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Streetcars and Recovery: An Analysis of Post-Katrina Building Permits around New Orleans Streetcar Lines

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Abstract

Researching traditional streetcars' development impacts is challenging: most U.S. lines operate in downtown areas with many development stimuli. This article addresses that challenge through analysis of New Orleans building permits after Hurricane Katrina. We estimate how post-Katrina permit frequency changes with distance from streetcar stops, controlling for damage, proximity to commercial areas, and pre-Katrina demographics. We find that distance to stops strongly predicts building permits. Residential permits increase with distance to stops; commercial permits decrease. Findings confirm streetcars support commercial development, yet suggest potential displacement of residential uses. Implications for future streetcar projects in New Orleans and elsewhere are discussed.

Keywords

land-use mix, neighborhood revitalization, rail transit, streetcar, transit-oriented development

Introduction

Traditional streetcars (also known as "heritage streetcars" or "vintage trolleys") feature rigid-body vehicles 45–50′ (14–15 m) long, either historic survivors or replicas. They may operate in mixed traffic or semiexclusive rights-of-way, such as boulevard medians, but with little or no physical separation from the surrounding streetscape. Stop spacings are generally a quarter-mile (400 m) or less, with schedule speeds in the 10–12 mph (16–20 km/h) range (Phraner 1992). Much research suggests that the widespread adoption of the electric streetcar in the 1880s and 1890s was the catalyst for the first great spatial expansion of American metropolitan areas (Muller 2004; Ward 1964). The Philadelphia streetcar system in the 1880s was found to flatten residential bid-rent gradients and reverse the relative bid-rents of high- and low-wage workers, with high-wage workers moving from the city center to the metropolitan fringe (Gin and Sonstelie 1992). The Boston streetcar system contributed to an increasingly diversified population in the large Boston suburb of Sommerville, Massachusetts, between 1870 and 1910 (Ueda 1984). According to Muller, streetcars had an impact far from serving a circulator function in downtown business districts: "The most dramatic impact of the Electric Streetcar Era was the swift residential development of those urban fringes" (Muller 2004). In Minneapolis and Saint Paul, Xie and Levinson find that "the rapid expansion of the streetcar system during the electric era . . . to a large extent led land development." This process led to narrow ribbons of development following radial streetcar lines, with less-developed areas in between due to a lack of feeder services (Xie and Levinson 2010).

Neighborhoods that grew up around streetcar lines often developed at lower densities than the "walking city" neighborhoods that preceded them, but retained a diverse mix of land uses. They also retained an essentially pedestrian-oriented internal built form due to the virtual universality of walking as a streetcar access mode (Warner 1978, 46–66). These neighborhoods generally featured densities around 15 dwelling units/acre (Hess and Lombardi 2004; Warner 1978, 67–116), as well as a mix of single-, two-, and small-scale multifamily residential, interspersed with small-scale, general needs commercial uses serving the immediate neighborhood (Appel 1972).

Although the development impacts of the early streetcar systems in U.S. cities are widely documented, the development impacts of the surviving or restored streetcar systems in contemporary U.S. cities have not been well studied. The limited literature on the existing streetcar lines (either

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surviving or restored) has focused on streetcars' influences in downtown business districts. Almost no research directly examines streetcars' present-day potential to influence redevelopment of and reinvestment in traditional urban neighborhoods, especially neighborhoods of a largely residential character (Phraner 1992, 2000; Porter 1998). The lack of research on streetcars' influences in urban neighborhoods is not surprising. *First*, few streetcar systems in the United States remain outside of downtown business districts. Most of the surviving and restored streetcar lines function as downtown circulators, with a focus on serving workers (who get downtown by other modes) and tourists (Kelly 1995; Phraner 1992, 2000; Osborne and Newmark 2008). *Second*, the few streetcar systems that operate outside of downtown business districts (including Boston, New Orleans, Philadelphia, and Toronto) often serve older, historic urban neighborhoods. These neighborhoods constantly experience reconstruction and redevelopment, but the pace of these activities can be quite slow absent an extraordinary stimulus. If traditional streetcars have an inherent capacity to influence development in a modern-day American city, that capacity may not be realized around existing lines because of mature neighborhoods. *Third*, most streetcar systems in North America operate alongside other transit services including bus and rail lines. For these systems, the impacts of streetcars may be difficult to distinguish from those of other transit services surrounding them.

Some argue that the development impacts of light rail transit (LRT) can inform streetcar planning. Borrowed from European evolutions of the streetcar, LRT generally employs moderately sized vehicles, overhead electrification, and largely at-grade alignments like streetcars but adds high-amenity stations, longer station spacings, and faster travel speeds. Light rail lines tend to be considerably longer than streetcar lines and often serve suburbs as well as central cities. Most lines also avoid mixed-traffic operation. Extensive research has examined the developmental impacts of LRT on residential neighborhoods (Boarnet and Compin 1999; Cervero and Duncan 2002; Knight and Trygg 1977; Loukaitou-Siders and Banarjee 2000; Porter 1998). However, it is difficult to generalize these studies' findings to streetcar services because of the service differences noted above. Transit-oriented development (TOD) at LRT stations tends to take the form of new, high-density nodes, rather than the support and revitalization of residual transit-friendly urban forms (Calthorpe and Mack 1989; Cervero 1984, 1996; Cervero and Duncan 2002; Landis et al. 1995; Porter 1998). In the LRT-related literature, a healthy supply of station-area land is frequently cited as a prerequisite for TOD (Boarnet and Compin 1999; Cervero 1984; Knaap, Ding, and Hopkins 2001; Knight and Trygg 1977; Porter 1998). Compared to suburban, LRT-focused TOD's, urban, streetcar-focused developments are likely to be smaller (because of intense existing development and small parcel sizes), and may be overlooked by researchers. According to Hess and Lombardi, "in older cities . . . they rarely call it TOD; it's simply regular development" (Hess and Lombardi 2004).

This article responds to the lack of research on traditional streetcars' development impacts in contemporary urban neighborhoods through analyses of building permits near streetcar stops in post–Hurricane Katrina New Orleans. The New Orleans Regional Transit Authority operates completely traditional streetcars in its primary, line-haul services, offering by far the purest example of traditional streetcar operations in the United States. New Orleans streetcars also operate both in the downtown business district and urban neighborhoods (New Orleans Regional Transit Authority: Maps and Schedules 2008; Currie and Shalaby 2007). Further, the recovery from Hurricane Katrina presents a flurry of reconstruction and redevelopment activities *mimicking* a major neighborhood change. When Hurricane Katrina effectively destabilized many of New Orleans's neighborhood structures, it allowed (or required) *more* redevelopment to occur at a *faster* pace than normal, potentially allowing existing streetcar lines' latent development impacts to appear. While this process differs from that of a newly implemented streetcar line, it does offer a rare opportunity to assess the inherent attractiveness of traditional streetcars to development. Streetcars are also the only rail transit mode operating in New Orleans. Finally, though a public decision had been made to fully rebuild the streetcar system soon after hurricane Katrina, no equivalent statements were made about bus service. Indeed, the New Orleans bus system was operating only 29–32 percent of its 2004 Vehicle Revenue Miles (VRM) in the three years following the hurricane, with little information available as to when—or if—pre-storm levels of service would return (To date, they have not; in 2011, NORTA buses operated 36 percent of 2004 VRM, while streetcar service had recovered to 98 percent a year before [Federal Transit Administration 2012]). This fact likely curtailed (at least temporarily) any development impacts of the bus system, making the streetcars' impacts easier to identify.

We hypothesize that streetcars will influence neighborhood development in a manner different from how they influence downtown development. Specifically, we expect commercial permits to be more frequent overall in downtown business districts because of a higher intensity and prevalence of commercial uses. We expect commercial permits to increase in frequency near streetcar stops both downtown and in urban neighborhoods, but for the increase to be more localized in neighborhood areas. We expect residential permits to be most frequent in urban neighborhood areas, because of a relative lack of residential uses in the storm-damaged areas of downtown New Orleans. In neighborhood areas, we expect residential permits to be more common near streetcar stops, but for the increase to be less localized than for commercial permits due to businesses having the ability to pay higher bid-rents near streetcar stops.

The Decline and Resurgence of Streetcars in U.S. Cities

After playing their central role in the initial buildout of residential neighborhoods, streetcar systems fell into decline in the 1930s through 1950s. The precise mix of causes is debated to this day: some emphasize competition from the automobile (O'Hanlon 1984; Slater 1997), others highlight the role of generous public subsidies for the automobile (contrasted with largely private, heavily regulated streetcar systems), and sprawl-inducing development policies (Cole 1998; Weyrich and Lind 2009). In regard to transit systems' internal decisions to abandon rail service, some point to low initial costs of buses compared with those of rehabilitating aging track and wire, along with failures to factor in buses' shorter service lives (Cole 1998; Slater 1997; Weyrich and Lind 2009); others point to a belief among transit providers that conversion to buses was the only way to remain profitable in the face of automobile competition (Cole 1998; O'Hanlon 1984; Slater 1997). By the 1960s, streetcars had vanished entirely from all but eight North American cities: Boston, Cleveland, Mexico City, New Orleans, Philadelphia, Pittsburgh, San Francisco, and Toronto.

The mid–twentieth century shift in urban transportation brought with it major changes to urban landscapes. In addition to shaping the development of post–World War II suburbs, the decline of transit systems and rise of the automobile reshaped older urban neighborhoods that had grown up around streetcar lines. One of the most profound changes was the proliferation of parking lots and other off-street automobile infrastructure. Beginning in the 1920s, and expanding dramatically by midcentury, parking lots supplanted large numbers of pedestrian- and transit-oriented buildings in central cities (Jakle and Sculle 2004, 47–92). Neighborhood-scale commercial uses—crucial in the age of walking and streetcars—were often supplanted by parking or service stations, frequently situated on the corner lots once favored by neighborhood stores along streetcar lines (Jakle and Sculle 1994, 130–62). In addition, changes in the retail industry—such as the rise of the supermarket and strip center—led to the decline of neighborhood stores (Longstreth 1999, 76–126; Niedercorn and Hearle 1964). From their beginnings in the 1930s, supermarkets and other large stores required large parcels of inexpensive land and depended on high sales volumes attained by attracting customers with automobiles from large trading areas (Appel 1972; Goldman 1976). These changes left neighborhood commercial nodes especially vulnerable to demolition or conversion to other uses and reduced the overall densities of older neighborhoods.

Since the late 1970s, LRT projects have been promoted in U.S. cities and metropolitan regions as encouraging sustainable development patterns and redevelopment of dilapidated areas (Cervero 1984; Cervero and Duncan 2002; Loukaitou-Siders and Banarjee 2000; Porter 1998). However, as LRT capital costs are highly dependent on specific alignments and design characteristics (Cervero 1984; Loukaitou-Siders and Banarjee 2000; Pilgrim 2000), design measures to contain costs often harm the development potential of station areas. For example, the common practice of building light rail lines on abandoned railroad grades often leads to stations isolated from nearby neighborhoods (Cervero 1984; Knight and Trygg 1977).

In this context, the streetcar has reemerged, offering an attractive service at low capital cost while integrating easily with existing activity centers—especially in a downtown circulator role (Phraner 1992, 2000). Poticha and Ohland found that the streetcar line opened in Portland, Oregon, in 2001 contributed significantly to the redevelopment of two largely abandoned industrial areas on opposite sides of Portland's downtown business district (Poticha and Ohland 2006). They identified $2.3-billion worth of development in the area surrounding the line since its opening. New streetcar lines may also have led the way for LRT, as with the largely volunteer-operated McKinney Avenue line in Dallas, Texas. This line pre-dated the Dallas Area Rapid Transit LRT system, helped build enthusiasm for light rail investments, and has been gradually integrated with the LRT system (Kelly 1995; Phraner 1992).

In exploring streetcars' development impacts in the urban neighborhood context, we hope to build knowledge of what roles streetcars can play in advancing development in neighborhood settings, and under what circumstances. Such knowledge may prove valuable as an increasing number of American cities—including New Orleans—propose and plan new streetcar lines outside downtown business districts.

System Studied

The New Orleans streetcar system at the time of data collection (2005–2008) included three lines: the 6.5-mile (10.5-km) Saint Charles Avenue line—a survivor of the original system—connecting downtown with several uptown residential neighborhoods, as well as Loyola and Tulane Universities, the 1.6-mile (2.6-km) Riverfront line—opened in 1988 on repurposed freight trackage—connecting the central business district and French Quarter riverfronts, and the 4.6-mile (7.5-km) Canal Street line, connecting downtown with the Mid-City neighborhoods and the historic city cemeteries, with a branch to City Park. Reopened in 2004, Canal was once the primary streetcar corridor in the city. Unlike the tourist-oriented Riverfront line, the new Canal Street line is built as a high-capacity practical transit line. Stops on all lines are frequent—generally every 2 blocks. New Orleans streetcars stop only when a passenger wishing to board is visible at a stop, or when a passenger wishing to alight signals the operator—much as in local bus service. Figure 1 shows the New Orleans streetcar system, as well as the land uses that surrounded it before Katrina.

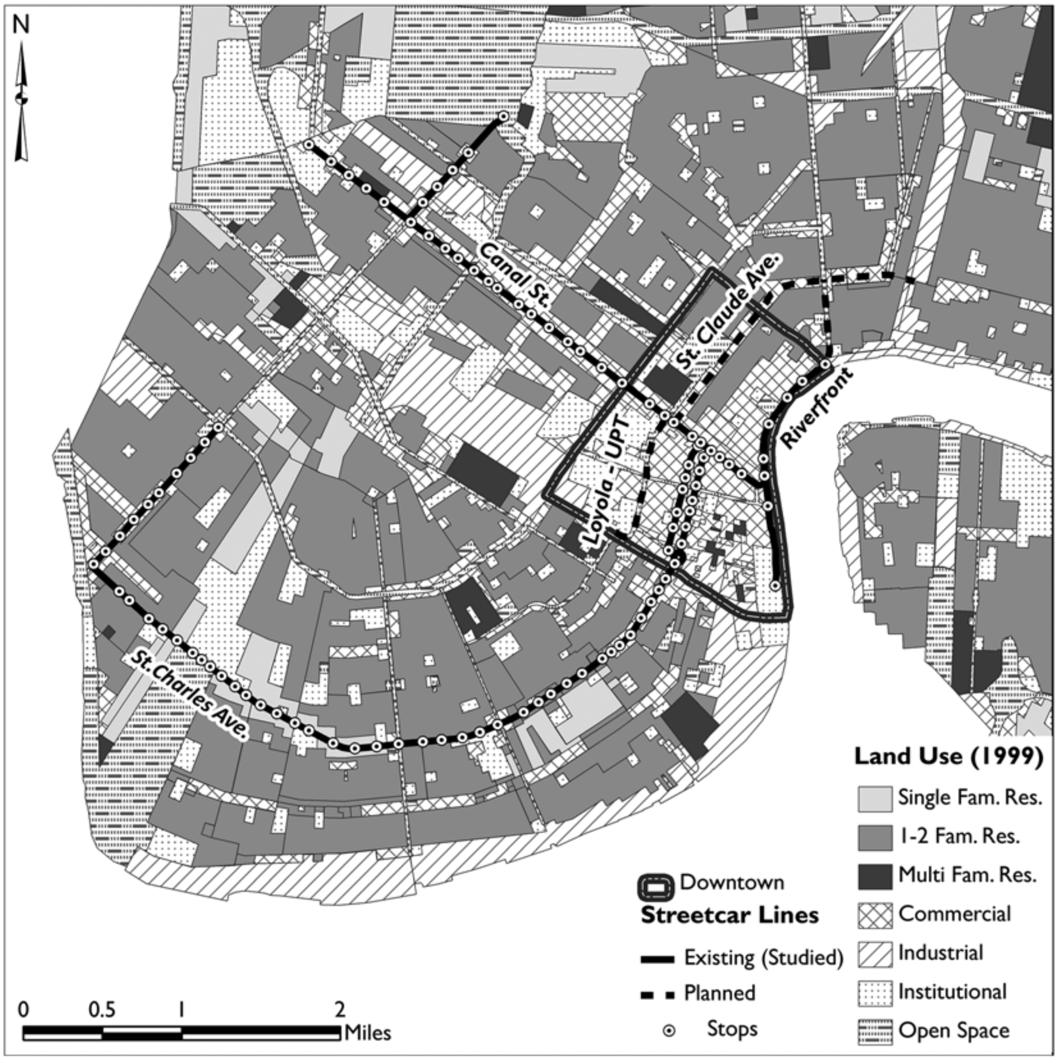

Figure 1. New Orleans streetcar system and pre-Katrina land uses.
Note: Streetcars do not always make all stops shown, only those at which a passenger wishing to board is visible or a passenger wishing to alight signals the operator.

Devastation and Recovery

In 2005, New Orleans was devastated by the flooding that followed Hurricane Katrina. The term "recovery" may be misleading in the sense that the city has likely been irrevocably altered. Still, a spatial analysis of building permits issued by the city since the storm offers something of a window into the role of New Orleans's iconic transit system in the rebuilding of its city. A 2006 survey found that New Orleans residents consider transit access an important part of the rebuilding process, with a majority attaching at least some importance to having a streetcar or bus line in their future neighborhoods (Hong and Farley 2008).

Planned Expansion

The New Orleans Regional Transit Authority (NORTA) started construction of two new streetcar lines in 2012. One (opened in January of this year) operates downtown, connecting Union Passenger Terminal to Canal Street; the second will follow Rampart Street along the northern border of the French Quarter, continuing to the Marginy and Bywater neighborhoods along Saint Claude Avenue, with a branch on Elysian Fields Avenue to connect with the Riverfront line. Roughly two route-miles of the project will serve predominantly residential neighborhoods outside downtown. The alignment for the new line is already selected, but numerous planning and community development decisions remain to be made in the surrounding neighborhoods. Though no development impacts of the new lines will yet be reflected in the data, now is an opportune time to investigate neighborhood redevelopment processes surrounding the existing lines in the years immediately following Katrina. Such an examination will provide valuable insight into how streetcars may soon begin to transform newly served neighborhoods.

Table 1. Comparison of Stop Area Characteristics along the St. Claude Avenue Streetcar Line with Those of the Existing Streetcar Lines.

Stop Area Characteristics	Planned Line	Existing Lines (Studied)	
	St. Claude Ave.	St. Charles Ave.	Canal St.
Years of development	1805–1890	1817–1920	1817–1893
Land use mix	Primarily residential; neighborhood commercial on major streets, corner stores/restaurants mixed into residential areas.	Primarily residential; commercial uses mostly confined to major streets; two major universities and one regional park.	Primarily residential; some commercial/mixed use on neighborhood streets; commercial and light industrial uses line major street corridors.
Residential density	12 units/acre	8–12 units/acre	7–12 units/acre
Residential stories	1–2	1–3	1–3
Commercial floor area ratio (FAR)	1–4	1–4	1–6
Alignment	Neighborhood commercial corridor; residential uses take over ~1/2 to 1 block from line.	Neighborhood residential corridor and residential boulevard	Major commercial corridor; residential uses take over ~1/2 to 1 block from line.

Table 1 compares key characteristics of the neighborhoods served by the existing Saint Charles Avenue and Canal Street lines, as well as the planned Saint Claude Avenue line. The neighborhoods have generally similar urban forms. Examination of the development impacts of existing streetcar lines in this study will help planners in New Orleans and elsewhere predict future development trends along planned streetcar corridors such as Saint Claude Avenue.

Methodology

Variables and Models

The analysis centered on the number of building permits issued on each block of a street relative to airline distance from that street segment's midpoint to the nearest streetcar stop. Permits describing new construction and major repairs are included in this research as these permits represent the best measure of *major* reconstruction and redevelopment activity. Demolition, electrical and mechanical permits are not included. Though our models' precision is limited by a lack of detailed information on dollar values and what specific activities permits cover, building permits do offer a broad-based, direct measure of capital investment in real estate, at least when considered in aggregate. Commercial and residential permits were considered separately, and served as the dependent variables in their respective models.

Permit data come from the City of New Orleans GIS Data Portal (City of New Orleans GIS Data Portal 2008), and cover the period from Hurricane Katrina to February 2008. The addresses listed for permit data have quality-control problems, particularly in the first year after the hurricane. Though the authors made every attempt to repair these problems through painstaking, manual comparisons with the GIS shapefile of New Orleans streets, some errors likely remain in the final data set. However, the data set is large, including more than 200,000 permits. A minority have apparent problems, as evidenced by more than 180,000 valid address matches. Permit addresses were geocoded, aggregated by street segment, and a table of distances to nearest streetcar stops was produced. Although the permit data included precise addresses, the attributes of GIS street data employed did not include full address ranges for each street segment; without this information, the Geocode Addresses function in ArcGIS is unable to correctly locate addresses *within* street segments. In this situation, the software's default assumptions produce systemic error toward one end of each street segment, necessitating the aggregation of permits. Explanatory variables included in the models were as follows:

- *Stop Distance*—The distance in hundreds of feet between the center point of the street segment and the nearest streetcar stop on any of the three studied lines.
- *Average Damage*—The average damage rate of properties on a street segment in percentages of property values (City of New Orleans GIS Data Portal 2008), included on the theory that many of the permits issued in New Orleans following Hurricane Katrina were likely issued for repairs of storm damage or the rebuilding of storm-destroyed buildings. All else equal, one would expect a street segment with a higher average damage rate to have higher permit frequencies.
- *CBD Distance*—The distance in hundreds of feet from the centroid of downtown New Orleans—the point is in the block adjacent to the junction of the two main streetcar lines. This variable is included on the theory that areas closer to the heart of the desirable downtown area may be more attractive to reconstruction and redevelopment. Based on this theory, a street segment closer to the heart of downtown could be

expected to have been issued more permits than one more distant.

- *Commercial Distance*—The distance in hundreds of feet from the nearest concentration of commercial land uses appearing in the city's pre-Katrina GIS land-use layer as a block or group of blocks with *predominately* commercial uses. (Blocks in which commercial is the most prevalent use.) The New Orleans zoning code permits some commercial uses in nearly all zoning districts, and numerous commercial permits were issued during the period of study outside areas that were dominated by commercial land uses. We hypothesize that the areas where pre-Katrina land uses were predominantly commercial are desirable areas for commercial development. We expect commercial permits to be more frequent closer to areas of established commercially dominated land use. In addition, as easy access to neighborhood business districts is often a valuable amenity to residents, proximity to commercial areas was expected to be associated with higher permitting frequencies of residential units as well.
- *Median Income*—The median household income, in thousands of dollars, of the census block group containing the street segment as reported by the 2000 Census (American FactFinder 2000). This variable is included in the analysis to control for neighborhoods whose residents were more or less likely to have the means to rebuild damaged properties after the storm. The socioeconomic makeup of New Orleans has changed since the hurricane. However, 72 percent of the street segments in the study area lie in block groups in which median household income (adjusted for inflation) changed by 50 percent or less between the 2000 census and the most recent data available (Census Bureau 2013). In addition, the use of data from before the disruption studied makes our results more relevant to proposed future lines.
- *Vacancy Rate*—The vacancy rate of census block groups in the percentage of total housing units unoccupied at the time of the 2000 Census. Included as a measure of the desirability and health of the housing market in the neighborhood prior to Katrina. Pre-Katrina (2000) vacancy rate data is more representative of New Orleans real estate market health in the time period studied than post-Katrina data because of demolitions of vacant buildings undertaken by the city (McCarthy et al. 2006), with the result that a block group could experience both significant disinvestment and a significant decline in vacancy rate after the hurricane.

The use of negative binomial regression avoids the biased results associated with ordinary least squares regression when dependent variables describe count outcomes with many small values. The length of street segments provided the exposure variable for all models as a measure of the opportunity for permits to be issued. An exposure variable allows the models to account for differences in the length of street segments, while still describing permit frequency using the correct probability distribution for our models. In negative binomial regression, this method generally produces superior results to a normalized response variable. To achieve comparable results, we use the model below in all cases:

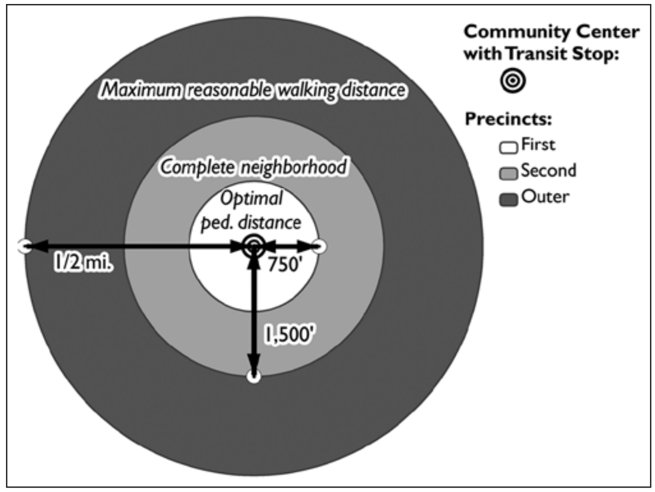

Figure 2. Radii and definitions of Nelessen's pedestrian precincts.

$$
\begin{aligned}
&ln\left(\#\ of\ Permits\right) = ln\left(Segment\ Length\right) + \\
&\beta_0 + \beta_1 * Stop\ Distance + \beta_2 * Average\ Damage + \\
&\beta_3 * CBD\ Distance + \beta_4 * Commercial\ Distance + \\
&\beta_5 * Median\ Income + \beta_6 * Vacancy\ Rate + \varepsilon
\end{aligned}
$$

Areas of Analysis

The research is intended primarily to study the development impacts of streetcars on neighborhood areas. As such, areas outside downtown New Orleans are the primary focus. Analysis of downtown is included for context. Downtown New Orleans was defined as the area bounded by Interstate 10 to the North, the Mississippi River to the South, the Pontchartrain Expressway to the West, and Esplanade Avenue—the traditional Eastern boundary of the French Quarter—to the East. The former three act as physical barriers between downtown and the surrounding neighborhoods and mark a clear shift in the character of development.

Neighborhood and downtown areas are further divided based on Nelessen's concept of pedestrian precincts (see Figure 2), referring to "walking distances that are acceptable to the average person" (Nelessen 1994). The first includes a radius of 750′ (230 m) from a community center, based on the distance an average person is willing to walk from a parked car to a destination such as a job or store. For our

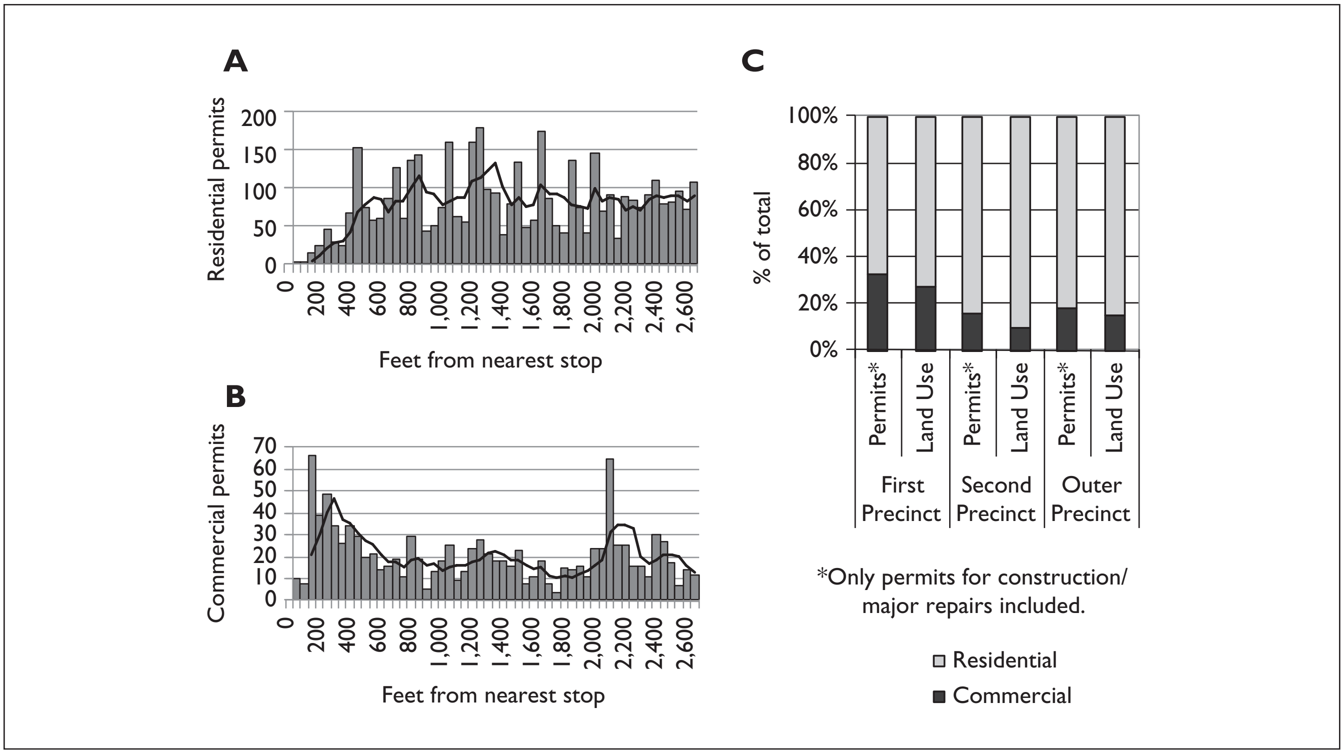

Figure 3. Post-Katrina urban neighborhood building permit frequency by distance from streetcar stops for residential (A) and commercial (B) permits, and residential/commercial percentage distribution of post-Katrina building permits and pre-Katrina land uses (C).

purposes, the first precinct is taken as optimal distance to/from motorized transportation—here, a streetcar stop. The second precinct corresponds to a five-minute walk, or a radius of 1,500′ (460 m), defining a complete neighborhood. Areas outside this limit but within half a mile (2,640′ or 800 m) of streetcar stops are included as well to ensure the capturing of stops' entire areas of influence. Half a mile (800 m) also corresponds to Nelessen's fourth (and largest) pedestrian precinct, used as the longest distance people can be expected to walk with any regularity.

To compare the relationship between permit frequencies and distances from stops with the theory of pedestrian precincts, histograms were produced comparing stop distances with numbers of permits per street segment for residential and commercial permits in neighborhoods and downtown. (Each column shows the number of permits issued within a 50′ [15 m] band from the nearest stop.) The relationship shown is likely to be complex, with many other factors (such as prevailing land use) coming into play. That relationship will be explored in regression modeling; these histograms simply identified general trends, and confirmed the validity of the pedestrian precinct theory in this particular case. Figures 3 and 4 show the histograms of permits relative to stop distance for urban neighborhood stations areas and downtown district station areas, including a moving average line to show overall trends, as well as residential/commercial percentage distributions of post-Katrina (9/2005–2/2008) permits and pre-Katrina (1999) land uses (by number of parcels) for each pedestrian precinct. Only permits issued for new construction or major repairs are included. (The City of New Orleans classifies all such permits as either residential or commercial.)

As shown in Figure 3A, neighborhood residential permits generally increase for the first 1,200′ (370 m) from a streetcar stop, and gently decline from there to the half-mile (800-m) limit. This trend extends well beyond the first pedestrian precinct, but is clearest within the first 850′ (260 m).

In neighborhood areas, commercial permits show nearly the opposite overall trends to residential permits (see Figure 3B). Commercial permits clearly decline from a relatively high frequency near zero to between 600′ (180 m) and 750′ (230 m) from a streetcar stop. This sharp decline is followed by erratic fluctuations, without clear trends until between 1,500′ (460 m) and 1,800′ (550 m), where permits once again increase in frequency. This increase continues until around 2,100′ (640 m), and then almost instantly reverses. Notably, the first two distance ranges correspond quite closely with the pedestrian precincts defined above.

Figure 3C shows percentages of residential and commercial permits issued after Katrina as well as percentages of pre-Katrina residential and commercial land uses (measured by number of parcels) in each pedestrian precinct. (Parcels with other uses are not included.) The overall prevalence of residential and commercial permits and land uses are similar, but commercial permits are slightly more common in each precinct than one would expect based simply on land-use

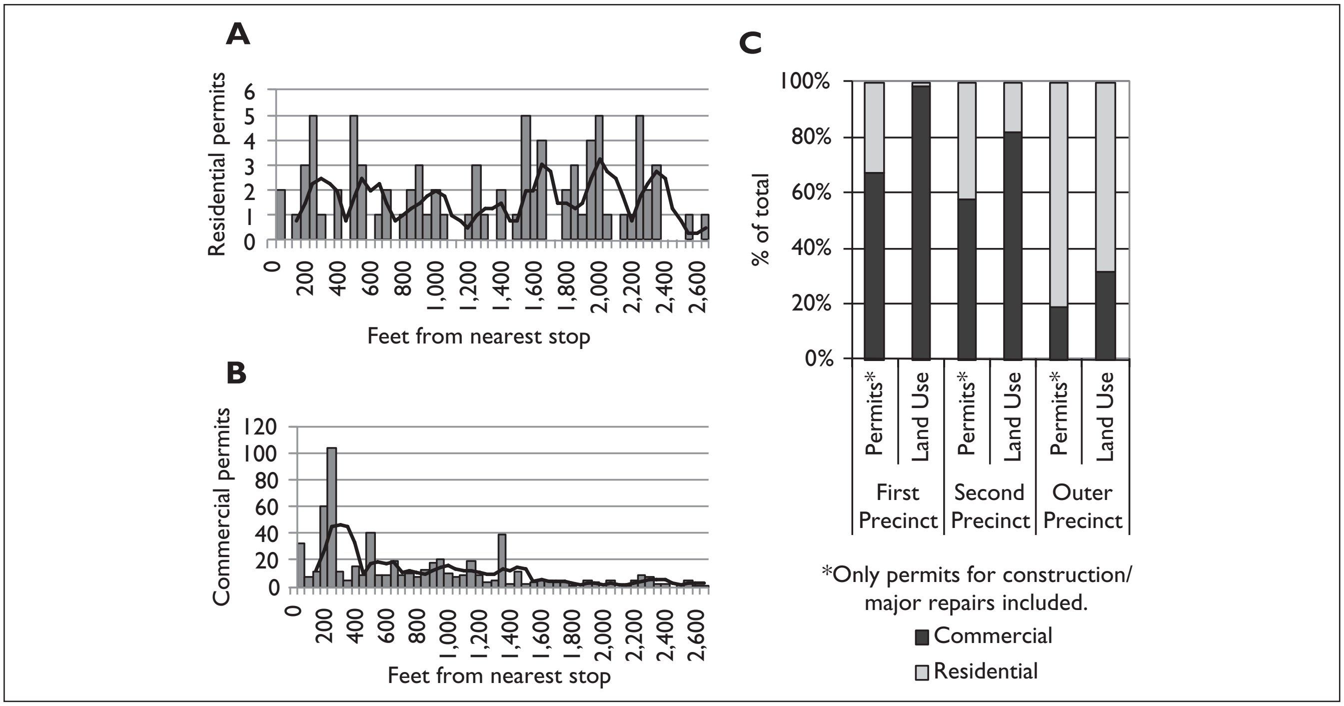

Figure 4. Post-Katrina downtown district building permit frequency by distance from streetcar stops for residential (A) and commercial (B) permits, and residential/commercial percentage distribution of post-Katrina building permits and pre-Katrina land uses (C).

mix. In particular, post-Katrina commercial permits account for 32 percent of the first precinct permit total, while pre-Katrina commercial parcels account for 27 percent of the residential-plus-commercial parcel total.

Downtown residential permits do not demonstrate a clear trend relative to distance from streetcar stops (see Figure 4A). In addition, residential uses are rare in downtown New Orleans with the exception of the French Quarter (nearly undamaged by hurricane Katrina and precluded from significant redevelopment by historic designations) and some public housing (whose repair is only weakly related to market forces). Analysis of downtown residential permits was deemed unreliable, and not included in the final analysis.

Downtown commercial permits show a much clearer trend, with a sharp decline from near stops to between 800′ (240 m) and 1,000′ (305 m) (see Figure 4B). The slope is much gentler farther out, though one-interval peaks—possibly influenced by outliers—are present outside 1,000′ (305 m). Most permits in the first and second precincts lie in commercial-dominated areas; the outer precinct is more mixed, but has a much smaller sample size and lies at the outer limit of downtown.

The relationship between post-Katrina permits and pre-Katrina land uses is more difficult to determine for the downtown business district than for the urban neighborhood areas (see Figure 4C). In all three downtown pedestrian precincts, residential permits are somewhat more common than one would expect based on land use, though the total number of residential permits issued is quite small.

Results

Descriptive Statistics

Table 2 shows descriptive statistics of the variables used in the regression models of building permits. As expected, the mean for commercial permits is considerably higher in downtown than in neighborhood areas—0.522 per street segment as opposed to 0.202, and in neighborhoods, the mean for residential permits—0.794—is significantly greater than that for commercial permits. Also, the standard deviations for permits of all types are much larger than the means, indicating that numbers of permits vary considerably from street segment to street segment. For reference purposes, the entire neighborhood area with a generally similar built form to the study area (including streetcar-served and non-streetcar-served areas outside downtown, south of I-10/610 and west of the Industrial Canal) contains an average of 0.173 commercial permits per street segment and 1.192 residential permits per street segment, respectively. Stop Distance also has a considerably larger mean and standard deviation than Commercial Distance downtown and in neighborhoods, suggesting a much more uniform distribution of commercial-dominated areas than streetcar stops. These differences also indicate that streetcar

Table 2. Descriptive Statistics of Variables used in Regression Models.

	Mean			Standard Deviation		
	All	Urban Neighborhoods[a]	Downtown	All	Urban Neighborhoods[a]	Downtown
Residential Permits per street segment	0.670	0.794	0.075	1.620	1.747	0.356
Commercial Permits per street segment	0.257	0.202	0.522	0.916	0.643	1.678
Stop Distance (×100′)	12.607	13.130	10.086	7.528	7.601	6.612
Average Damage (%)	7.326	8.742	0.492	15.010	15.987	4.775
CBD Distance (×100′)	105.877	121.953	28.283	56.822	48.570	12.546
Commercial Distance (×100′)	6.628	7.624	1.824	6.637	6.799	2.372
Median Income (×$1,000)	30.850	31.6367	27.053	24.406	25.012	20.836
Vacancy Rate (%)	14.985	13.151	23.840	8.714	6.750	11.312
Segment Length (feet)	296.847	300.285	280.250	173.068	171.246	180.768

Note: N = 6,520 street segments (5,401 in urban neighborhoods 1,119 in downtown district).
[a]*Urban neighborhoods* refers to all areas studied outside downtown (i.e., areas near the parts of the St. Charles Ave. and Canal Street lines that are outside the downtown boundary as illustrated in Figure 1).

Table 3. Negative-Binomial Regression Models, Neighborhood Commercial Permits.

y = Neighborhood Commercial Permits	First Precinct 0′–750′		Second Precinct >750′–1,500′		Outer Precinct >1,500′–2,640′	
N	1,534		1,586		2,281	
LR χ^2	118.29		83.86		99.35	
Probability, χ^2	0.000		0.000		0.000	
Pseudo-R^2	0.064		0.055		0.048	
	β	IRR	β	IRR	β	IRR
Stop Distance (×100′)	–0.219***	0.803	0.055*	1.056	0.012	1.012
Average Damage (%)	0.015***	1.015	0.015***	1.015	0.003	1.003
CBD Distance (×100′)	–0.005***	0.995	–0.002	0.998	–0.002	0.998
Commercial Distance (×100′)	–0.093***	0.912	–0.067***	0.935	–0.091***	0.913
Median Income (×$1,000)	0.004	1.004	–0.003	0.997	–0.018***	0.982
Vacancy Rate (%)	–0.007	0.993	0.024	1.025	–0.018*	0.983
Constant	–5.419***		–7.806***		–6.298***	
ln Alpha Constant	0.724***		0.407*		1.485***	

*$p < 0.1$. **$p < 0.05$. ***$p < 0.01$.

corridors are not the only important commercial districts within the study areas.

Regression Analysis

Negative binomial regression coefficients cannot be interpreted in the same manner as ordinary least squares (OLS) regression coefficients. As a result, we report both coefficients and incidence rate ratios (IRRs), which describe the *percentage* increase or decrease in the dependent variable associated with one *unit* of increase in each explanatory variable. In addition, negative binomial regression does not produce an independently interpretable goodness-of-fit score equivalent to the *R*-squared score of OLS regression. The probability chi-square statistics of <0.05 (for all nine models) indicate that the fitted models explain the observed variation in the dependent variable better than a constant-only, null model. Downtown residential permits are not included in regression analysis because of their small number and lack of discernable relationship to distance from streetcar stops.

Neighborhood Commercial Permits. Table 3 shows regression model results for neighborhood commercial permits. In the first precinct, Stop Distance shows a significant and negative association with neighborhood commercial permits, with an IRR of 0.803, predicting a 19.7 percent decrease in the number of neighborhood commercial permits per street segment for every 100′ (30 m) increase in Stop Distance. Stop Distance is a much stronger predictor of neighborhood commercial permits than distance to significant concentrations of commercial land uses. For each

Table 4. Negative Binomial Regression Models, Neighborhood Residential Permits.

y = Neighborhood Residential Permits	First Precinct 0–750′		Second Precinct >750–1,500′		Outer Precinct >1,500–2,640′	
N	1,534		1,586		2,281	
LR χ^2	298.03		363.75		328.77	
Probability, χ^2	0.000		0.000		0.000	
Pseudo-R^2	0.113		0.095		0.062	
	β	IRR	β	IRR	β	IRR
Stop Distance (×100′)	0.216***	1.241	0.024	1.024	–0.016	0.984
Average Damage (%)	0.049***	1.050	0.042***	1.043	0.036***	1.036
CBD Distance (×100′)	0.002	1.002	0.001	1.001	0.005***	1.005
Commercial Distance (×100′)	0.022*	1.022	0.056***	1.057	0.005	1.005
Median Income (×$1,000)	–0.005	0.995	–0.016***	0.984	–0.008***	0.992
Vacancy Rate (%)	–0.036***	0.965	–0.009	0.991	0.005	1.005
Constant	–7.777***		–6.722***		–6.678***	
ln Alpha Constant	0.433***		0.150*		0.365***	

*$p < 0.1$. **$p < 0.05$. ***$p < 0.01$.

100′ increase in Commercial Distance, the number of neighborhood commercial permits per street segment only decreases 8.8 percent. Average Damage and CBD Distance also achieve statistical significance, with predicted changes of 1.5 percent and –0.5 percent in neighborhood commercial permits per unit of independent variable change.

In the second precinct, Stop Distance, Average Damage, and Commercial Distance achieve statistical significance. Stop Distance shows a marginally significant positive relationship ($p < 0.1$) with neighborhood commercial permits with a predicted 5.6 percent increase in neighborhood commercial permits per street segment for each 100′ (30-m) increase in Stop Distance. Average Damage shows the same positive relationship to neighborhood commercial permits as in the first precinct. Commercial Distance continues to show a negative relationship to neighborhood commercial permits (now a *stronger* relationship than Stop Distance), with a predicted 6.5 percent decrease in neighborhood commercial permits per street segment for each 100′ (30-m) increase in Stop Distance.

In the outer precinct, Commercial Distance, Median Income, and Vacancy Rate produce statistically significant results. Both Median Income and Vacancy Rate show a modest and negative relationship with neighborhood commercial permits. In the outer precinct, Commercial Distance shows a similar negative relationship to neighborhood commercial permits as in the inner two precincts. The consistency of Commercial Distance stands in stark contrast with the marked differences in results for Stop Distance between the three precincts.

Neighborhood Residential Permits. The regression models for neighborhood residential permits, as shown in Table 4, predict similar trends to the histogram in Figure 3; however, Stop Distance is only statistically significant in the inner precinct. With an IRR of 1.241, Stop Distance predicts a 24.1 percent increase in neighborhood residential permits per street segment for each 100′ (30-m) increase in stop distance.

Average Damage achieves statistical significance in all three models with a predicted 3.6–5 percent increase in neighborhood residential permits per one percentage point increase in average damage assessment. CBD Distance is statistically significant in the outer precinct, though with a predicted change in permits of only 0.5 percent for every increase of 100′ (30 m). Commercial Distance is positively significant in the first and second precincts. Median Income is significant in the outer two precincts and, interestingly, shows a negative relationship with neighborhood residential permits. Vacancy Rate is significant in the first buffer only, and predicts a 3.5 percent drop in neighborhood residential permits for each one percentage point increase in vacancy rate.

Downtown Commercial Permits. Much as expected for downtown commercial permits (see Table 5), Stop Distance demonstrates a strong, negative relationship with downtown commercial permits within the first precinct; the IRR is 0.8, which translates to a predicted 20 percent decline in downtown commercial permits per 100′ (30-m) increase in distance to the nearest streetcar stop. CBD Distance also shows a negative association with downtown commercial permits, with an IRR of 0.954. Vacancy Rate shows a positive association with downtown commercial permits, with an IRR of 1.029. In the second precinct, Stop Distance shows no association with downtown commercial permits, yet Average Damage and Vacancy Rate show a positive association and CBD Distance shows a negative association with downtown commercial permits. In the outer precinct, Stop Distance and Median Income show a positive association with downtown

Table 5. Negative Binomial Regression Models, Downtown Commercial Permits.

	First Precinct		Second Precinct		Outer Precinct	
y = Downtown Commercial Permits	0–750′		>750–1,500′		>1,500–2,640′	
N	451		422		246	
LR χ^2	58.58		52.92		13.85	
Probability, χ^2	0.000		0.000		0.031	
Pseudo-R^2	0.061		0.09		0.046	
	β	IRR	β	IRR	β	IRR
Stop Distance (×100′)	–0.223***	0.800	0.057	1.058	0.146**	1.157
Average Damage (%)	0.016	1.016	0.132*	1.141	0.010	1.010
CBD Distance (×100′)	–0.048***	0.954	–0.098***	0.907	–0.097***	0.908
Commercial Distance (×100′)	0.049	1.051	0.075	1.078	0.003	1.003
Median Income (×$10,000)	0.002	1.002	0.006	1.006	0.034*	1.034
Vacancy Rate (%)	0.028**	1.029	0.022*	1.022	–0.027	0.974
Constant	–5.111***		–5.595***		–6.935***	
ln Alpha Constant	0.910***		1.299***		0.986***	

*p < 0.1. **p < 0.05. ***p < 0.01.

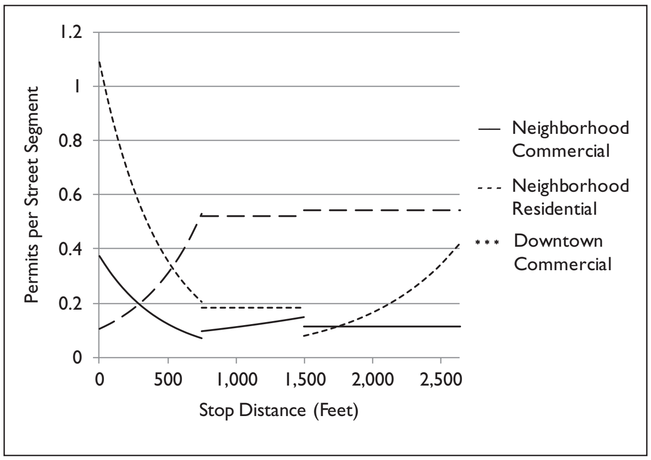

Figure 5. Predicted permits by Stop Distance.

commercial permits; CBD Distance shows a negative association with downtown commercial permits. All other factors are statistically insignificant in the outer precinct.

Discussion of Results

To allow for easier interpretation of the regression results, we use the estimated models to graph how the number of permits per street segment changes in relation to Stop Distance. Figure 5 displays predicted values for permits per street segment, with all other variables held at their mean values for the model in question. In buffers where Stop Distance is insignificant, it is held at its mean value as well, demonstrating the lack of a statistically significant relationship between Stop Distance and permits.

The estimated values appearing in Figure 5 illustrate the results in Tables 3–5 dramatically. Downtown commercial permits decline sharply from a distance of 0 to a distance of 750′ (230 m), dropping from 1.1 to 0.2 permits per street segment. Neighborhood commercial permits show a slower decline within the first precinct, dropping from 0.4 to 0.1 permits per street segment. Neighborhood residential permits increase within the innermost buffer. Starting from roughly 0.15 permits per street segment, neighborhood residential permits increase to over 0.5 per street segment by 750′ (230 m).

When compared across precincts, the first precinct shows the largest changes in predicted numbers of permits relative to Stop Distance. This suggests that development effects of proximity to streetcar stops are strong relatively close to stops, yet weak (or nonexistent) further out. The differences between precincts in the impacts of streetcar stops on building permits are especially evident when compared to the moderate differences in the impacts of existing commercial clusters on building permits across precincts as shown by the narrow range of the Commercial Distance variable's IRR values in Tables 3–5. These findings suggest that although proximity to pre-Katrina concentrations of commercial land uses is an important predictor of post-Katrina neighborhood commercial building permits, proximity to streetcar stops is a stronger predictor.

Finally, the upward trend of neighborhood commercial permits and the downward trend of neighborhood residential permits in Figure 5 (previous) suggest that commercial uses may have outbid residential uses in the immediate areas near streetcar stops. This theory is especially plausible given New Orleans's cumulative zoning code, which permits some commercial uses as accessory or conditional uses in most residential areas. Based on the GIS data describing post-Katrina permit locations and pre-Katrina land use, 30 percent of commercial permits issued in the first pedestrian precinct were issued on predominantly residential blocks. However, the trend is not exclusive: 24 percent of residential permits in the same area were actually issued on commercial-dominated blocks. Considering the large quantity of pre-storm residential uses (see Figure 1) in neighborhood areas, it appears that the increased frequency of commercial permits near streetcar stops leads to an increase in the diversity of land uses in the impacted area more so than to the wholesale takeover of stop areas by commercial uses. This pattern, however, does not necessarily mean that displacement of residential uses will not occur in the future, since such displacement impacts might take years to play out.

Implications of Results

This analysis of post-Katrina building permits in New Orleans gives a glimpse of the impact traditional streetcar systems can have on present-day residential and commercial development activities. It provides compelling evidence that traditional streetcar lines are capable of supporting increased commercial development/redevelopment activity in modern-day, American urban neighborhoods—even outside downtown business districts. Plans for new lines in New Orleans, as well as the City's land use plan (Plan for the 21st Century: New Orleans 2030 Comprehensive Plan. 3 USC § 3 [2010]), focus on areas immediately surrounding alignments as targets for mixed-use redevelopment. Empirical findings from this research indicate such a goal is achievable in New Orleans, at least in the areas within the prime walking distance from the streetcar stops represented by Nelessen's first pedestrian precinct. The positive relationship observed in this research between commercial permit frequency and distance from stops suggests that traditional streetcar lines are worthy of consideration for supporting mixing of uses and the formation of commercial corridors in neighborhood areas outside of downtown business districts.

Determining the applicability of this research to other cities will require consideration of the unique circumstances in which this research takes place. New Orleans is admittedly a unique city, and Hurricane Katrina is certainly a unique specific event. Practitioners and researchers should not necessarily assume the findings of this paper apply to a specific corridor without first considering similarities with and differences from the study area. Physically, neighborhoods developed in the late nineteenth and early twentieth centuries with dense development and at least some residual land-use diversity (or zoning allowing them), as well as proximity to a major downtown employment and entertainment center offer the best equivalent. Socially, neighborhoods experiencing some level of reinvestment and revitalization (which planners wish to support and guide into more mixed-use forms) for reasons independent of streetcar investments offer the best parallel. Although such neighborhoods are not the predominant form in North America, they are common—present to some extent in most metropolitan areas.

Given the pattern observed of commercial permits seeming to supplant residential permits in the neighborhood areas closest to stops, it seems important to consider any displacement effects on existing residential development in planning streetcar lines in residential neighborhoods. Admittedly, some displacement of residential uses may be inherent, even intended in the retrofitting of neighborhoods to a more mixed-use form. Nonetheless, the effects observed in this research seem strong enough to suggest potential unintended consequences. The New Orleans zoning code is less restrictive than most in that some commercial uses are permitted by right even in most residential districts (Comprehensive Zoning Law of the City of New Orleans of 1995, as Amended § 3 [2007]). In addition, much of the area immediately along neighborhood sections of the streetcar corridors is zoned for considerably more intense uses than were present before Katrina (in the case of the St. Charles Avenue and Canal Street lines) or are present now (in the case of the St. Claude Avenue line). Many predominantly residential blocks are, in fact, zoned commercial (City of New Orleans GIS Data Portal 2008). In other cities, any unintended displacement impacts of traditional streetcars might be mitigated by judicious use of the more restrictive zoning generally present. In New Orleans, proactive planning and community involvement efforts are needed to advance the dual goals of promoting mixed-use redevelopment and protecting existing residents. Future study of the actual impacts of new lines, as well as of more detailed permit data may shed further light on the present-day development impacts of traditional streetcars.

When comparing findings in this research with findings in the LRT literature, it appears streetcars impact development in urban neighborhoods in a fundamentally different fashion from light rail. While the LRT literature indicates LRT lines can have very intense impacts on development in station areas, those impacts act on geographically small nodes of development because of station spacings (Cervero 1984; Cervero and Duncan 2002; Phraner 1992). Streetcars appear to have impacts that are less intense at each stop, but which act on geographically large areas because of continuous corridors created by close stop spacings. In neighborhoods capable of supporting the reinvigoration of traditional, diverse development patterns, streetcars may be capable of similar or even larger aggregate impacts than light rail.

To conclude, this study provides positive evidence that traditional streetcars can support the reinvigoration of neighborhood business districts, as well as the reintroduction of mixed land uses to traditional neighborhoods that lost neighborhood-scale commercial uses during the automobile era. While such neighborhood revitalization effects may be less visible than the attraction of large TOD projects, stimulating supportive reinvestment in—rather than the transformative redevelopment of—existing, traditional urban neighborhoods is a major planning goal of numerous cities. This analysis cannot hope to account for all factors involved in shaping the reconstruction of New Orleans; there are simply too many of them, including demographic shifts, political processes, and Federal disaster aid. However, the findings do indicate that access to streetcar stops was one of those factors. Based on the experience in New Orleans, it seems traditional streetcars may be useful planning tools for advancing reinvestment in traditional urban neighborhoods.

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