		-0.036	0.085	-0.423		-0.033	0.085	-0.385		-0.033	0.085	-0.386	
FV_STRY	0.083	0.127	0.657		0.085	0.127	0.668		0.078	0.126	0.619		0.078	0.126	0.619	
BDGCLS_A	0.496	0.147	3.376	*	0.491	0.147	3.342	*	0.045	0.064	0.707		0.045	0.064	0.701	
BDGCLS_B	0.057	0.064	0.893		0.055	0.064	0.861		0.479	0.147	3.265	*	0.480	0.147	3.272	*
CNER	0.066	0.057	1.147		0.064	0.058	1.109		0.061	0.057	1.072		0.062	0.057	1.078	
RETAILUSE	0.495	0.158	3.129	*	0.495	0.158	3.131	*	0.495	0.157	3.148	*	0.493	0.158	3.126	*
HOSTLUSE	0.336	0.112	2.998	*	0.338	0.112	3.016	*	0.349	0.112	3.119	*	0.349	0.112	3.118	*
MAS	-0.055	0.059	-0.938		-0.058	0.059	-0.976		-0.063	0.059	-1.075		-0.063	0.059	-1.068	
METAL	0.119	0.261	0.457		0.112	0.261	0.431		0.085	0.261	0.326		0.081	0.261	0.311	
RCNCRT	-0.029	0.110	-0.263		-0.026	0.110	-0.233		-0.028	0.110	-0.258		-0.029	0.110	-0.261	
STEEL	0.218	0.131	1.658	***	0.215	0.131	1.639		0.202	0.131	1.540		0.202	0.131	1.543	
WOODF	-0.208	0.279	-0.745		-0.210	0.279	-0.751		-0.223	0.279	-0.799		-0.225	0.279	-0.808	
PKRATIO	0.039	0.013	3.052	*	0.039	0.013	3.102	*	0.043	0.013	3.339	*	0.043	0.013	3.332	*
AGE	-0.004	0.001	-3.031	*	-0.004	0.001	-3.093	*	-0.005	0.001	-3.391	*	-0.005	0.001	-3.369	*

Table 8-14 (Continued)

	Spatial Error Model 1				Spatial Error Model 2				Spatial Error Model 3				Spatial Error Model 4			
Variable	Coef.	Std. Err.	z-value		Coef.	Std. Err.	z-value		Coef.	Std. Err.	z-value		Coef.	Std. Err.	z-value	
Neighborhood Socioeconomics & Amenities																
LAKEMICH	0.219	0.124	1.760	***	0.214	0.125	1.720	***	0.212	0.124	1.707	***	0.212	0.124	1.712	***
HISRATIO	-0.006	0.002	-2.951	*	-0.006	0.002	-3.007	*	-0.006	0.002	-3.166	*	-0.006	0.002	-3.117	*
AARATIO	-0.005	0.001	-4.099	*	-0.005	0.001	-4.140	*	-0.005	0.001	-4.312	*	-0.005	0.001	-4.224	*
POPDEN00	0.005	0.003	1.908	***	0.005	0.003	1.699	***	0.003	0.003	1.208		0.003	0.003	1.218	
DENOALL	0.001	0.000	2.547	**	0.001	0.000	2.428	**	0.001	0.000	2.371	**	0.001	0.000	2.380	**
ODI	0.534	0.231	2.309	**	0.538	0.231	2.325	**	0.511	0.231	2.216	**	0.513	0.231	2.223	**
Transportation & Accessibility																
PACE_SP18	-0.095	0.070	-1.347		-0.094	0.070	-1.343		-0.071	0.071	-0.996		-0.068	0.072	-0.935	
CTA_Q_IM	0.362	0.124	2.920	*	0.313	0.148	2.114	**	0.147	0.169	0.870		0.150	0.170	0.882	
MTRA_18	0.286	0.144	1.989	**	0.290	0.144	2.013	**	0.247	0.144	1.710	***	0.242	0.146	1.662	***
MTRA_1814	-0.094	0.125	-0.753		-0.094	0.125	-0.750		-0.110	0.125	-0.878		-0.111	0.125	-0.889	
MTRA_1412	0.088	0.110	0.800		0.084	0.110	0.759		0.056	0.111	0.502		0.056	0.111	0.504	
EXPHALFM	-0.045	0.073	-0.616		-0.044	0.073	-0.598		-0.035	0.073	-0.478		-0.032	0.074	-0.432	
ARTHALFM	-0.010	0.081	-0.122		-0.012	0.081	-0.155		-0.011	0.080	-0.143		-0.013	0.080	-0.162	
MI_2CBD	--	--	--		-0.005	0.009	-0.611		--	--	--		--	--	--	
AI_ATOPP12	--	--	--		--	--	--		--	--	--		-0.128	0.579	-0.221	
AI_PTOPP12	--	--	--		--	--	--		1.032	0.557	1.853	***	1.119	0.683	1.640	
Summary Statistics																
Observation No.		383				383				383				383		
R-squared		0.8985				0.8985				0.8992				0.8993		
Adj. R-squared		--				--				--				--		
Log Likelihood		-274.71				-274.50				-272.86				-272.83		
Akaike info criterion		609.42				611.00				607.72				609.65		

* Significant< 1%; ** Significant < 5%; ***Significant < 10%

8.5 South Works Case Study Data and Assumptions

Model Variable Inputs

For all land value and property tax simulations, we used as variables City of Chicago averages (Cook County for Commercial), except as otherwise described below. Table 8-15 includes variables applied for parcel improvement (*I*), Neighborhood (*N*), and regional Transportation (*T*) variables that are different from City-wide (or County-wide for commercial properties) averages. Table 8-16 describes the model inputs for local Transportation variables corresponding to each development area/district, including distances to the nearest CTA and Metra stations, as well as distances from CTA and Metra lines, respectively. Basically, each “share” represents the corresponding variable input for properties in each development district, with the exception of the CTA walk impedance factor, which requires an additional step.

While Table 8-16 provides the share of properties within each project area at different linear distances from proposed CTA stations, the walk impedance variable is not binary but continuous. To simplify the calculation, we calculated average walk impedance variables at different “tiers”: between zero to one-quarter mile, one-quarter and one-half mile, and one-half to one mile. For each project area we calculated the walk impedance variable by multiplying the share of properties at different distances by corresponding average walk impedance factor and summing the total (for Metra station and CTA and Metra line effects, we simply multiplied the shares of each discrete distance-based variable by one; there is no need to sum these data as the hedonic price model includes individual variables for each distance threshold).

Table 8-17 summarizes the key variables and parameters for calculating the net change in property values due to the proposed CTA infrastructure at South Works. Included are walk impedance parameter estimates and CTA line effect parameter estimates as well as walk impedance factor average estimates at different distances from CTA. The data are presented under both OLS and spatial error model parameter assumptions (with regional automobile and transit accessibility index controls) for both single-family and multi-family residences.

Model Structure and Data

Regarding financial model inputs, the hedonic price models were used to generate base property values in 2016. To populate the 40-year NPV model, we developed assumptions about the pace, timing, and value of the development project. Table 8-18 describes ranges for key uncertain data: project pace, timing, and year-over-year land appreciation. We apply a random variable for each model year (2016-2055), to determine whether or not a project would be delivered in that year and, if so, the quantity of delivery and the property values at the time of delivery. A “project” is defined by each of the six project areas, so that we have six discrete “projects.” In the years subsequent to project delivery in a given project area, no additional construction will occur but property values will continue to appreciate. We applied the random variable such that in any given year, a higher value will lead to a faster pace of development, a greater quantity of development, and higher property values (or simply a faster rate of property value appreciation if the project area has already been developed).

Other key financial model assumptions are included in Table 8-19: discount rates, shares of residential property types, and property tax assessment rates and levels.

Table 8-20 details base property estimates under different assumptions (without CTA, with CTA and line effects, and with CTA and no line effects) and calculation methods (OLS and spatial error models) with regional accessibility controls for automobile and transit. In this particular case we demonstrate the forecast base values using the spatial error model without calculating a spatial weights matrix purely for illustrative and broad comparative purposes.

Finally, in Figure 8-11 through Figure 8-16, we present the probability density functions and cumulative distribution functions for each simulated scenario. These include three different scenarios (Tax Transfer, CTA as Tax Authority, and CTA as Tax Authority with Commercial) under two different methods (with CTA line effects and without).

Table 8-15 OLS Simulation Hedonic Price Model Variable Assumptions (If Different from City/County Averages, and Excluding Local Transportation Variables)

Variables	SF	MF	Comm
Project-Area-Specific Assumptions			
Percent Near CTA Bus	100%	100%	100%
Percent Near Arterial Road (Relocated Highway 41)	100%	100%	100%
Percent Neaer Highway/Expressway	33%	33%	33%
Percent Two-Story MF ONLY (To the Exclusion of Other Types)	AVG	1	AVG
Other Multi-Story Types MF ONLY	AVG	0	AVG
Percent in Mixed TIF (To the Exclusion of Other TIF Types)	1	1	N/A
Percent in Other TIF Types	0	0	N/A
Percent with Three-Car Garages	0	0	N/A
Building Age	1	1	1
Distance to Nearest Park is Less than 1/4 Mile	1	1	N/A
Percent within 1/8 mile of Lake Michigan	1	1	1
Hyde Park Comparables			
Distance in Miles to Nearest Cemetery	1.603	1.644	N/A
School Test Score	62.518	57.483	N/A
Population Ratio: Hispanic	3.845	3.856	3.856
Population Ration African-American	29.363	43.719	43.719
Crime Rate	2.289	2.762	N/A
Density of Low Income Persons	7.697	7.832	N/A
Density of Middle Income Persons	4.137	4.294	N/A
Density of High Income Persons	7.925	6.750	N/A
Density of All Opportunities	13.159	19.040	19.040
ODI	0.289	0.270	0.270
Composite Accessibility to Opportunities 1/2 Mile	0.348	0.349	0.349
Accessibility Via Transit to Opportunities 1/2 Mile	0.224	0.222	0.222

N/A = Not Applicable to the Calculation; AVG = City/County-wide average

Table 8-16 OLS Simulation Hedonic Price Model Variable Assumptions: Local Transportation Variable Assumptions

Property Type & Development Area	Non-Variable Percentage Shares for Each Project Area												
	Metra Station Proximity				Metra Line Proximity			CTA Station Est. Proximity			CTA Line Proximity		
	1/8 Mile	1/8-1/4 Mile	1/4-1/2 Mile	1/2-1Mile	1/8 Mile	1/8-1/4 Mile	1/4-1/2 Mile	1/8 Mile	1/8-1/4 Mile	1/4-1/2 Mile	1/8 Mile	1/8-1/4 Mile	1/4-1/2 Mile
Residential													
Market Com.	0.000	0.182	0.818	0.000	0.000	0.182	0.818	0.818	0.182	0.000	0.227	0.591	0.182
US 41	0.000	0.091	0.598	0.311	0.000	0.091	0.598	0.795	0.205	0.000	0.886	0.114	0.000
Ore Wall	0.000	0.000	0.236	0.764	0.000	0.000	0.236	0.491	0.509	0.000	0.236	0.364	0.400
The Slip	0.000	0.000	0.051	0.949	0.000	0.000	0.051	0.127	0.873	0.000	0.418	0.253	0.329
Central Park	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.524	0.476	0.000	0.485	0.447	0.068
Lakefront	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.447	0.553	0.000	0.224	0.224	0.553
Commercial (SF)													
Market Com.	0.000	0.182	0.818	N/A	N/A	N/A	N/A	0.818	0.182	0.000	N/A	N/A	N/A
US 41	0.000	0.091	0.598	N/A	N/A	N/A	N/A	0.795	0.205	0.000	N/A	N/A	N/A
Ore Wall	0.000	0.000	0.236	N/A	N/A	N/A	N/A	0.491	0.509	0.000	N/A	N/A	N/A
The Slip	0.000	0.000	0.051	N/A	N/A	N/A	N/A	0.127	0.873	0.000	N/A	N/A	N/A
Central Park	0.000	0.000	0.000	N/A	N/A	N/A	N/A	0.524	0.476	0.000	N/A	N/A	N/A
Lakefront	0.000	0.000	0.000	N/A	N/A	N/A	N/A	0.447	0.553	0.000	N/A	N/A	N/A

N/A = Not applicable to the calculation

Table 8-17 Key Model Variable and Parameter Estimates

	Spatial Error (Mean)	OLS (Mean)
Single-Family		
Imp.*Walk Time at 1/4 Mile Tier	0.150	0.095
Within 1/8 Mile of Line	-0.150	-0.124
Within 1/4 Mile of Line	-0.093	-0.081
Within 1/2 Mile of Line	-0.048	-0.044
Avg. Impedance Value at 1/4 Mile	1.000	1.000
Avg. Impedance Value at 1/2 Mile	0.724	0.724
Avg. Impdedance at 1 Mile	0.452	0.452
Multi-Family		
Imp.*Walk Time at 1/4 Mile Tier	0.084	0.091
Within 1/8 Mile of Line	-0.065	-0.077
Within 1/4 Mile of Line	-0.026	-0.025
Avg. Impedance Value at 1/4 Mile	1.000	1.000
Avg. Impedance Value at 1/2 Mile	0.728	0.728
Avg. Impdedance at 1 Mile	0.452	0.452

Table 8-18 Land Development Assumptions for the NPV Financial Model

Project Area Land Development Assumptions	Lower Bound	Upper Bound
Pace of Development		
Residential		
Market Common	440	1056
US 41	1320	3168
Ore Wall	550	1320
The Slip	790	1896
Central Park	1030	2472
Lakefront	1520	3648
Commercial (SF)		
Market Common	7,400,000	7,400,000
US 41	400,000	400,000
Ore Wall	400,000	400,000
The Slip	4,900,000	4,900,000
Central Park	1,900,000	1,900,000
Lakefront	1,900,000	1,900,000
Commercial (Equivalent Units)		
Market Common	81	81
US 41	4	4
Ore Wall	4	4
The Slip	54	54
Central Park	21	22
Lakefront	21	21
Timing of Development		
Residential		
Market Common	2016	2018
US 41	2016	2021
Ore Wall	2016	2030
The Slip	2025	2040
Central Park	2030	2050
Lakefront	2040	2060
Commercial		
Market Common	2016	2018
US 41	2016	2021
Ore Wall	2016	2028
The Slip	2023	2038
Central Park	2028	2048
Lakefront	2038	2058
Land Value Appreciation (%)		
Model Range	-3.3%	9.0%

Table 8-19 Other Financial Model Assumptions

Assumptions	Value
Discount Rate	**6.0%**
Property Tax Rate (Residential & Commercial)	**5.5%**
Percent of Market Value Assessed	
Residential	**20%**
Commercial	**75%**
Residential Property Type	
Single-Family	**33%**
Multi-Family	**67%**
Typical Units per Avg. Multi-Family	**2**
Typical Commercial Property SF (Cook County Averages)	91,341

Table 8-20 Base value Calculations for Properties by Project Area and Method (2016 $)

	OLS	SE
Average Simulated Value without CTA		
Single Family		
Market Common	$310,650	$303,396
US 41	$307,299	$300,216
Ore Wall	$302,613	$295,760
The Slip	$300,834	$294,062
Central Park	$300,350	$293,601
Lakefront	$300,350	$293,601
Multi-Family		
Market Common	$412,625	$405,765
US 41	$415,244	$406,891
Ore Wall	$418,781	$407,672
The Slip	$419,960	$407,218
Central Park	$420,282	$407,095
Lakefront	$420,282	$407,095
Commercial		
Market Common	$7,586,313	N/A
US 41	$9,133,636	N/A
Ore Wall	$10,036,764	N/A
The Slip	$10,354,876	N/A
Central Park	$10,443,333	N/A
Lakefront	$10,443,333	N/A
Avg. Simulated Value with CTA & CTA Lines		
Single Family		
Market Common	$312,658	$317,269
US 41	$298,407	$299,623
Ore Wall	$304,333	$307,979
The Slip	$296,537	$297,581
Central Park	$295,382	$297,360
Lakefront	$303,616	$307,506
Multi-Family		
Market Common	$435,415	$426,445
US 41	$421,461	$414,597
Ore Wall	$440,596	$427,528
The Slip	$433,059	$419,754
Central Park	$433,259	$419,480
Lakefront	$443,707	$428,405
Commercial		
Market Common	$10,039,874	N/A
US 41	$12,065,317	N/A
Ore Wall	$12,934,101	N/A
The Slip	$12,954,608	N/A
Central Park	$13,494,588	N/A
Lakefront	$13,410,483	N/A

	OLS	**SE**
Average Simulated Value with CTA, but no CTA Lines		
Single Family		
Market Common	$340,109	$349,857
US 41	$336,240	$345,864
Ore Wall	$328,472	$336,468
The Slip	$323,429	$329,536
Central Park	$326,302	$334,473
Lakefront	$325,643	$333,411
Multi-Family		
Market Common	$449,776	$439,492
US 41	$452,377	$440,484
Ore Wall	$452,817	$438,271
The Slip	$450,031	$434,155
Central Park	$454,814	$437,983
Lakefront	$453,952	$437,215
Commercial		
Market Common	$10,039,874	N/A
US 41	$12,065,317	N/A
Ore Wall	$12,934,101	N/A
The Slip	$12,954,608	N/A
Central Park	$13,494,588	N/A
Lakefront	$13,410,483	N/A

Figure 8-11: Distribution Functions –Tax Transfer Scenario, Total Revenue (NPV, 2016 $), Including Line Effects, Residential Only

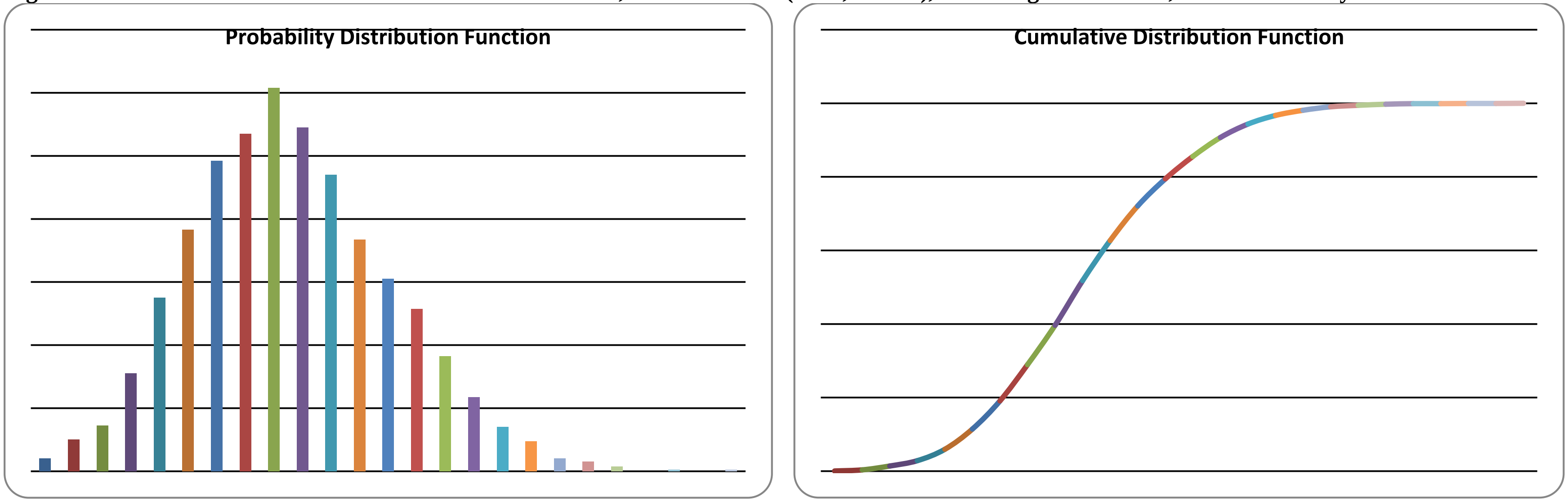


Figure 8-12: Distribution Functions –CTA as Tax Authority, Total Revenue (NPV, 2016 $), Including Line Effects, Residential Only

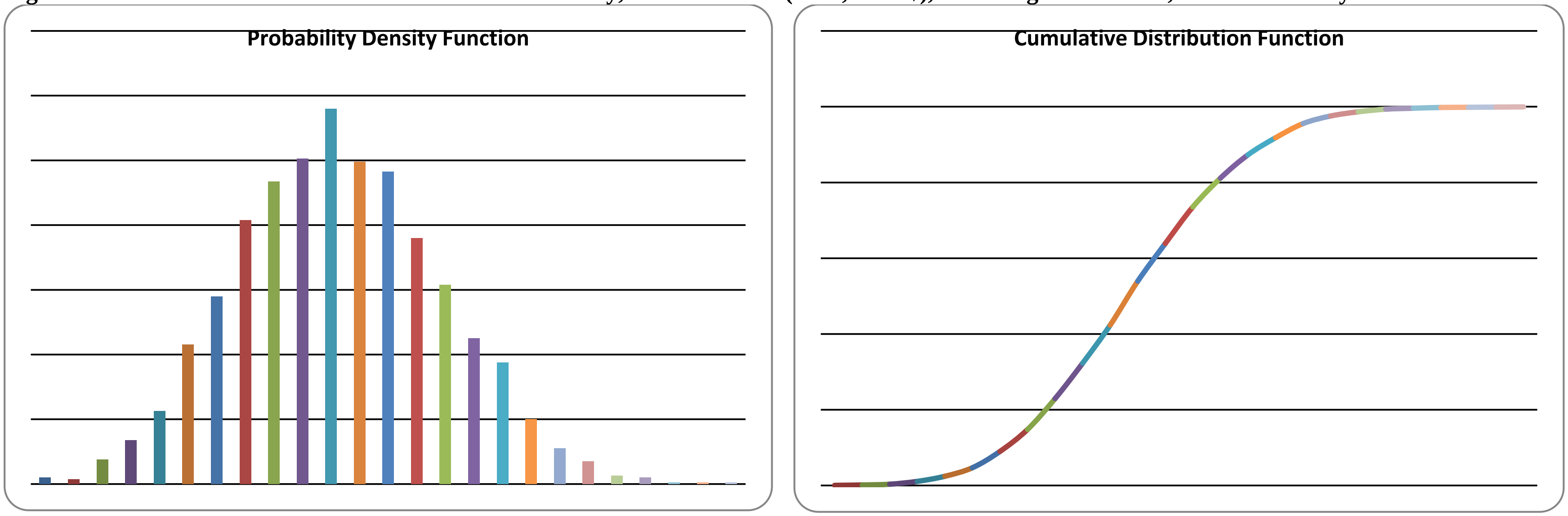


Figure 8-13: Distribution Functions –CTA as Tax Authority, Total Revenue (NPV, 2016 $), Including Line Effects, Commercial and Residential

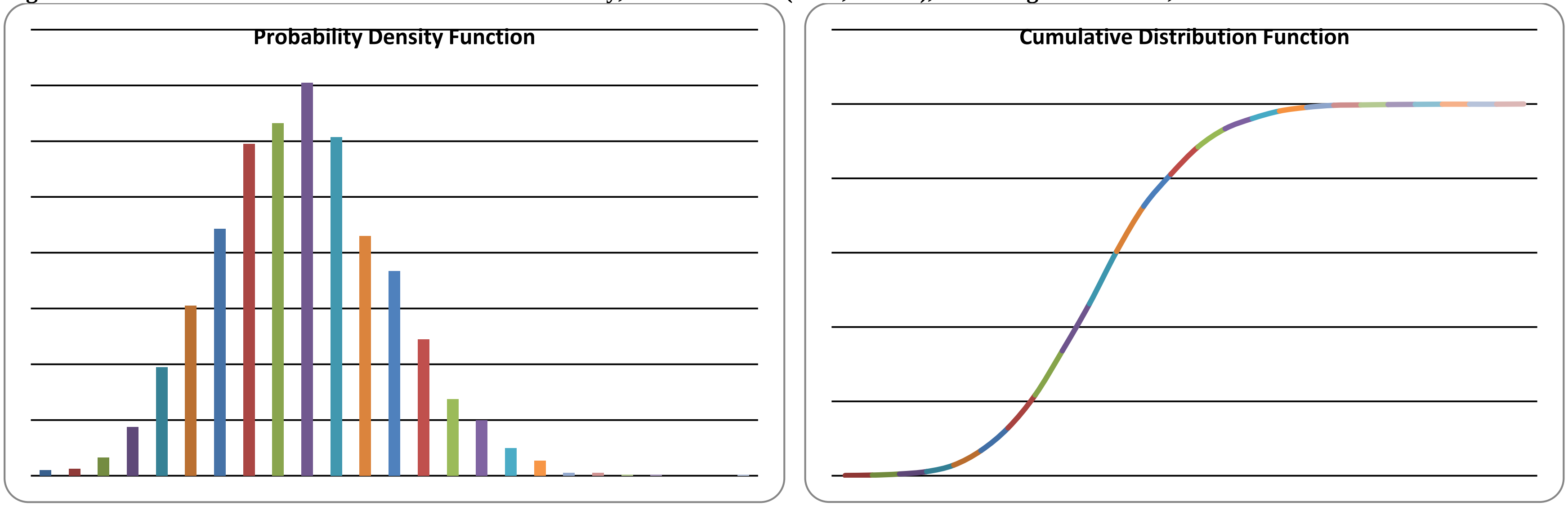


Figure 8-14: Distribution Functions –Tax Transfer Scenario, Total Revenue (NPV, 2016 $), Excluding Line Effects, Residential Only

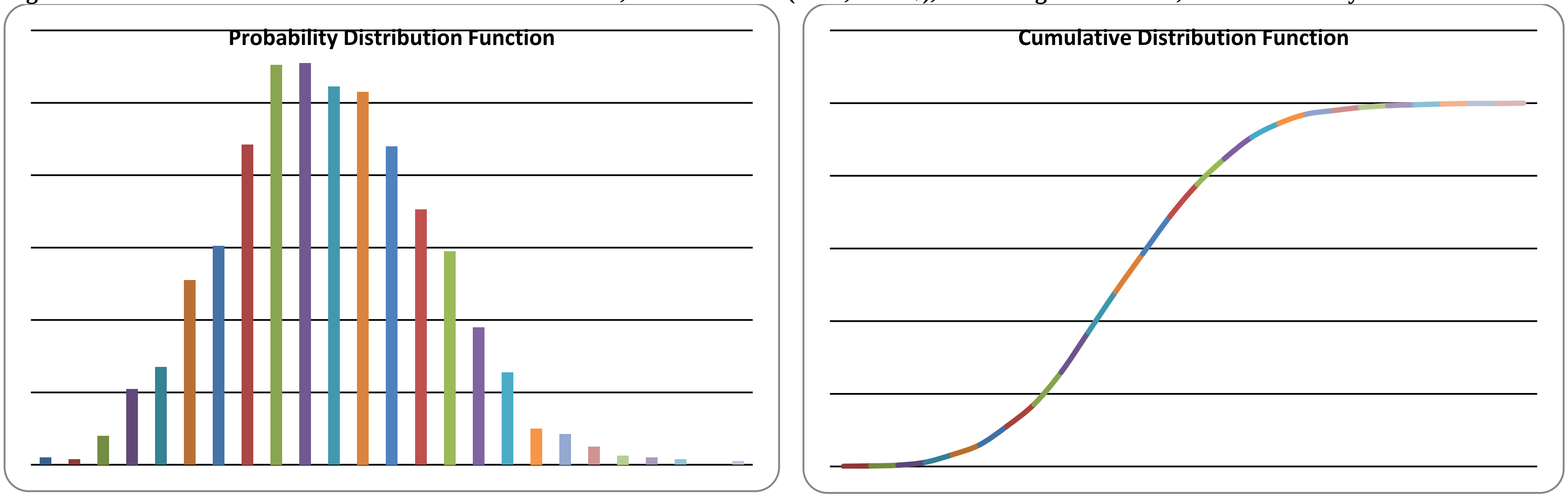


Figure 8-15: Distribution Functions –Tax Transfer Scenario, Total Revenue (NPV, 2016 $), Excluding Line Effects, Residential Only

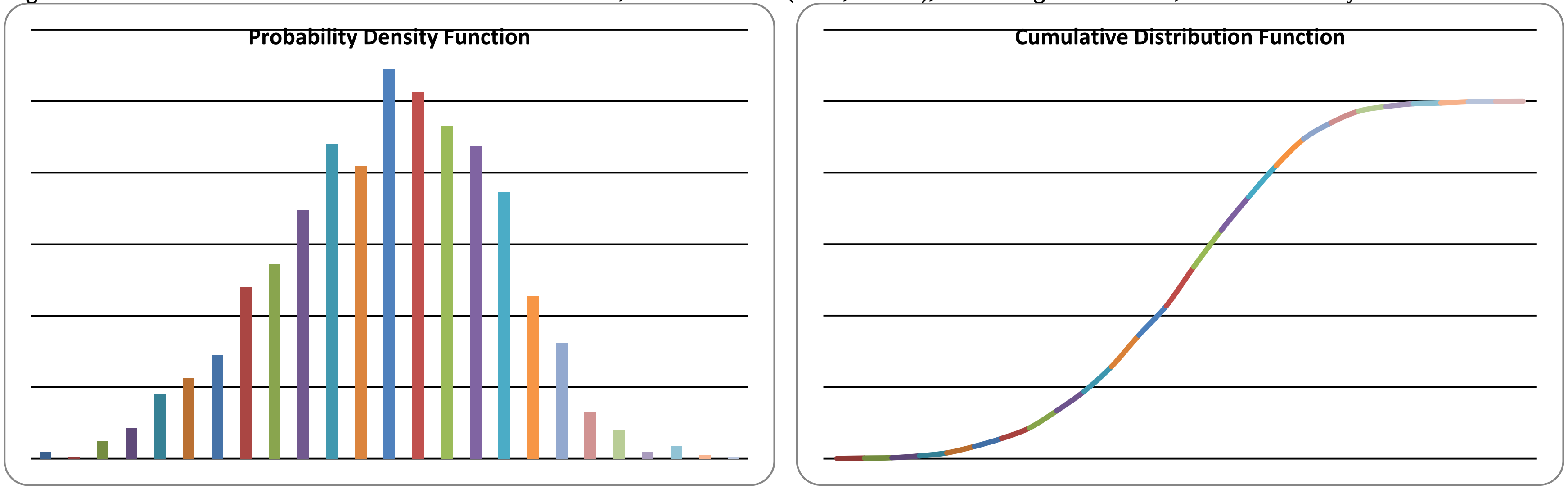


Figure 8-16: Distribution Functions –CTA as Tax Authority, Total Revenue (NPV, 2016 $), Excluding Line Effects, Residential Only