doi:10.1111/pirs.12038

The impact of Hudson-Bergen Light Rail on residential property appreciation

Kyeongsu Kim[1], **Michael L. Lahr**[2]

[1] Geography in Earth and Environmental Sciences, The Graduate Center of the City University of New York (CUNY), 365 Fifth Avenue New York, NY 10016-4309 USA (e-mail: kkim@gc.cuny.edu)
[2] Edward J. Bloustein School of Planning & Public Policy, Rutgers-The State University of New Jersey, 33 Livingston Avenue, New Brunswick, NJ 08901-1982, USA (e-mail: lahr@rutgers.edu)

Received: 9 February 2012 / Accepted: 20 March 2013

Abstract. This paper analyses the impact of the Hudson-Bergen Light Rail (HBLR) on residential property prices. Unlike similar studies that use a hedonic model with cross-sectional data, this one uses repeat-sales data of properties that sold at least twice between 1991 and 2009. It shows how proximity to the nearest HBLR station, relative accessibility gains across stations, and anticipation of the commencement date of the HBLR station influence home price change. Our results show that properties near the two commuting stations farthest from the revitalized central business district experienced high appreciation. It also reveals that different accessibility gains across areas were produced based on the availability of existing public transportation options. Using a negative–exponential gradient, we find that these higher appreciation rates tended to dissipate about 1/4 mile (402 m) from stations. This supports that properties around urban commuting stations enjoy higher marginal benefits through improved transit accessibility and reduced transportation costs as Alonso's model predicts.

JEL classification: R14, R21, R42

Key words: Housing prices, light rail transit, accessibility, hedonic, Alonso model

1 Introduction

Even before the Hudson-Bergen Light Rail line (HBLR) began operation in 2000, a debate was underway in the US that weighed in on the advantages and disadvantages of investment in light rail systems. Listed advantages were reduced pollution, congestion, and energy consumption levels along with more compact economic development. The prime disadvantage was the size of annual government subsidies required to underwrite such projects that appeared to benefit a relative few. Nevertheless, rising environmental awareness, sky-rocketing real prices of petrol and diesel fuel, local bonds, and federal and state transportation capital funding enabled several new light rail transits (LRT) in the US. Admittedly, enhancing economic development around light rail stations was another substantial bullet point to booster LRT (Garrett 2004). METRO-

Rail in Houston, Hiawatha light rail in Minneapolis, Lynx in Charlotte, the RiverLine along the Delware River in southern New Jersey, and the HBLR, for example, were planned and opened during an LRT revival.

Despite the surge in new LRT facilities, naysayers did not let up. They subsequently pointed to higher-than-expected construction costs, low passenger use, and the slow progress of development near LRT stations. Supporters noted that LRT is believed to be a more sustainable transportation option *vis-à-vis* highway-oriented infrastructure investment; and economic development near transit stations was never expected to be quick. Both groups agree, however, that one aspect of economic development should be fairly fast, that is, residential properties near transit stations should appreciate in value. This is because they should capitalize immediately on their new-found accessibility, perhaps even speculatively, before the transportation investment operates. The Alonso-Wingo model, purported by planners and developers alike, suggests when transit lowers commuting costs property values should rise throughout transit's urban reach. The underlying assumption for higher property values is that a rail system must reduce commuting costs, either in the form of perceived total transit time or monetary costs.

In the wake of Alonso's 1964 book, many studies were undertaken, valuating properties along new commuter and heavy rails. A few studies have found mixed, no, or negative impacts on property values of rail transit (Dornbush 1975; Armstrong 1994; Bowes and Ihlanfeldt 2001). Yet, they generally found that properties proximate to the rail stations owned a property value premium (Graybeal and Gifford 1968; Boyce et al. 1972; Lee 1973; Dewees 1976; Damm et al. 1980; Bajic 1983). Some recognized that businesses are even more likely to enjoy the accessibility gain than households (Weinstein et al. 1999; Cervero and Duncan 2002; Debrezion et al. 2007). These findings were no real surprise, for historically rail had altered both the nature of urban systems and the internal structural form of cities from its infancy (Jackson 1985; Xie and Levinson 2010). Admittedly, accessibility gains cannot be identical among different rail types (i.e., commuter rail, subway, light rail and others) due to dissimilar magnitude of their realized accessibility gain. Relatively lower speeds realized by LRT service compared to other forms of commuting are expected to result in lower rates of appreciation for residential properties than are obtained via other forms of transportation. Still, home price rises are expected.

When it comes to property appreciation, it is clear that multifarious factors, not just rail alone, are involved. Land use controls and economic growth independent of the rail network can influence land-market responses (Knight and Trygg 1977). Over time, therefore, the burgeoning literature on housing hedonics has attempted to valuate or control for many items that could affect properties' values such as tax payments; proximity to recreational amenities, quality schools, retail establishments, and churches; and even proximity to 'bads' such as nuclear electricity generation stations, brownfields, and superfund sites. As early as Graybeal and Gifford (1968), analysts formally recognized in hedonic analysis that highways and automobiles combined are after all a prime competitor to rail, so that properties can also capitalize on accessibility enabled by them (Voith 1993). Admittedly, being too close to a major road also can engage some negative externalities. In general, however, the increasing density of US highway networks has lowered the marginal value of accessibility through reduced road transportation costs (Fernald 1999). Indeed, the marginal value has been asymptotically approaching negligible levels (Giuliano 1989; Glaeser and Kohlhase 2004). Consequently, as the density of highways has increased, the value of moves (relocations) for each household to exploit transportation cost reduction has declined, perhaps to the point that it no longer overcomes the friction of moving to improve workplace accessibility alone.

In light of the capitalization impact from new LRT investment, Hudson County, New Jersey may be an ideal setting to evaluate the ability of properties to capitalize on their proximities to a light rail station. First, the road network in Hudson County was largely built decades ago: and only minor repairs and realignments have been made since plans for the HBLR were announced.

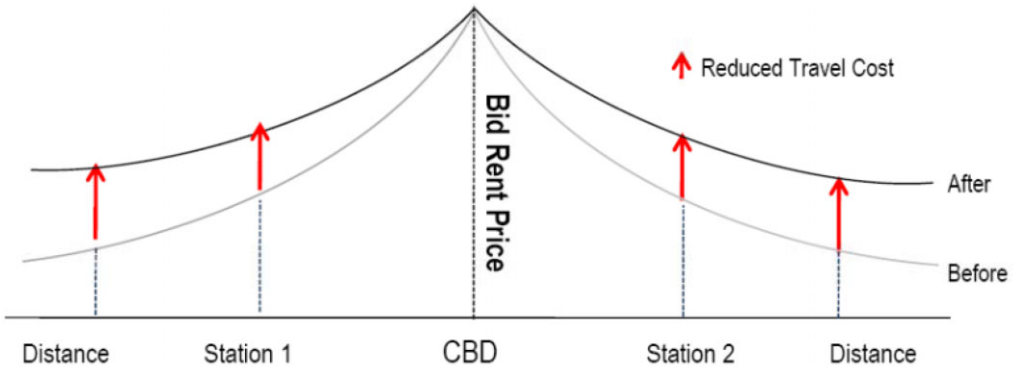

Fig. 1. Theoretical effect of reduced transportation costs on property values

Hence, the effect of highway accessibility on recent property prices should be negligible. Insofar as accessibility's impact on property prices is concerned, then, only recent transit investment (opened since about 2000) should reveal itself as important. Second, HBLR provides a new public transportation link to Jersey City's newly developed waterfront central business district (hereafter, JCCBD waterfront), where direct transit connections exist between New Jersey and New York City (NYC) as well. Thus, according to the Alonso-Wingo model, new accessibility gains due to the presence of the HBLR should raise bid-rents around HBLR stations. In particular, the price effect is likely to be greatest (for a fixed quantity of property) as properties distant from the central business district (CBD) (Figure 1 demonstrates this relationship). In reality, however, the accessibility gain cannot simply be justified by distance. An actual accessibility is not justified by distance but rather by net gains in transit time for residents' everyday trips. Regardless, people who prefer the HBLR to other forms of travel should want to live close to its transit stops. In this vein, Alonso-Wingo theory suggests these transit-preferring residents will pay a premium for this prospect up to some amount less than the life-time savings (in terms of actual transportation expenses and the opportunity value of their time) that they will enjoy at the location. Thus, the HBLR is likely to be capitalized in the real estate market.

In this paper we strictly report the effect of the HBLR that has had on residential (one to four units) properties sold at least twice between 1991 and 2009. We initially assumed that properties near three HBLR stations (called urban commuting stations here) farthest from the JCCBD waterfront gain the greatest benefits. That is, we realized the relative magnitude of accessibility gains will be different throughout the HBLR service areas due to dissimilar existing public transportation options as well as dissimilarities in the percentage change due to improved accessibility. In particular, the northern part of Hudson County, which has good bus connections to Manhattan (the regional job hub), is expected to experience lower service gains than will other areas of the county. Thus, we hypothesized that net accessibility gains are not only likely to be higher when costs are reduced due to longer distances travelled but also when existing public transportation options are less abundant. Hence, we tested how the impacts of the HBLR differ by station. Because the analysis is performed on price changes between the first and second (most recent) sales at any time during the period, we also investigate multiple ways to put the sales prices into constant (real) monetary terms.

In Section 2 we describe the HBLR's progressive development, current ridership trends, pre-HBLR accessibility, and socio-demographic characteristics of HBLR service areas. We believe this all helps the reader understand the magnitude of relative accessibility gains made possible by the HBLR. Section 3 reviews the literature on the effect of LRT on property values, to further develop research hypotheses already briefly touched upon. Section 4 discusses the study dataset and approach used to perform the analysis. Section 5 presents and discusses our findings, including comparative analyses to prior studies. Section 6 concludes with a summary of findings, policy implication for LRT and suggestions for further research.

2 Description of the HBLR and its service area

As planned in 1984, the HBLR was to regenerate Hudson County's economy by improving transit accessibility in which the highway and street network had dominated. The $2.2 billion LRT project was executed in 1996 with a design/build/operate/maintain contract via a public and private partnership that was forged between the Washington Group International and New Jersey Transit. The first phase of a 9.5 mile (15.2 km) segment extended from Exchange Place south as far as to 34th Street in Bayonne and southwest to West Side Avenue in Jersey City in 2000 (two lines share a track between a Liberty State Park station and Newport station in Jersey City; see Figure 2). Extensions northward to the waterfront at Newport station followed in 2001, and another north to NJ Transit's Hoboken Terminal in 2002. In 2003, the line extended south to 22nd Street in Bayonne. The following year, it extended even further northward to Lincoln Harbor in Weehawken. Port Imperial in Weehawken, Bergenline Avenue in Union City, and Tonnelle Avenue in North Bergen were added in 2006. The most recent extension was completed in 2011, adding 8th Avenue in Bayonne. As of January 2011, the HBLR is 20.6 miles (33.2 km) long and serves seven municipalities via 24 stations along the Hudson River waterfront as Figure 2 shows. Today, the HBLR operates as a 'proof-of-payment' fare collection system. A

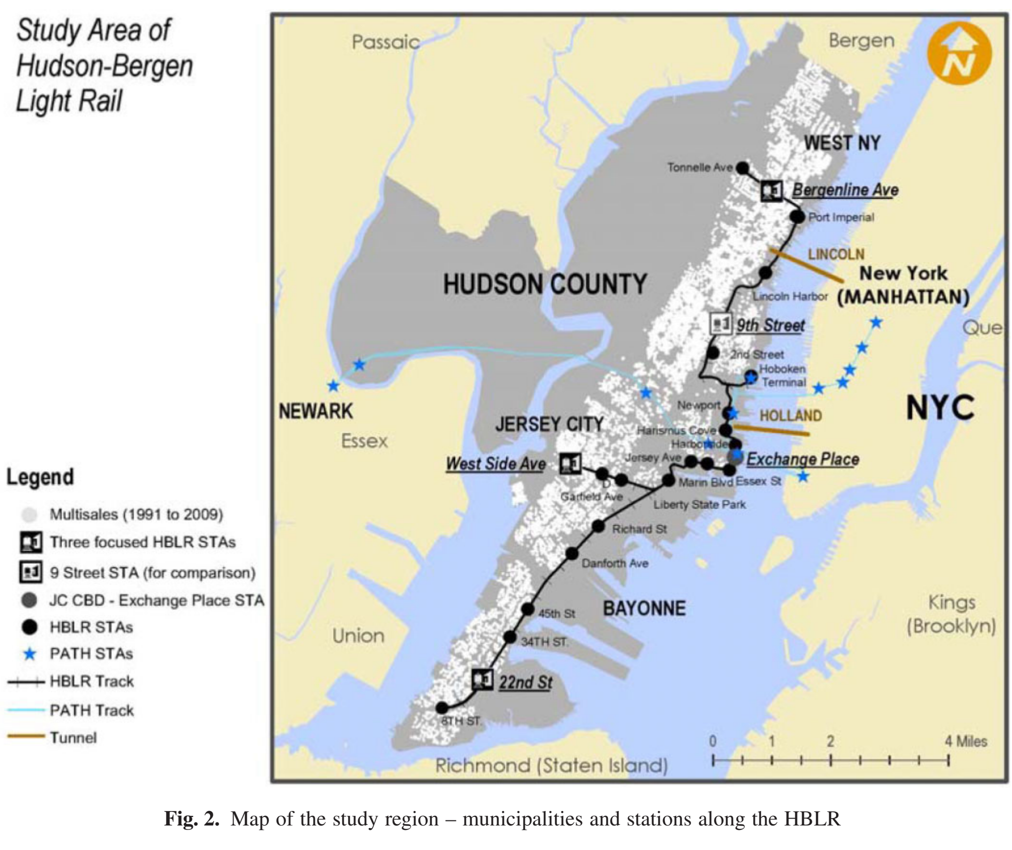

Fig. 2. Map of the study region – municipalities and stations along the HBLR

Table 1. HBLR's average daily boardings since operations commenced through to 2009

2008 Ranks	Stations	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	Newport		411	2,725	2,885	2,625	2,997	3,256	4,825	5,447	5,824
2	Hoboken				1,931	2,391	3,710	4,707	5,048	5,381	5,830
3	Exchange Place	1,453	2,302	2,641	2,806	2,584	2,853	3,092	4,196	4,830	4,997
4	Bergenline Avenue							1,413	2,125	2,641	2,872
5	Liberty State Park[1]	618	1,390	2,048	2,071	1,852	1,913	1,808	2,450	2,725	2,771
6	9th Street						620	923	1,812	2,193	2,427
7	22nd Street[1]					468	1,141	1,313	1,748	1,811	1,995
8	West Side Avenue[1]	204	368	613	771	711	870	931	1,342	1,634	1,693
9	34th Street[1]	638	935	1,266	1,211	955	907	948	1,236	1,495	1,720
10	Harborside		338	958	1,363	1,142	1,219	1,222	1,609	1,726	1,801
11	Essex Street	68	107	499	915	665	763	766	991	1,153	1,159
12	MLK Drive	109	233	408	444	464	612	640	882	1,037	1,109
13	Tonnelle Avenue[1]							608	873	995	1,071
14	Harsimus		61	195	285	330	453	519	756	793	918
15	2nd Street						196	325	739	854	924
16	Port Imperial							417	618	784	840
17	Jersey Avenue	56	113	139	146	184	390	409	610	698	810
18	45th Street	291	449	557	500	496	611	607	804	824	903
19	Danforth Avenue	135	223	331	350	372	480	483	657	719	773
20	Lincoln Harbor						305	491	821	890	878
21	Garfield Avenue	58	120	190	222	237	328	380	491	589	684
22	Richard Street	71	131	232	234	274	345	336	439	499	552
23	Marin Boulevard	99	169	248	266	350	337	256	328	382	449
	All Stations	3,800	7,350	13,050	16,400	16,100	21,050	25,850	35,400	40,100	43,000

Note: [1] Parking lot is available.
Source: NJ Transit.

$100 fine is applied for failure to show a ticket upon official request. A one-way adult fare is $2.10 and unlimited monthly pass is $64. The HBLR shuts down daily from 2 AM to 5 AM. It has peak headways of about 5 minutes but they are relaxed to as much as 10 minutes during off-peak hours. During peak hours, occasional express train services operate between Bayonne and Hoboken Terminal.

Table 1 presents the average daily boardings since its inception. Newport, Hoboken, Exchange Place, and Harborside stations are defined here as within the JCCBD waterfront, where a professional and financial industry cluster developed starting in the 1980s, due in part to fairly direct access to both Downtown and Midtown Manhattan through the Port Authority Trans-Hudson (PATH) train. It also includes one outlier station – Liberty State Park. This station is essentially a feeder for a tourist venue. It is home to a science museum largely visited by student groups, which also yields access to Ellis Island, and is the base of operation for ferries that run to the Statue of Liberty. Also, generous parking at the station makes it a natural HBLR collection point for CBD and Manhattan workers who live southwest of the county. The stations that follow represent extreme ends of the HBLR: Bergenline Ave, West Side Avenue, 22nd Street and 34th Street.

The municipalities served via HBLR have rather diverse local characteristics. Distinct socio-economic and socio-demographic characteristics and dissimilar existing accessibility with public transportation may influence a HBLR ridership propensity; thereby, produce different accessibility gains capitalized in property values. To better recognize these local circumstances, three political and demographic groups can roughly be categorized: Jersey City/Hoboken, Bayonne, and the cluster of northern municipalities. Like other Rustbelt cities, Jersey City experienced decline during the early 1960s. Since the 1990s, new commercial/office and luxury residential developments in the JCCBD waterfront (near PATH stations; Pavonia-Newport and Exchange Place) have occurred; there, residential property prices have been buoyed by their accessibility to Manhattan. Areas beyond walking-distance to PATH stations have yet to partake in this revival, however. Investment in the HBLR was intended to stimulate the local economy by enhancing accessibility to the JCCBD waterfront – particularly areas, the county's low-income neighbourhoods in inner Hudson County, which retain high shares of minority populations.

Hoboken is unique in the region because of its geographic and a long-established transportation link to Manhattan. The Lincoln Tunnel, PATH, and ferries make that connection. Historically it is a well-preserved urban ambience with brownstone and brick residential buildings, a variety of retail stores, and numerous restaurants and bars have made Hoboken an attractive residential community for Manhattan-based workers. Additionally similar to JCCBD waterfront, Hoboken's waterfront has experienced a surge in luxury residential developments since the 1990s. Moreover, young professionals who seek ready access to Manhattan's many amenities but at a lower housing price are particularly attracted to relocation to Hoboken. High and rising median household income and a drop in the share of senior population compared to the county- and state-average in Table 2 underline this fairly recent trend.

Bayonne, located at the southern end of Hudson County's peninsula, was a home to a set of vibrant refineries, a port, and rail yards prior to the Second World War. Yet, it ceased to be an attractive location for business and residence even before a major naval terminal closed in 1995. Due to its geographical isolation, transit accessibility to Manhattan prior to the HBLR had almost always been inferior to that available to the northern part of the county. According to the US Census Bureau's 2005–2009 American Community Survey (ACS) 5-Year Estimates, Bayonne showed the county's highest share of senior population (14.2%)

Finally, the northern municipality cluster includes Union City, North Bergen, and West New York; all of which have been immigrant communities since their foundation. The cluster is composed of neighbourhoods with high percentages of foreign-born (mostly Hispanic) populations and high shares of low-income households. As seen in Table 2 about two thirds of cluster's population is Hispanic in ACS estimates (and has long been higher than the county's average) with a correspondingly lower median household income than other areas. Yet, it has easy access to the Port Authority Bus Terminal (PABT) in Midtown Manhattan, thanks to the Lincoln Tunnel, which maintains designated bus lanes during peak hours. Hence, this area's accessibility gains from the added presence of the HBLR may be lower than it is in other areas of the county where public transportation options were more limited prior to the HBLR.

3 Literature Review and Research Hypotheses

A large literature has formed on the effect of commuter and intercity rail on property values. Much of it has been reviewed and summarized by various researchers (Knight and Trygg 1977; Huang 1996; Ryan 1999; Bartholomew and Ewing 2011). Ryan (1999) tells future researchers that, thanks to improved accessibility, property value changes tend only to be captured when travel time savings to existing commercial centres are present and are accurately measured. For this reason, she underlines the importance of connecting new track to existing commercial centres. Ultimately, her point is that urban redevelopment can still be transit-oriented but it seems to have fairly well-defined spatial limits, especially when dealing with rail.

While studies of commuter rail in general are relatively abundant on an international scale, those of light rail are more limited in quantity. This is partly because many light rail systems had been put in place since the first third of the twentieth century. Interest in light rail has renewed. Indeed, it has been a wave of enthusiasm in the US akin to the subway/ commuter rail 'boomlet'

Table 2. Socio-demographic characteristics (and changes in them) for HBLR municipalities

	Total Population	Pop – 65 years and over; (%)			Primary Race ; Percent[1]						Med HH Income[3]		
					White (Black[2])			Hispanic or Latino (of any race)					
	2009	2009	1999	1989	2009	1999	1989	2009	1999	1989	2009	Increasing Ratio from 1999	Increasing Ratio from 1989
New Jersey	8,650,548	13.2	13.2	16.3	70.2	72.6	79.3				68,981	1.25	1.69
Hudson County	593,615	10.8	11.4	15.4	58.5	55.6	68.8	40.6	39.8	33.2	53,475	1.33	1.73
Hoboken	39,978	5.8	9.0	13.4	83.5	80.6	79.0		20.1	30.1	101,782	1.63	2.92
Jersey City	239,127	9.4	9.8	13.5	37.4 (27.1)	34.0 (28.3)	48.2 (29.7)	27.9	28.3	24.2	54,280	1.43	1.87
Bayonne	58,004	14.2	16.6	22.1	72.0	78.6	90.4				53,587	1.29	1.68
North Bergen	55,715	14.2	13.8	18.4	72.2	67.2	84.2	65.6	57.1	41.2	52,726	1.29	1.57
Union City	62,629	11.7	10.0	12.2	71.2	58.4	74.7	79.6	82.3	75.6	40,173	1.31	1.57
West New York	46,058	12.4	12.7	16.8	65.1	60.1	76.7	79.0	78.7	73.3	44,657	1.40	1.69

Notes: [1] As for brevity, over 20 per cent cells for Race are only in display.
[2] Only Jersey City in our study area involves over 20 per cent of Black Population.
[3] The ratio is based on nominal Median Household Income (not CPI-adjusted).
Source: 1990 and 2000 Decennial Census & 2005–2009 ACS 5-Year Estimates.

of the early 1970s that brought MARTA to Atlanta, BART to the Bay Area, and the Metro to Washington, DC. The single thing that separates the current light-rail boom from the subway-building era of the 1970s is that transit systems are now being designed not only to move commuters but to drive and shape urban (re)development. This underlines the importance of properly evaluating the effect of these systems on land values and the change in land uses near them.

The City of San Diego launched the first modern light-rail line in 1981 in the US. But it was only after Portland, Oregon, demonstrated how light rail could drive development patterns and after Dallas showed that trains in less densely urbanized urban areas could attract solid passenger numbers. Since these early efforts, more cities have decided to seek systems of their own and the following light rail have been evaluated: Metro of Buffalo, Metro of Houston, Hiawatha light rail in Minnesota, Lynx in Charlotte and DART in Dallas. To estimate the capacity of housing to capitalize on proximity to transit, most researchers have examined various characteristics of the property and of the neighbourhood that correlate with property prices. A key set of variables related to the property is that relating to its proximity to the LRT and competing modes of transportation. The following subsections detail some theory and hypotheses behind variables of interest to the present study.

3.1 Hedonic distance effects

In general, studies show that proximity to LRT stations tends to be more influential on property value than any other characteristics of the properties or their neighbourhoods. In essence, the findings have been similar to those for commuter rail and recently debuted bus rapid transit (BRT). A key manner in which studies differ is the way they estimate rent surfaces near transit stations. Two basic approaches have been employed: one estimates the average premium that accrues to properties within some pre-specified distance of transit stations and the other estimates a property value gradient for properties that results from their relative proximities to transit stations. In both cases, various distances between 0.25 miles (0.4 kilometre) to 1.25 miles (2.0 kilometres) have been used.

When an average premium is estimated, the size of the pre-defined study area, a so-called 'buffer boundary', can affect the magnitude of effects obtained (Dowall 1980). If the distance selected is larger than it actually is, estimates that result are downwardly biased; on the other hand, they are biased upwardly when the distance selected is smaller than it actually is. Hence, in evaluating the same station for the same transit line, two researchers could easily conclude differently about the magnitude of transit capitalization by properties. The inability to obtain such bias lends the gradient approach greater appeal. The approach also adheres more closely to Alonso-Wingo theory. In fact, armed with gradients and estimates of capitalized values immediate to the stations, one could measure the aggregate capitalization premium over the entire service area of an LRT. To do so, however, one must assume that the gradient is the same in all directions around each given station and that it diminishes to no less than a zero value. Of course, Alonso-Wingo theory suggests such an assumption may not be so idealistic since the cost of transport to stations – in this case walking – should be the same across stations. That said, this theory also asserts less realistically that all commuters have the same preference set.

Very few studies of property values near LRT lines have opted to use the gradient approach (Chen et al. 1998; Hess and Almeida 2007; Goetz et al. 2009). These teams of researchers have tended to estimate non-linear gradients with quadratic terms rather than the negative exponential gradient, typically used in urban analysis of related concepts (Manson 1981; Breuckner 1982). Quadratic functions, however, can undoubtedly approximate the negative exponential distribution within the range of distances examined. By leaning on Li and Brown (1980), Chen et al.

(1998) rationalized using something other than a negative exponential decay function. Their implicit point for property values near LRT lines is that the LRTs themselves could increase the production of public *bads* in the form of noise, transient traffic of pedestrians unknown in the neighbourhood, and loitering near LRT stations. Thus, they hypothesized that property values very near LRT lines as well as stations are likely to be depressed compared to those distant from the line or station. Despite the interesting hypothesis, Chen et al. (1998) failed to find any nuisance effects related to stations. They did detect nuisance effects elsewhere along the Portland's MAX line, however. To date all research on the topic of LRTs has tended to adopt the rather strong assumption that the gradient across stations is the same, which is unlikely to be a case due to dissimilar cost savings across stations as suggested by Figure 1.

3.2 Neighbourhood characteristics

As important to the value of a property as its own quantity and quality, is the perceived value of neighbouring properties. Using this as a basic rationale, many hedonic studies have included the neighbourhood's median household income or median home value. Higher values of these factors are hypothesized to affect property values in a positive manner. Similarly, district-average student scores on national or state standardized tests have been applied to control for school quality, since schools are the main local public good provided. To account for discrimination on the part of home buyers (and perhaps sales agents as well), hedonic models have also controlled for many neighbourhood attributes of households including share that have minority heads, that are headed by women, that are not fluent in English, and that are foreign born. To control for a different housing segment, some models have also controlled for the share of homes in the neighbourhood that are rented as opposed to being owner-occupied. In all cases, property prices are hypothesized to be lower in the presence of such factors.

4 Data description and formulation of the regressand

Bailey et al. (1963) first applied the repeat sales approach using this sales record data, although McMillen and McDonald (2004) and Chatman et al. (2012) have applied it more recently. The advantage of this approach is examining the actual object of analyses – property price appreciation – rather than inferring it from cross-sectional or pooled cross-sectional analyses of sales prices or assessed values, which is what the large body of literature on transit capitalization has leaned upon.

In essence, the basic theoretical model to measure repeat sales should look as follows:

$$\Delta P^h = P_2^h - P_1^h = \sum\nolimits_i ((P_{i2}\Delta Q_i) + (\Delta P_i Q_{i1})). \tag{1}$$

$\Delta P^h = P_2^h - P_1^h$ is the change in the property value where P_1^h and P_2^h are property values in time 1 and 2 respectively. The P_{i2} is the price of each attribute i in time 2 and ΔP_i are the price changes of those attributes between time 1 and time 2; Q_{i1} is the quantity of attribute i in time 1 and ΔQi is the change in the quantity of attribute i. That is, the change of a property value is the sum of two sets of basic measurements: the total value of any new attributes (or changes in existing ones) and the change in value of existing attributes.

State of New Jersey's property sales records are publicly available. They are not without problems, however. They lack details on the attributes of recorded properties: at best, beyond location identifiers, they include information on lot size and year the primary structure was built. Thus, it is impossible to estimate the price change in all attributes that the theoretical model requires. Contrary to Goetzmann and Spiegel's (1995) conjectures, this level of data omission may not be so damning, The work of Coulson and Lahr (2005) on older neighbourhoods in Memphis suggests that few variables on changes in attributes affect assessed property values at least over a four-year period. Indeed, they included variables on changes only for the number of bedrooms and bathrooms, despite having at their disposal a full array of variables for their analysis. Hence, we rely strongly on Wang and Zorn's (1997) notion that a major advantage of the repeat sales approach is that researchers can largely avoid specifying critical characteristics that determine a property's value.

As mentioned earlier, we want to measure how the presence of the HBLR influenced property price change. The ratio of values between two sales events is our main interest. Clearly, however, there are some issues in measuring this ratio given that the value of money differs over time. Also, housing markets are both segmented and cyclic. In the related empirical literature, using a price index to control for relative prices has rarely been a concern since the typical analysis has tended to use cross-sections, cross-sections paired across just two points in time, or unrelated cross-sections pooled over many periods; none of which require explicit control for relative prices over time. Besides, if the two sets of house sales are reported for the same years across all observations, concerns about general inflation and housing market cycles need not come into play, especially in the case of small geographic areas. This was the case for the work on assessed values performed by Coulson and Lahr (2005). In this vein, the use of repeat sales data makes matters more complex, for such sales do not occur in a regular pattern across time. Successive sales of an observed property could more or less occur at any time during that period. Bearing this in mind, we tested three different dependent variables that convert the sales prices into a constant-value form.

For the first alternative, we used the ratio of the two sales; both adjusted to 2009 monetary terms using the housing component of CPI-U, which is typically practiced in a pooled cross-session analysis, for the New York metropolitan area.[1] Using the metro-wide price-adjusted ratio, we also estimated the annual average appreciation rate as the second alternative. This latter additionally controls for the time that transpired between the two sales, which we believed would make it superior. The following formulae were used. The first formula used for annual average appreciation takes the form: $y_{t=T}/y_{t=o}$, where $y_{t=T}$ represents the consumer price index (CPI)-adjusted last year (T) price, and $y_{t=o}$, the CPI-adjusted first year (0) price. The second formula used for annual average appreciation involves an adjustment for length of time between sales:$(y_{t=T}/y_{t=o})^{1/(T-t)}$, where $1/(T-t)$ is the inverse number of years between sales.

The third alternative is created similarly. The main difference is that, rather than using the housing component of the area CPI-U, we deflate by the average value of all sales within each municipality during the specified year. Our thinking here was that each municipality acts as a separate segment within the larger northern New Jersey housing market. This consideration should automatically control for other attributes of municipalities that affect property sales prices, particularly those that are fiscally related. The formula for this municipal-oriented dependent variable is $\left(\frac{Y_{t=T}}{Y_{t=o}}\right)\Big/\left(\frac{P_{t=T}}{P_{t=o}}\right)$, where $Y_{t=T}$ is a nominal sales (not CPI-adjusted) price in the last year (T) price and $Y_{t=0}$, the first year (0) price while $P_{t=T}$ and $P_{t=o}$ represents the average local sales price in the last year (T) and the first year (0).

As Table 3 shows, we included a range of regressors: proximity measures to different entities, neighbourhood characteristics, and transaction features. We tested distinct effects for the three stations. These stations were chosen based on their distance to the JCCBD waterfront and the relative magnitude of hypothesized accessibility gains by HBLR. Both 22nd Street (8th

[1] Following the example of the present piece, Chatman et al. (2012) apply this same method although with only repeat-sales properties transacted before and after LRT (the RiverLine in southern New Jersey) began its service.

Table 3. Summary of descriptive statistics for the study variables

Variable	Description	Obs.	Mean	Std. Dev.	Min	Max
Regressand						
AppRate	Appreciation rate: CPI adjusted	13,599	1.73	0.96	0.08	23.38
A_AppRate_CPI	Annual average appreciation rate: CPI adjusted	13,599	1.17	0.43	0.20	23.38
A_AppRate_Mket	Annual average appreciation rate: market adjusted	13,599	1.10	0.42	0.20	27.39
regressor						
NetD2HBLAsta	Network distance to the nearest HBLR Station (feet)	13,599	4,542.59	2,382.26	17.46	13,390.04
NetD2PATHsta	Network distance to the nearest PATH Station (feet)	13,599	15,702.81	8,585.22	2,641.53	38,523.67
D2CBD	Aerial distance to Jersey City CBD (feet)	13,599	19,375.18	7,687.19	1,844.56	38,916.81
D2HBLRtrack	Aerial distance to the nearest HBLR track (feet)	13,599	3,089.81	2,222.23	2.53	11,665.51
NetD2Hwyexit	Network distance to highway ramp (feet)	13,599	5,831.76	3,402.14	115.84	18,194.93
BLineAve	Properties near Bergenline Avenue Station	13,599	0.20	0.40	0	1
WSideAve	Properties near Westside Avenue Station	13,599	0.08	0.27	0	1
E22ndSt	Properties near East 22nd Street Station	13,599	0.06	0.24	0	1
9thSt	Properties near 9th Street Station	13,599	0.22	0.41	0	1
SATscore	Municipal average SAT score	13,599	1,264	58	1,192	1,406
MedHHInc1999	Median household income in 1999 ($) by census tract	13,599	38,977	10,188	12,376	83,441
P_WorkAGroup	% of working age group (18–54 yrs old) by census tract	13,599	0.56	0.05	0.47	0.88
P_FBornPop	% of foreign-born pop by census tract	13,599	0.40	0.17	0.02	0.74
1stSPrice_CPI	Sales price at the first transaction ($); CPI adjusted	13,599	221,613	125,212	30,248	1,282,156
1tSPrice_Mket	Sales price at the first transaction ($); market adjusted	13,599	177,440	194,101	2,757	4,998,686
Ratio_SPvsTAV	Ratio of sales price vs. tax assessment value	13,599	1.30	0.62	0.5	3.5
DiffYR	Year difference between the first and the last transaction	13,599	5.27	3.78	0	18
SalesFreqA2000	Sales frequencies after 2000	13,599	1.67	0.93	0	6
PrePost1996	Properties sold pre-post year of construction started	13,599	0.32	0.47	0	1
PrePost1994	2 yr lag of construction started; anticipation impact dummy	13,599	0.19	0.39	0	1
PrePostSTAOpen	Properties sold pre-post station opening	13,599	0.45	0.50	0	1
Union	Dummy for Union City	13,599	0.05	0.21	0	1
Jcity	Dummy for Jersey City	13,599	0.42	0.49	0	1
Bayonne	Dummy for Bayonne	13,599	0.11	0.31	0	1

street opened in 2011; out of our study period) in Bayonne and Westside Street in Jersey City are the furthest ends in south and southwest respectively. Only rare and inconvenient bus (or combined modes with PATH) access to NYC were available from the stations before the HBLR was even planned. Bergenline Avenue was not the furthest station in the north but as a densely mixed residential and commercial area the accessibility benefits within walking distance of the station would have been larger than Tonnelle Avenue, the furthest. In fact, Tonnelle Avenue was mostly surrounded by industrial properties and few residential buildings (see Figure 1; there were only a few white dots, representing location of repeat sales' properties). Meanwhile, we included 9th Street Station in Hoboken for comparison purposes. It is not as far from the CBD as the other three, but a high number of daily boardings (see Table 1) would seem to reflect higher accessibility benefits from proximity to this station, which should result in improved home prices. Thus, we intend to examine net accessibility gains that highlight cost savings reflected in ridership propensity.

We used both network and aerial distances, albeit for different purposes. The former was applied for actual walking distances to the nearest HBLR station while the latter was used for more perceptional distances such as those to the CBD and to the HBLR track. As discussed earlier, since we focused upon accessibility to each station, actual network distance was preferred to some pre-defined buffer boundary. We recognized that a pre-defined boundary approach may be appropriate for estimating possible nuisance effects, which arise as a dampening of property prices very near stations and track. Nonetheless, we applied the network-distance gradient approach not only because it ameliorates possible bias in measuring the magnitude of transit capitalization, but also because we anticipate few negative externalities in the study areas. This was because much of the HBLR line, in fact, was aligned along the path of abandoned industrial rail track. Newly constructed sections, mostly along the JCCBD waterfront segments, were excluded from this study since they were within a half mile (805m) of PATH stations, which have been more heavily used for commuting. More importantly, given relatively low accessibility gains expected from LRT compared to other rail systems in general, very short distance thresholds are not very meaningful since an insufficient number of homes in our sample of repeat sales lie within close proximity to the track.

We used selected socio-demographic information on census tracts from the 2000 dicenniel US Census. Tracts have long been used as proxies for neighbourhoods (Goodman 1985). The 2005–2009 five-year estimates from the American Community Survey (ACS) were not used due to a paucity of observations at the census tract level. Also as described earlier (see Table 2), the socio-demographic characteristics of the study area has changed little over the period. In any case, we believe 2000 Census data well represent the neighbourhood characteristics for the broader period of sales records that we examine – 1991 to 2009. Share of population that is in prime working age groups (between 18 and 54 years old), share of foreign-born population, and the median household income are included. We expected that a preponderance of working-age individuals causes home values to rise because this group is likely to put greater value on accessibility. We hypothesized that neighbourhoods with high foreign-born populations enjoy the increased accessibility more than do other groups due to their high preference for public transit (urban areas outside of the US tend to depend more on public transit), which should put upward pressure on home prices. Median household income, a proxy of neighbourhood's economic status, was also expected to cause home price appreciation since being near higher-income groups should yield home price premia. In addition to tract-level data, the municipal-level average SAT test score was included, since school quality is an important consideration for in-migrants. We used the two-year average (2005–2006 and 2006–2007) SAT score for public school districts, which largely align with municipality boundaries.

Our model controls for the sales price of the first transaction since lower-priced homes tend to appreciate more rapidly. We also tested other related attributes – ratio of actual sales price vs. tax assessed value, the time that transpires between the first and the second (the most recent) sales, and a frequency of sales after operation of the HBLR – to see the relation with home price appreciation. Lastly, the year of HBLR ground breaking and a two-year lag of it were included to find effects of actual transit construction and partial effects of its anticipation, respectively.

To implement this study, two different property sales data sets of seven municipalities were used; one from online New Jersey state records (from 2000 to 2009) and the other from a private vendor, Econsult Corporation, which gained special access to earlier version of the state data set (from 1991 to 2002). After eliminating duplicate records, 149,037 single recorded transactions were trimmed to create appropriate repeat sales dataset. We first removed records with unrealistic sales prices – in particular sales records with prices below $1,000 and those with sales prices that were either more than 3.5 times or less than 50 per cent than their assessed values since they suggest intrafamily transactions, possible input-coding errors, and the like. Further, records with prices in the highest and lowest percentile were dropped to minimize possible leverage issues from the observations. Consequently, 79,877 single sales records were left that enabled 17,435 repeat sales property observations in the dataset.

A range of geocoding efforts were invoked to add network and spatial attributes via ESRI ArcGIS (ESRI, Redlands, CA, USA). First, we executed a GIS parcel match with parcel identifiers for each property; then for those unmatched addresses geocoding by each municipality was further implemented to prevent possible mis-geocoding across municipalities due to similar street identifiers. The result was that 14,068 geocoded repeat-sales properties between 1991 and 2009 remained. We then eliminated all repeat sales within a half mile of PATH stations for the final analysis. This effectively discarded properties in both the newly developed JCCBD waterfront and Jersey City's CBD near Journal Square, and prevented any confounding impact from existing PATH accessibility on property value. In the end, we undertook our investigation with a data base that included 13,599 usable repeat-sales properties for seven municipalities that HBLR covers.

4.1 Model and functional form

Using the usual hedonic form (Cropper et al. 1988), we assume that the housing price equation takes the form

$$\begin{aligned}
\mathrm{P}_i = {} & \beta_0 + \beta_1 \cdot \log(\text{NetD2HBLAsta}) + \beta_2 \cdot \log(\text{D2CBD}) + \beta_3 \cdot \log(\text{D2HBLRtrack}) \\
& + \beta_4 \cdot \log(\text{NetD2Hwyexit}) + \beta_{5,6,7,8} \cdot (\text{BLineAve, WSideAve, E22ndSt, 9thSt}) \\
& + \beta_{9,10,11,12} \cdot \log(\text{NetD2HBLAsta of BLineAve, WSideAve, E22ndSt, 9thSt}) \\
& + \beta_{13} \cdot \log(\text{Median HH Income1999}) + \beta_{14} \cdot \text{\% of Work Age Group} \\
& + \beta_{15} \cdot \text{\% of FBornPop} + \beta_{16} \cdot \text{SAT Score} + \beta_{17} \cdot \text{Sales Price of the 1st transaction} \\
& + \beta_{18} \cdot \text{Ratio of Sales Price vs. Tax Assesed Value} + \beta_{19} \cdot \text{Year Difference bewteen sales} \\
& + \beta_{20} \cdot \text{Sales frequency after 2000} + \beta_{21,22,23} \cdot (\text{PrePost sales, PrePost2004, PrePost2006}) \\
& + \beta_{24,25,26} \cdot (\text{Union, Jersey City, Bayonne}) + \varepsilon
\end{aligned}$$

$$\mathrm{P}_i = \beta_0 + \beta_1 D_i + \beta_2 N_i + \beta_4 S_i + \varepsilon, \tag{2}$$

where p_i = log of property price appreciation; D_i = distance attributes; N_i = neighbourhood attributes; S_i = stages of transaction attributes; β_j = parameters to be estimated and ε = error term

We start off using ordinary least squares (OLS) regression. We then apply robust regression, an automated algorithm (in Stata statistical software; StataCorp, College Station, TX, USA) that removes observations with extraordinarily large standardized residuals. It specially tends to target observations for which the dependent variable's value is close to its maximum and minimum – so called 'leverage observations'. By comparing the results from both OLS and robust regression we hope to learn the extent of heteroscedasticity induced by outlier and leverage observations, which are removed in the course of applying robust regression.

5 Interpretation of results

Table 4 presents our findings for six different specifications. We naturally found that robust regression yields higher R^2 than OLS, although both provide expected signs for the independent

Table 4. Different models of the dependent variable: the home price appreciation rates in Hudson County, New Jersey

	Model 1: robust	Model 2: OLS 1	Model 3: robust	Model 4: robust	Model 5: robust	Model 6: robust
Variables	Appreciation rate	Annual appreciation rate (CPI Adjusted)	Annual appreciation rate (CPI Adjusted)	Annual appreciation rate (market adjusted)	Annual appreciation rate (CPI adjusted) – only pre-post open sales	Annual appreciation rate (market adjusted) – only pre-post open sales
ln_NetD2HBLsta	0.0469***	0.000206	0.00713**	0.00277	0.00849***	0.00392*
ln_D2CBD	–0.0477*	–000192	0.00105	–0000579	–00117***	–000398
ln_D2HBLRtrack	0.00531	0.0111	0.00194	0.00245*	0.000103	0.00168
ln_NetD2Hwyexit	–00174**	–000177	–000282**	–000101	–000392***	–000226**
BLineAve	0.239	0.0718	0.0380	0.00593	–00681**	–00272
WSideAve	0.632***	0.267	0.153***	0.121***	0.120***	0.0593**
E22ndSt	0.518*	0.221	0.177***	0.0809**	0.160***	0.101***
9thSt	0.505***	–0123	0.0459	0.00940	0.116***	0.0552**
BLineAve_ln_NetD2HBLRsta	–00226	–000775	–000249	0.000186	0.00836**	0.00422
WSideAve_ln_NetD2HBLRsta	–00782***	–00344*	–00190***	–00155***	–00163***	–000826**
E22ndSt_ln_NetD2HBLAsta	–00646*	–00289	–00218***	–00102**	–00174***	–00118***
9thSt_ln_NetD2HBLAsta	–00567***	0.0144	–000446	–0000286	–00124***	–000588*
MedHHInc1999	6.79e-07	9.10e-07	4.05e-07***	1.06e-07	5.50e-07***	1.82e-07*
Union	–00576**	0.0561***	0.0144***	0.0259***	0.000888	0.00977***
Jersey city	–00736***	0.0178	–000254	0.00491**	–00105***	–000107
Bayonne	–00548**	–00270	–0000303	0.0139***	–00116***	0.00512
SAT score	0.000256**	0.000295***	3.89e-05*	8.67e-05***	2.05e-05	7.64e-05***
P_WorkAGroup	0.396**	–00779	0.0591**	0.116***	–00209	0.0806***
P_FBornPop	–00463	–00397	0.000814	0.0136**	0.0226***	0.0247***
Ratio_SPvsTAV	–0391***	–00992***	–00657***	–00376***	–00725***	–00373***
DiffYR	0.0420***	–00387***	–00101***	–000635***	–00131***	–000511***
SalesFreA2000	0.105***	0.0387***	0.0159***	0.00737***	0.00419***	0.00406***
PrePostSTAOPEN	0.0774***	0.0205**	0.0129***	–000424***		
PrePost1994	–0285***	0.0501***	–000790***	0.0127***	0.0155***	0.0166***
PrePost1996	–0149***	–00283**	–00331***	–00123***	–00122***	–000712***
1stSPrice_CPI	–0361***	–0213***	–00545***		–00431***	
1tSPrice_Mket				–00282***		–00249***
Constant	5.860***	3.620***	1.722***	1.211***	1.833***	1.231***
Observations	13,599	13,599	13,599	13,599	6,151	6,151
R-squared	0.416	0.192	0.372	0.318	0.523	0.400

Notes: Standard errors in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

variables. Models 3 and 4 are the base models but between them apply two different price indices when obtaining the dependent variable, which is the properties' annualized appreciation rate. They include observations that sold twice pre-HBLR and/or post-HBLR. Models 5 and 6 are shown for the sake of comparison to Models 3 and 4. They focus on pre-post HBLR sales, which can eventually detect the extent of the temporal effects of increased accessibility.

Model 3 explains 37.2 per cent of the variance inherent to annual home appreciation. The R^2 for model 5, which limits observations to those for which the first sale occurred before and the second sale after the HBLR was operating, explains 52.3 per cent of home appreciation – the highest fit of the six models. The lower R^2s in model 4 and model 6 suggest that producing constant home prices using municipally segmented housing market prices is empirically inferior to using a metro-wide CPI market price. Meanwhile, model 1 used a dependent variable with total periodic appreciation: that is, it was not annualized. Despite the high R^2 in model 1, the lack of annualization leads this model to be the least preferred.

Our models show that properties closest to HBLR stations display lower-than-average home appreciation rates in general. Proximity to highways, on the other hand, continues to play a positive role in home price appreciation despite their long-established nature. Recall, however, that locations and distances for the HBLR's distant stations were our main research focus. Based on interpretation of the coefficients of dummy variables in semi-logarithmic regressions (Halvorsen and Palmquist 1980), properties near the West Side Avenue station experienced annual price appreciation that were nearly 16.9 (12.0 in model 5) percentage points greater than for other properties in the study area. The premium was 20.0 (16.5 in model 5) percentage points for properties near the East 22nd Street station. The coefficient of the binary variables denoting 9th Street was also statistically significant although the relative small size of the coefficient implies a weaker rate of price appreciation. There is no significant magnitude and sign for properties near Bergenline Ave station. As described earlier, Bergenline Avenue is located in Union City where the bus network to Manhattan was already superior to that at the other stations. The fact that good public transportation to a major job hub pre-existed there suggests few new significant accessibility gains at Bergenline Avenue. This set of results supports our hypothesis that the newly created accessibility by HBLR was capitalized at stations farthest from the CBD. Also, although the passenger count is associated with accessibility benefits, these results support the notion that distance of a station from the CBD has greater influence on households' cost savings. Of course, individual property appreciation truly is a household-based measure, while passenger change is more collective in nature, and indicative of how many households are affected. Thus, the overall net benefit to an area of a particular transit facility is some combination of both.

Looking into station-specific effects, as one moves away from the West Side Ave and East 22nd Street stations, properties appreciate by about one percentage point (the coefficients are 0.97 and 1.1, respectively) for every 50 feet (or 15 metres – a typical lot width in an urban area). This implies that the station-based premium fully dissipates within a quarter mile (400 m) of the stations. Thus a quarter-mile buffer appears to exist for the HBLR, whereas a half mile (800 m) appears appropriate for PATH, perhaps due to its greater age and direct connections to Manhattan. This all supports the Alonso-Wingo-based hypothesis that properties around the HBLR stations most-distant from the CBD should capitalize more value from a new transit offering due to the larger transportation cost savings potentially generated there.

Properties in municipalities with higher-than-average student SAT scores tended to appreciate more rapidly than did properties in municipalities where average SAT scores were lower. But, the small coefficient suggests a marginal impact on the price appreciation. Together with small coefficients for municipality dummies (Union City, Jersey City and Bayonne), this also implies that property sales prices adjusted to a rather localized market are not a clearly better option than those adjusted to the CPI of the much broader labour market area. The share of the working-age group is positively associated with the home appreciation rate. The shares of foreign-born population revealed no significant effect on home appreciation rates in our base model (models 3 and 4). Yet, they were influential in models 5 and 6. This implies higher temporal accessibility gains in the areas of high foreign-born population with relatively low-income population in our study areas than others. This supports the hypothesis that improved accessibility should demonstrate a greater capacity to capitalize in communities that exhibit attributes suggesting greater transit dependence.

Table 4 displays interesting period attributes as well. Overall, they show higher annualized home appreciation for homes that were held for longer periods prior to their sale. Despite controlling for inflation in the housing component of the price index, this effect from ownership duration may reflect some sort of anomalous non-linearity in home appreciation in the immediate area during the housing market boom to 2007. According to model 3, no statistically detectable capitalization in housing took place during construction and planning stages of the HBLR (i.e., the housing market adjusted to the transit investment just before it was put in place). The coefficient of pre-post HBLR sales, however, points strongly to the positive impact of an operating HBLR on home prices. On the other hand, once we limit the sample to those homes that had a first sale prior to the start of HBLR operations and that had the second sale after it began operating (model 5), we did find some evidence of capitalization during the HBLR's planning stages. The difference between the models appears to be due to the inclusion of both pre-HBLR (even pre-construction) and post-HBLR only samples in model 3, which may have led to bias in (distortions to) the coefficients due to omitted variables such as those factors that led to the housing market bubble, rather than improved accessibility via the HBLR. Finally, property prices in the study area display the usual equilibrating effect; that is, lower-valued properties tended to appreciate more rapidly than did higher priced ones. In fact, it shows that those properties nearest HBLR stations, in least developed areas farthest from the CBD, tended to appreciate most as predicted by Alonso-Wingo theory.

Across the six models in Table 4, the signs and statistical significance of key explanatory variables relating to accessibility are generally the same. This robustness across specifications lends added credence to the overall analysis. Still, dissimilar parameter magnitudes do exist across models. They tend to be somewhat more-intense when robust regression is applied to the CPI-adjusted appreciation rate when compared to models for which the dependent variable is municipally price-adjusted.

6 Conclusions

In this study we demonstrated unequivocally that light rail can have a positive impact on property appreciation rates near urban commuting stations. We arrived at this finding by focusing our analysis on properties near stations in the urban periphery that would receive the most benefit from a new transit system as the Alonso-Wingo model predicts. At these stations, we found that properties appreciated at an annual average rate of 18.4 percentage points higher than did other study-area properties. The appreciation premium evaporates rather rapidly, at about one percentage point every 50 feet. Hence, the appreciation premium appears to dissipate completely within a quarter mile of the stations. This is a somewhat shorter distance than reported in other studies. This leads us to question, even more strongly, the theoretical validity of the usual practice of applying arbitrarily developed buffer zones (binary variables) to valuate distance to stations, as opposed to the gradient approach that we apply. Aggregate home price appreciation by census block or tract (see Voith 1993) was not elaborated in this paper.[2] Although it was given some

[2] This matter also was suggested by an anonymous referee.

thought, the dataset we used had a general lack of observations at such areal disaggregation in any given year and the possibility of creating an endogeneity issue with the dependent variable.

Our study is striking among hedonic studies on transit's impact on property values. We collectively examined changes in the values of individual properties with multiple appreciation ratios, and tested how both a distance from the nearest station and its distance from the CBD are related to the price change. Almost all have, instead, valuated transit's impact on property values using cross-sections or, at best, pooled cross-sections (Voith 1993). The problem with using standard cross-sections is that transit lines are often built where population densities and properties values are high (so as to assure passengers and a reasonable revenue stream) and to move people with cars off the road and onto transit. In sum, a transit system, by design, is likely to be placed in high-priced neighbourhoods. Hence, nowadays it is not clear when evaluating property values whether the rail's placement caused property prices to rise or whether high property prices near a transit system are what enticed the light rail to locate where it is. There is no reason not to expect that the latter is why researchers have been finding high property values near transit lines. We are aware of few studies on the property-value impacts transportation systems have examined repeat sales data. Yet, their approaches were also limited to either compare gradients based on pooled cross-sessions of data in different time periods (McMillen and McDonald 2004) or to test pre-post LRT sales only with no annualized appreciation adjustment (Chatman et al. 2012).

Because we were concerned about the effects of different housing market cycles across an area even as small as Hudson County, we decided to normalize property sales prices by municipality to identify relative annualized appreciation rates of properties. It appeared not to be superior to prices normalized by the housing component of the metropolitan-wide consumer price index. Still, this innovation may prove useful in other future research.

Despite our contributions to the literature, we note a couple of avenues that need further investigation. More work needs to be undertaken to give analysts a better understanding of the ideal period of study for property value change near transit facilities. While we based our examination on available literature by Agostini and Palmucci (2008) and McDonald and Osuji (1995), we study properties using a somewhat arbitrarily selected two-year prior with respect to station openings in order to capture any 'anticipation effect' of new investments in the end. We seem to have derived some evidence for anticipatory effects. The duration of post-operation appreciation on the other hand, has not yet been studied inasmuch as our review of the extant literature has revealed. Similarly, we did not uncover much evidence, despite an attempt. Perhaps, our 'non-findings' derived from a lack of sales records for those properties near the stations of prime interest, which opened as recently as 2006. Hence, additional exploratory analysis of this issue should be quite useful to others using repeat sales data.

Another issue with our dataset was that too few of the observations were accompanied by characteristics of the properties (structure's living space, structure's age, lot size, floor-to-area-ratio, stories, number of bedrooms, number of bathrooms, number of kitchens, presence of a garage, architectural differences, etc.). While Coulson and Lahr (2005) suggested that changes in these property attributes may not be important, they also show that such characteristics do, in fact, help determine appreciation rates, at least for assessed property values. Hence, it would be worthwhile to pursue this line of inquiry to confirm or reject Wang and Zorn's (1997) conjecture that one need not specify critical characteristics when using the repeat sales approach.

Lastly, the issue of how improved accessibility and thus property appreciation influences surrounding neighbourhoods is an area for further research.[3] Given the complex nature of myriad interest groups with respect to transportation investment, more effort should be placed toward exploring other opportunities and negative externality created by LRTs beyond the

[3] We acknowledge and thank an anonymous referee who made this suggestion.

appreciation of residential property values. For example, do LRTs create of new job opportunities for municipalities' existing residents? Do they enhance densities in 'built out' areas?

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doi:10.1111/pirs.12038

Resumen. Este artículo analiza el impacto del sistema de ferrocarril ligero Hudson-Bergen (HBLR por sus siglas en inglés) sobre los precios de inmuebles residenciales. A diferencia de estudios similares que utilizan un modelo hedónico con datos transversales, aquí se utilizan datos de ventas repetidas de inmuebles que se vendieron al menos dos veces entre 1991 y 2009. Se muestra la influencia en el precio de las viviendas de la proximidad a la estación más cercana del HBLR, una mejor accesibilidad relativa a diferentes estaciones y la fecha de inauguración esperada de la estación de HBLR. Nuestros resultados demuestran que las propiedades cercanas a las dos estaciones más alejadas del distrito central de negocios, ahora revitalizado, experimentaron un alza en el precio. También muestran que se produjo un aprecio en áreas con un mejor acceso gracias a las opciones de transporte público disponibles. Por medio de un gradiente negativo-exponencial, descubrimos que estas tasas de apreciación más elevadas tendían a disiparse aproximadamente a 1/4 de milla (402 m) de las estaciones. Esto apoya la idea de que las propiedades que circundan las estaciones de transporte urbano ligadas al desplazamiento al trabajo disfrutan de mayores beneficios marginales debido a una mejor accesibilidad de tránsito y una reducción de los costos de transporte, como predice el modelo de Alonso.

要約：本論文では、ハドソン・バーゲン・ライトレール（HBLR）が、住宅不動産価格に与えた影響を分析する。クロス・セクション・データとヘドニック・モデルを使う同様の研究とは異なり、本論文では、1991年から2009年の期間に少なくとも2度売却された不動産の、リピート販売データを使用する。分析によれば、HBLRの最寄り駅との距離、駅間のアクセスの相対的優位性、HBLRの駅がする日の見通しなどが、価格変動に影響を与えている。分析の結果によれば、再活性化された中心業務地区から最も離れた2駅に近接する不動産価格が、大きく上昇している。また、既存公共交通機関というオプションがあるかで、地域間のアクセス優位性の相違が生じている。負の指数勾配を使うと、価格上昇は駅から約1/4マイル（402m）で見られなくなる傾向がある。これは、Alonsoモデルが予測するように、都市部の通勤圏内の駅付近の不動産で、良好な交通アクセスと移動コストの減少により限界的便益が高くなることを裏付けるものである。