

Impacts of Commuter Rail Service as Reflected in Single-Family Residential Property Values

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Limited empirical evidence currently exists concerning the capitalization effects of commuter rail facilities. Both positive and negative influences may be present. Transportation agencies and property owners often differ in their views over both the existence and the extent of such impacts from commuter rail facilities, and resulting public participation can have a significant impact on the planning and design process of commuter rail facilities. Single-family residential properties in metropolitan Boston, Mass., are examined. Results indicate that there is an increase in single-family residential property values of approximately 6.7 percent by virtue of being located within a community having a commuter rail station. At the regional level there appears to be a significant impact on single-family residential property values resulting from the accessibility provided by commuter rail service. Findings related to commuter rail-generated right-of-way proximity effects are inconclusive. The potential policy implications of these findings are discussed in the context of property value impacts associated with the construction and operation of new commuter rail facilities.

Property value impacts, and the consequent public reaction and citizen participation resulting from such impacts, can have a significant effect on the planning and design process for new transportation facilities. Such has been the case in the Boston metropolitan area with the Massachusetts Bay Transportation Authority's Old Colony Railroad Rehabilitation Project. This project, first proposed in 1983, aims to rehabilitate three rail lines south of Boston to carry commuter rail service. In some areas significant pockets of opposition have arisen concerning the potential impacts, with station and right-of-way proximity impacts often cited as primary concerns (1). Public reaction has led to continued reevaluation of various aspects of the project and has led to a second impact review process on one of the three lines as construction on the other two lines begins. Throughout the project strong differences of opinion have been expressed concerning its impact on residential areas; however, there is limited empirical evidence directly related to commuter rail service with which to support the various positions that have been taken.

Proximity to commuter rail stations may have positive or negative impacts on residential property values. In the case of heavy rail rapid transit, station-related traffic and noise have been observed to have a depreciative effect on residential property values (2,3). The same is expected in the case of commuter rail, although this impact may be less in locations where commuter rail stations have smaller parking capacities than those typically found at suburban heavy rail rapid transit stations. In addition stations may in many cases be located in higher-activity areas, making nearby residences suscep-

tible to additional traffic and noise that may not be directly related to the station itself. Proximity to rail stations may also confer certain benefits, such as improved accessibility to commercial centers. In the case of heavy rail rapid transit, this has been observed to result in increased residential property values (4-9). Again, similar impacts are expected to exist in the case of commuter rail stations. Both positive and negative property value impacts from stations may be present (10-12).

One study in Philadelphia of Southeastern Pennsylvania Transportation Authority and Port Authority of Pennsylvania and New Jersey commuter rail service found strong evidence that accessibility from commuter rail stations is indeed capitalized into house values, with an increase of 6.4 percent of the average house value being observed (13). However, this study's use of census tract median values does not allow for more disaggregate analysis, nor does it examine possible impacts related to commuter rail rights-of-way.

Proximity to commuter rail rights-of-way should result in negative impacts on residential property values. Environmental externalities including noise, ground-borne vibration, airborne pollution, and visual intrusion can be generated by rail operations along rights-of-way and can result in significant public concern and involvement, particularly in the case of new facilities that use completely new or long-abandoned rights-of-way. Empirical evidence concerning the property value impacts of proximity to rail rights-of-way is extremely limited, with most studies focusing solely on stations. In San Francisco there was no evidence that proximity to either the elevated or at-grade Bay Area Rapid Transit right-of-way resulted in a decline in property values (3). Analysis of highway facilities has indicated property value losses resulting from proximity to highway rights-of-way. A study of highway alignments in New Jersey, Maryland, and Virginia revealed that the average loss in value in four study areas was about 6.6 percent of the property value, with most value losses occurring within 305 m (1,000 ft) of the highway right-of-way (14). A study in Troy, Mich., showed that the values of homes away from the highway were about 5 percent higher than the values of homes whose property lines abutted the highway right-of-way (15).

The study presented herein attempts to examine both station and right-of-way property value impacts resulting from commuter rail service. Although a new commuter rail facility will probably have varied property value impacts over time during the planning, construction, and operation of the facility, this study will focus on the spatial, rather than the temporal, element of these property value impacts. This is due in large part to the fact that commuter rail service in the Boston area, as in many other areas around the United States, has operated over existing rights-of-way for a significant number of years, limiting the availability of appropriate study areas with newly

implemented services and facilities, which would be required for a more involved time series analysis using pooled or longitudinal data sets. Identification of the existence and magnitude of property value impacts from a well-established commuter rail facility at a given point in time will therefore be used to satisfy the purpose of the study.

STUDY AREA

Potential study areas within the metropolitan Boston area were considered. An extensive commuter rail system operated by Amtrak under contract to the Massachusetts Bay Transportation Authority (MBTA) provides a variety of potential study areas. To further limit the study area to a more manageable extent, only 1 of the 11 commuter rail routes was chosen for analysis.

Several criteria were considered in the selection process. First, to provide the ability to identify property value changes resulting from varying regional and local accessibility, the rail line should extend a significant distance from Boston proper. Second, there should be a sufficient sample of bona fide arms-length transactions of detached single-family residential properties, available in as limited a time period as possible to reduce the introduction of any unwanted time series variation in the data set. The third criterion is that the line be representative of the type and quality of service available throughout the entire commuter rail system. A fourth criterion was that there be minimal impact from freight train operations on the same line used by the commuter rail operations. This will serve to prevent freight rail-generated right-of-way proximity effects from complicating the measurement and interpretation of commuter rail-generated right-of-way proximity effects occurring on shared

rights-of-way. One final criterion was that there be minimal influence from other commuter rail lines upon the study area. Such an influence would be potentially difficult to differentiate from the impact of the line under study and could complicate the interpretation of the empirical findings.

The commuter rail line that met most of the required criteria was the Fitchburg/Gardner Line, running northwest from North Station in Boston, with a terminus located approximately 72 km (45 mi) away, in Gardner, Mass. (Figure 1). This line, however, operates on a right-of-way that is shared with freight service. Based on analysis of freight rail lines operating in New England in 1990, the only commuter rail lines operating exclusively commuter rail service included the Needham Line and a limited portion of the Rockport Line. These lines, however, did not meet the other criteria. Specifically, the Needham Line had undergone significant rehabilitation during the mid-1980s, perhaps resulting in some perceived service impacts, and also extends only 14.5 km (9 mi) from its terminus in Boston. The portion of the Rockport Line operating only commuter rail service does not provide a large enough study area to obtain an adequate sample size without introducing unwanted time series variation. Therefore, the Fitchburg/Gardner Line was chosen as best meeting the remaining criteria for selection. Service from Fitchburg to Boston only was analyzed, since the Gardner terminal received only limited service during the 1990 study period. Therefore, the line will henceforth be referred to as the Fitchburg Line.

Because both the sales transaction data for the single-family residences and much of the public services information were available by municipal jurisdictions only, it was necessary to determine which municipalities surrounding the Fitchburg Line could be reasonably considered to be within the service area for the line. No

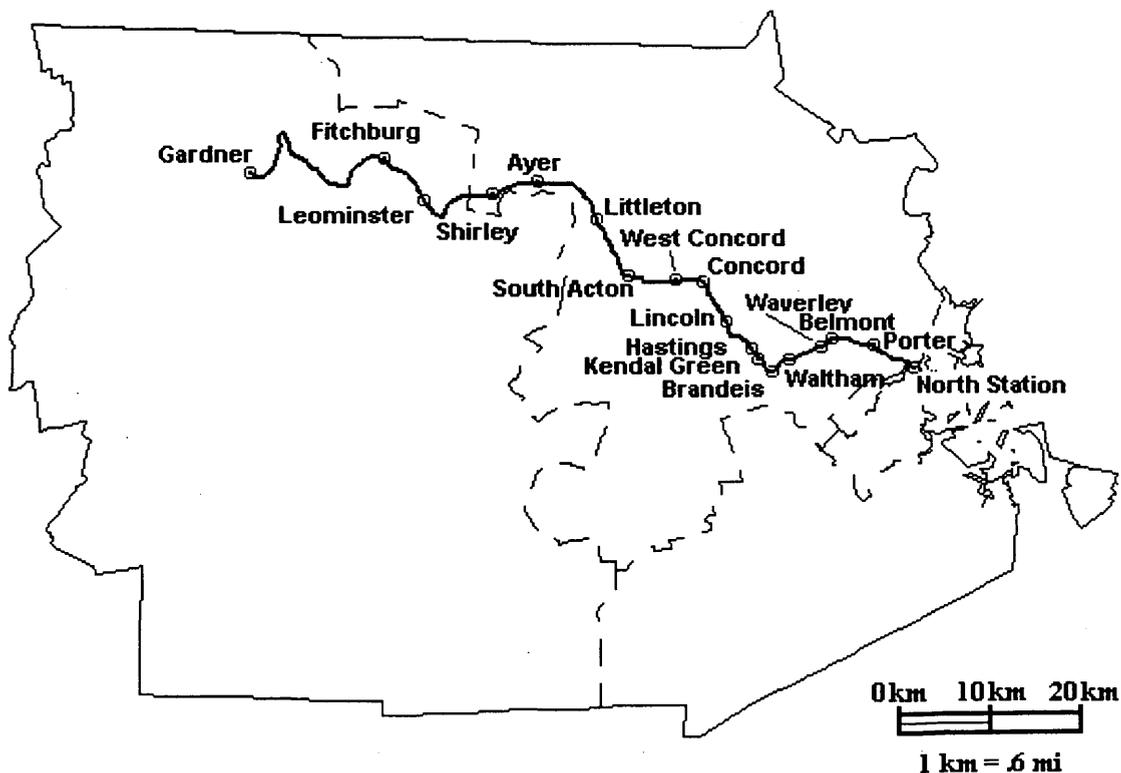


FIGURE 1 Fitchburg/Gardner commuter rail line.

data, such as parking lot license plate survey information, were available for use in delineating a service area. Therefore, assuming that the service areas of individual commuter rail lines do not overlap to any significant extent, delineation of the extent of the line's service area involved including those municipalities that fell more than 50 percent within a region roughly 16 km (10 mi) from the line. To be conservative this distance was chosen as the maximum extent of the service area in regions that were beyond the influence of other commuter rail lines.

The study area that resulted from this process is shown in Figure 2 and encompasses 1920 km² (741.8 mi²) and 38 municipalities with a total 1990 population of 630,478 persons. Analysis of the dates when these municipalities were established indicates that there is no correlation between the age of these communities and whether they are served by commuter rail. Table 1 presents the 1990 populations and the housing characteristics of these communities.

MODEL AND VARIABLE SPECIFICATION

The methodology followed involved the collection of 1990 sales prices from bona fide arms-length transactions of detached single-family residential properties (land and improvements) from the 38 municipalities in the study area. A universe of 451 properties transacted between June and August of 1990 is used. The general form of the model used is

$$P_h = \alpha + \sum_{i=1}^I \beta_i B_i + \sum_{j=1}^J \beta_j S_j + \sum_{k=1}^K \beta_k T_k + \sum_{l=1}^L \beta_l A_l + \sum_{m=1}^M \beta_m E_m + u_h \quad (1)$$

where

- P_h = h th observation of housing prices,
- α = intercept term,
- β = estimated coefficients or implicit marginal prices on each individual variable or characteristic,
- B_i = structural attribute variables,
- S_j = site attribute variables,
- T_k = the local service provision and costs variables,
- A_l = locational and accessibility variables,
- E_m = local environmental impact variables, and
- u_h = stochastic disturbance.

Transaction data from a real estate trade journal covering all residential property transactions in Massachusetts by county registry and municipality were used to obtain bona fide arms-length transactions of detached single-family residential properties only (16). For each observation a detailed and extensive set of data was collected representing five major categories of independent variables.

Structural Attribute Variables

Structural attribute variables include

- Usable living area,
- Number of bedrooms,
- Number of bathrooms,
- Heating system attributes (type and fuel),
- Architectural style,
- Number of stories,

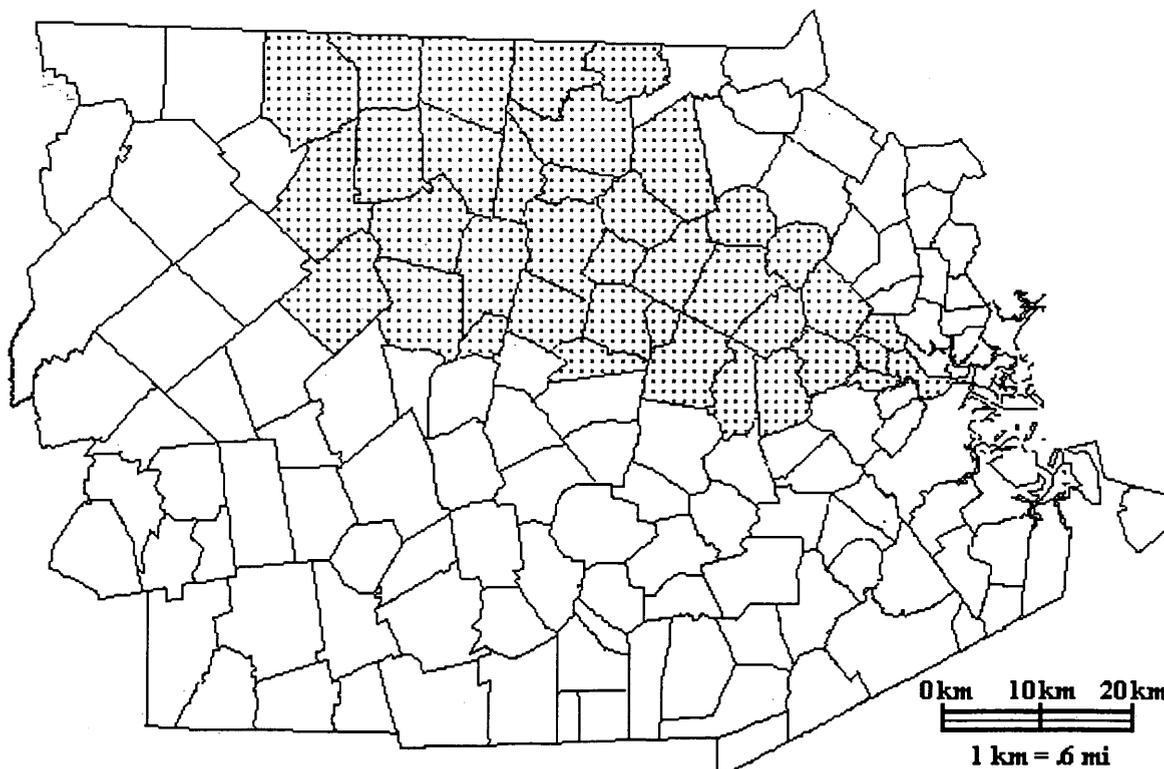


FIGURE 2 Study area.

TABLE 1 Population and Housing Characteristics of Study Area Communities

	1990 Population					Single-Family Housing Units (b)
	Total	Pop. Density per sq km (a)	1980-90 Growth	% 18-64 Years	Median Age	
Massachusetts Total	6,016,425	282	4.9%	63.89%	33.57	1,237,786
Middlesex County						
Acton	17,872	344	1.9%	68.26%	34.78	4,263
Arlington	44,630	3,328	-7.4%	65.54%	37.02	7,946
Ashby	2,717	44	17.6%	60.88%	33.11	867
Ayer	6,871	301	-1.7%	65.65%	29.54	1,066
Bedford	12,996	366	-0.5%	66.44%	36.87	3,048
Belmont	24,720	2,080	-5.3%	63.18%	38.01	4,568
Boxborough	3,343	124	6.9%	72.66%	31.90	657
Cambridge	95,802	5,921	0.5%	75.28%	31.11	3,295
Carlisle	4,333	109	31.1%	66.42%	38.37	1,433
Concord	17,076	264	4.8%	66.43%	38.38	4,465
Dunstable	2,236	52	33.8%	66.99%	33.01	701
Groton	7,511	89	22.1%	64.77%	33.95	2,276
Hudson	17,233	571	5.0%	66.33%	33.47	3,885
Lexington	28,974	679	-1.7%	61.95%	41.08	8,774
Lincoln	7,666	203	8.0%	60.70%	32.59	1,405
Littleton	7,051	165	1.2%	65.01%	35.44	2,158
Maynard	10,325	761	7.7%	65.39%	33.81	2,467
Pepperell	10,098	173	25.0%	62.15%	31.23	2,351
Shirley	6,118	149	19.4%	66.92%	32.18	1,119
Stow	5,328	115	3.6%	66.35%	35.84	1,690
Sudbury	14,358	228	2.4%	66.19%	37.07	4,616
Townsend	8,496	100	18.0%	60.69%	31.15	2,395
Waltham	57,878	1,801	-0.6%	71.50%	31.63	8,257
Watertown	33,284	3,166	-3.2%	68.77%	34.72	3,098
Wayland	11,874	300	-2.4%	64.17%	39.38	3,856
Westford	16,392	209	22.0%	64.68%	33.72	4,760
Weston	10,200	229	-8.7%	64.61%	40.97	3,198
Worcester County						
Ashburnham	5,433	54	33.3%	61.61%	32.71	2,037
Bolton	3,134	61	23.9%	65.60%	36.76	1,005
Clinton	13,222	953	3.5%	62.52%	32.85	1,999
Fitchburg	41,194	579	4.1%	60.34%	31.27	5,813
Harvard	12,329	181	1.3%	69.28%	25.05	1,683
Lancaster	6,661	93	5.2%	66.58%	31.31	1,643
Leominster	38,145	511	10.5%	63.69%	32.82	6,903
Lunenburg	9,117	132	8.5%	62.95%	35.73	2,968
Princeton	3,189	35	31.5%	63.94%	35.11	1,015
Sterling	6,481	82	19.1%	63.18%	33.96	1,861
Westminster	6,191	67	20.5%	62.61%	35.13	2,061
Study Area Total	630,478	328	4.3%	66.86%	34.29	117,602

1 sq km = .386 sq mi

Source: 1990 U.S. Bureau of the Census Data

(a) Population density per sq km of land area only (water not included), except for Massachusetts, which is total area

(b) Not directly comparable to "single family residential properties" utilized in this study

- Number of garage spaces, and
- Age.

These data were collected from property record cards obtained from local assessor offices throughout the study area.

Site Attribute Variables

Site attribute variables include

- Land area,
- Number of pools,
- Zoning, and
- Neighborhood type.

Land area and the existence of a pool were determined from the property record cards. The determination of whether the property was zoned residential or commercial was based on both property record card data and local zoning maps. Neighborhood type acts as a control variable for variations in community income levels, development patterns, population density, economic activity levels, cultural diversity, and other factors not explicitly included in the model that may affect the value of the property within the community. Rather than develop neighborhood type indicators from census data and other primary sources, an existing formal classification system developed in the mid-1980s by the Massachusetts Department of Education was used (17). This classification system consists of seven community types, including

- Urbanized centers, which are manufacturing and commercial centers, densely populated, and culturally diverse;
- Economically developed suburbs, which are suburbs with high levels of economic activity, social complexity, and relatively high income levels;
- Growth communities, which are rapidly expanding communities in transition;
- Residential suburbs, which are affluent communities with low levels of economic activity;
- Rural economic centers, which are historic manufacturing and commercial communities with moderate levels of economic activity;
- Small rural communities, which are small towns, sparsely populated, and economically undeveloped; and
- Resort/retirement and artisan, which are communities with high property values, relatively low income levels, and enclaves of retirees, artists, vacationers, and academicians.

Local Service Provision and Cost Variables

Local service provision and cost variables include

- Actual school quality (standardized test score index),
- Perceived school quality (per pupil expenditure),
- Violent and nonviolent crime, and
- Tax rate (\$ per \$1,000 assessed valuation).

Actual school quality is measured by a weighted index developed from state standardized test scores in various grade levels and subject areas (18). Perceived school quality is measured by per pupil expenditure in each community (19). Violent and nonviolent crime

data are used as proxies for the quality of local police services, with crime data reported by the Massachusetts Department of Safety. When considering the quality of local services, one must also consider the costs involved with the provision of such services. The local property tax rate serves as an indicator of the cost for local services.

Locational and Accessibility Variables

Many of the locational and accessibility variables were developed by means of an extensive analysis with geographic information systems (GISs). These accessibility variables include.

- Travel time to the nearest local commuter rail station;
- Mainline commuter rail travel time from the nearest local station to the central business district (CBD);
- Travel time to the nearest local highway interchange;
- Mainline highway travel time from the nearest local highway interchange to the CBD;
- If the residence is within a 1.6-km (1-mi) walk shed of a commuter rail station, the walking distance to the nearest commuter rail station is estimated, using a walking speed of 82 m (270 ft)/min and the straight-line distance; and
- The existence of an MBTA rail rapid transit station within the same community as the residence.

The 451 residential properties were geocoded and assigned explicit latitude/longitude coordinates such that relative distances to various transportation facilities could be accurately measured. U.S. Bureau of the Census TIGER/Line files provided the spatial framework for this analysis (20) and were supplemented with 1:25,000-scale and 1:100,000-scale U.S. Geological Survey quadrangle maps and rail system maps from MBTA and freight rail operators.

Accessibility to the Boston CBD was measured for both commuter rail and automobile/highway modes. Accessibility measures for both modes were disaggregated into local accessibility to the rail station or highway interchange and regional accessibility, represented by mainline travel times on either the rail line or highway network. Regional accessibility on mainline portions of both commuter rail and the highway network represents actual observed travel times in minutes. Actual travel times on the Fitchburg Line were taken directly from the operating schedule in effect during the sample period. Since MBTA commuter rail operations typically keep to their scheduled departure and arrival times, the scheduled times should be a highly accurate measure of the actual mainline travel times. Actual travel times on all segments of the study area limited-access freeway network were sampled by the author between April 1992 and September 1992 from interchange to interchange, at peak periods and in peak directions, using the average-speed technique. Existing freeway travel time estimates that were available from public sources were not believed to be detailed enough for the purposes of this analysis. Sample days were chosen so as not to coincide with holidays and any other days that would have resulted in abnormal travel patterns.

Local accessibility to either rail station or highway interchange is estimated on the basis of the latitude/longitude coordinate-derived straight-line distances, in combination with an average local access speed weighted by local population density. Local access times were estimated in this way rather than by shortest path routines using GIS because limited resources would not permit the vast numbers of individual shortest-path routines that would have been necessary.

Additionally, the necessary data describing the characteristics of each individual link in the local road network file were not immediately available. Therefore, a number of actual travel times for these local accessibility variables were measured to calibrate a weighting system in which average speeds on local road networks increased somewhat with decreasing local population density. This allowed for reasonably accurate estimates of local access times in different communities based on a limited number of actual observations.

Local Environmental Impact Variables

Local environmental impact variables include

- Distance to nearest railroad right-of-way, used as a proxy for noise, vibration, and other proximity effects from the railroad right-of-way, and
- Distance to nearest highway right-of-way, used as a proxy for noise, vibration, and other proximity effects from the highway right-of-way.

In addition care was taken to note any homes that were within measurable sound contours of local airports or military bases; however, none of the study properties were affected by these types of facilities. Because both commuter rail and freight rail operations share the right-of-way, an attempt was made to differentiate the two impacts by using various sets of dummy variables representing different threshold distances corresponding to various threshold impact levels and the maximum impact level for both freight rail and commuter rail operations and their predominant proximity impact, noise.

It should be noted briefly that although the data set is cross sectional in nature, this does not rule out the possibility of the existence of autocorrelation. In studies that use cross-sectional data on observations ordered in space, these observations may be correlated because of their relative locations in space. One would expect the correlative effect to be much stronger at shorter relative distances.

A study of assessed values in Ann Arbor, Mich. revealed that by using an autoregressive model with higher-order autoregressive terms representing relative distance lags between the dependent variables, approximately 79 percent of the explanatory power of the equation was found to be originating from the autoregressive terms (21). Independent variables that had been significant before the inclusion of the lag terms, such as distance to the city center, became insignificant. Much of the effect was thought to be related to local street patterns and local neighborhood characteristics.

This finding sheds doubt on the reliability of estimated coefficients in multiple linear regression models that use dependent variables exhibiting close relative distances. In particular studies that use observations from homogeneous neighborhoods to control for variation in neighborhood attributes may unintentionally introduce spatial autocorrelation into the data set. An analysis of the relative distances of the 451 observations used in this analysis reveal that the vast majority of these relative distances are well over 3048 m (10,000 ft), making the potential for significant spatial correlation in this analysis minimal.

RESULTS AND INTERPRETATION

Ordinary least-squares regression was used along with a log-log model specification, with the natural logarithm of sales price used

as the dependent variable. Early model specifications revealed that the number of pools, actual school quality as represented by the weighted index of standardized test results, heating system type (forced air, forced hot water, etc.), and zoning designation (residential, commercial) were consistently insignificant even at the .10 level by a one-tailed test. In the case of zoning designation, only 4 of the 451 properties were located in commercially zoned areas, such that insufficient variation in this variable existed to make any determination as to its impact upon property values. Therefore, the first model specification presented in Table 3 includes only those variables defined in Table 2.

It is anticipated that the bed, bath, and story variables will all exhibit positive coefficients. Age is anticipated to exhibit a negative coefficient; however, the AGE100 dummy variable is expected to have a positive coefficient, since this indicates that the home is of antique status, typically resulting in a significant property tax reduction. The three style categories are all expected to exhibit positive coefficients, since these styles are those that were generally more in demand at the time of the study. The variable representing no garage is expected to exhibit a negative coefficient, whereas the cardinal measurement of the number of garages used for those homes with garage space is expected to exhibit a positive coefficient.

Lot size is expected to exhibit a positive coefficient. It is unclear how the three community type variables will affect property values, yet it is believed that all three will exhibit positive coefficients. However, the variable GROWTH may exhibit a negative coefficient, resulting from the potentially negative aspects of rapid growth and transition within a community.

School quality indicators are expected to exhibit positive coefficients, and both the crime rate and tax rate variables are expected to exhibit negative coefficients.

Accessibility-related variables are anticipated to exhibit negative coefficients, indicating a decrease in property value with increasing distance from either regional or local activity centers. Both of the dummy variables STATN and MBTA, indicating a location in a community with a commuter rail station or a rapid transit station, respectively, are expected to exhibit positive coefficients.

Finally, the proximity effects variables FT700 and FT400 are both expected to exhibit negative coefficients since they are dummy variables representing proximity to the Fitchburg Line right-of-way. The two remaining variables, RAIL30 and HWY25, are expected to exhibit positive coefficients, indicating increasing property values as distance from freight rail and highway rights-of-way increases.

Output for this first specification is presented in Table 3. This specification does not perform exceptionally well, with half of the independent variables insignificant at even the .10 level by a one-tailed test. Nine of the coefficients, including HTWATR, CAPE, GAR0, GROWTH, lnTXRATE, lnAUTO1, lnWLKTIM, MBTA, and FT750, react in directions opposite to that which is hypothesized. Of these, only lnTXRATE and lnWLKTIM are significant. The variable MBTA, indicating that the residence was located within a community that had an MBTA rail rapid transit station (sometimes offering connections with commuter rail service), is both insignificant and reacts in the direction opposite to that which is hypothesized, suggesting that the ability to transfer between commuter rail service and rail rapid transit service at any given station has an insignificant impact on residential property values in the community in which the station is located.

lnTXRATE does not conform to that which would be anticipated, for example, a negative sign indicating increasing tax rates result-

TABLE 2 Model 1 Variable Definitions

<u>Dependent Variable</u>	
lnSLPRIC	- the natural log of the sales price (fair market property value) in thousands of dollars
<u>Structural Attribute Variables</u>	
lnBEDS	- the natural log of the number of bedrooms in the residence
lnBATHS	- the natural log of the number of bathrooms in the residence
OIL	- heating fuel type is oil (0/1 dummy variable)
HTWATR	- heating system type is forced hot air (0/1 dummy variable)
lnAGE1	- the natural log of the age of the home as of 1990. If age=0, it was changed to 1 before taking the natural log.
AGE100	- a dummy variable indicating that the home is 100 years of age or older, and therefore classified as antique by the local assessor (0/1 dummy variable)
COLONL	- structural style is colonial (0/1 dummy variable)
CAPE	- structural style is cape cod (0/1 dummy variable)
MODERN	- structural style is modern/contemporary (0/1 dummy variable)
lnSTRYS	- the natural log of the number of stories the residence has
GAR0	- if the home has no garage capacity, then this variable takes the value 1, otherwise this variable takes the value 0 (0/1 dummy variable)
lnGARG0	- if the home has garage capacity for one or more vehicles, then this variable takes the value of the natural log of that value.
<u>Site Attribute Variables</u>	
lnLTSQFT	- the natural log of the lot size, as measured in square feet
DVLSUB	- the residence is located within a municipality characterized as an economically developed suburb (0/1 dummy variable)
GROWTH	- the residence is located within a municipality characterized as a growth community (0/1 dummy variable)
RESSUB	- the residence is located within a municipality characterized as a residential suburb (0/1 dummy variable)
<u>Local Service Provision and Cost Variables</u>	
lnPUPIL	- the natural log of expenditure per pupil, measured as an integrated student cost (1989)
lnVCRIME	- the natural log of the number of violent crimes per 1,000 population (1989)
lnTXRATE	- the natural log of the residential property tax rate per \$1,000 of assessed valuation (FISCAL year ending June 30, 1990)
<u>Locational and Accessibility Variables</u>	
lnAUTO1	- the natural log of the estimated travel time in minutes from the residence to the nearest limited access highway interchange
lnAUTO2	- the natural log of the actual travel time in minutes from the preferred highway interchange to North Station
lnRAIL1	- the natural log of the estimated travel time in minutes from the residence to the nearest Fitchburg/Gardner line commuter rail station (includes a 5 minute transfer time at station)
lnRAIL2	- the natural log of the actual travel time in minutes from the preferred Fitchburg/Gardner line commuter rail station to North Station
lnINT1	- the natural log of an interaction term defined as [(AUTO1 + AUTO2)/RAIL1]
lnWLKTIM	- the natural log of the walking time from homes within one mile of a commuter rail station to the station (at a rate of 82 meters ¹ per minute)
STATN	- the municipality in which the residence is located has an MBTA commuter rail station within its corporate border (0/1 dummy variable)
MBTA	- the municipality in which the residence is located has an MBTA rail rapid transit station within its corporate border (0/1 dummy variable)
<u>Local Environmental Impact Variables</u>	
lnRAIL30	- if the residence is within 915 meters of an active freight rail right-of-way, then this variable is the natural log of the distance in feet to that right-of-way. Otherwise this variable takes the value 0.
FT400	- the residence is within 122 meters (corresponds to the 55 Ldn commuter rail noise contour) of the Fitchburg/Gardner commuter rail line (0/1 dummy variable).
FT750	- the residence is within 229 meters (corresponds to maximum extent of potential commuter rail noise impact area) of the Fitchburg/Gardner commuter rail line (0/1 dummy variable).
lnHWY25	- if the residence is within 762 meters of a limited access highway right-of-way, then this variable is the natural log of the distance measured in feet to that right-of-way. Otherwise this variable takes the value 0.

¹ 1 meter = 3.28 feet

ing in lower property values. One possible rationalization for this outcome is that higher tax rates are correlated with higher overall quality of public services, and that this effect of increasing quality of public services affects the tax rate variables. However, this seems unlikely given that indicators of public service quality such as public safety and school quality are included in the model to control for these attributes. lnWLKTIM indicates that a depreciative effect on residential property values predominates in close proximity to station locations. This may be the result of station-generated pedestrian and automobile traffic and noise, as well as the generally higher-activity areas in which stations appear to be located, resulting in relatively more traffic and other activity that is not directly the result

of the stations. This negative impact may be less than that experienced in proximity to a rail rapid transit station, however, since data obtained from MBTA reveals that parking facility capacities at Fitchburg Line stations are significantly less than typical parking facilities at many MBTA heavy rail rapid transit stations.

Because of the relatively poor performance of this specification, the following specification was analyzed by using the variables defined in Table 4. A more simplified model than Model 1 is used in hopes that variable significance and indicated direction of influence will improve. Model 2 still uses 19 independent variables representing a broad range of attributes; therefore, no significant specification bias should be introduced by the removal of some of the

TABLE 3 Model 1 OLS Regression Results

Variable	Coefficient	Std. Error	t-ratio
Dependent Variable	= LNSLPRIC		
Observations	= 451		
R-squared	= 0.742		
Adjusted R-squared	= 0.723		
Standard Error of the Estimate	= 0.2554582		
F-Ratio	= 38.93817		
InBEDS	0.17252	0.05041	3.422 ^{†††}
InBATHS	0.24206	0.04426	5.469 ^{†††}
OIL	0.04555	0.02782	1.637 [†]
HTWATR	-0.01813	0.02646	-0.685
InAGE1	-0.04902	0.01305	-3.758 ^{†††}
AGE100	0.11140	0.06171	1.805 ^{††}
COLONL	0.03875	0.04071	0.952
CAPE	-0.00369	0.03756	-0.098
MODERN	0.22595	0.06525	3.463 ^{†††}
InSTRYS	0.06443	0.05365	1.201
GAR0	0.00023	0.03511	0.007
InGARG0	0.23656	0.05209	4.541 ^{†††}
InLTSQFT	0.09272	0.02121	4.372 ^{†††}
DVLSUB	0.07605	0.05004	1.520
GROWTH	-0.02036	0.07919	-0.257
RESSUB	0.07380	0.05717	1.291
InPUPIL	0.63497	0.13360	4.753 ^{†††}
InVCRIME	-0.04504	0.01403	-3.209 ^{†††}
InTXRATE	0.44299	0.14220	3.115 ^{***}
InAUTO1	0.00660	0.04962	0.133
InAUTO2	-0.04550	0.02039	-2.231 ^{††}
InRAIL1	-0.13991	0.09870	-1.418 [†]
InRAIL2	-0.10929	0.04967	-2.201 ^{††}
InINT1	-0.06026	0.11080	-0.544
InWLKTIM	0.10139	0.05889	1.722 [*]
STATN	0.04774	0.04788	0.997
MBTA	-0.07615	0.07322	-1.040
InRAIL30	0.01515	0.03478	0.436
FT400	-0.28809	0.14430	-1.997 ^{††}
FT750	0.12965	0.11200	1.158
InHWY25	0.00906	0.03109	0.291
Constant	-1.91220	1.33400	-1.433

***, **, * denote coefficient significantly different from zero at the 1%, 5%, and 10% level of significance (two-tailed test)

†††, ††, † denote coefficient significantly different from zero at the 1%, 5%, and 10% level of significance (one-tailed test)

variables used in Model 1. Anticipated results are similar to those anticipated for Model 1. Output for this second specification is presented in Table 5.

The performance of Model 2 appears much improved over that of the previous model, Model 1. As anticipated the overall explanatory power of the model has not been reduced by the removal of the insignificant variables. Only 4 of the 19 independent variables are now insignificant. Analysis of the variance-covariance matrix for Model 2 reveals relatively low zero-order correlations among the independent variables. Also the consistently significant *t*-ratios for most of the independent variables would suggest the absence of any notable multicollinearity.

One of the variables of primary interest to this analysis, InRAIL1, is insignificant in Model 2, although it is statistically significant

from zero at the .10 level using a one-tailed test in Model 1. However, at the same time the estimated parameter on this variable also consistently exhibits the anticipated sign (negative), which is interpreted as a reduction in property value as one moves away from the station site and the RAIL1 travel time, as measured in minutes, increases. Additionally, in Model 2, the (0/1) dummy variable STATN, indicating that the residence was located within a community that had a commuter rail station within its borders, is statistically significant at the .10 level using a two-tailed test of significance.

In this model specification as well as the previous specification used in Model 1, the coefficients on the (0/1) dummy variables, when multiplied by 100, can be approximately interpreted as the percent change in the dependent variable P_h for an absolute change in the independent dummy variable, since the model essentially acts as a semilogarithmic model of the log-lin type for these (0/1) dummy variables. In this case with STATN representing a (0/1) dummy variable rather than the natural log of a cardinal measurement, the coefficient of .067 indicates that for single-family residential properties located in communities that have a commuter rail station there is an increase in value of approximately 6.7 percent. It is believed that this impact results primarily from the perceived effect of having a station in the same community as the residence, regardless of the actual travel time involved in accessing the station from particular individual locations within the community.

This finding is consistent with the way in which residential properties are marketed by real estate firms. Often, the fact that the home is located within a community with commuter rail access to Boston may be extolled, and whether the property is 3 min from the station or 8 min from the station is not focused on. This is reasonable, however, considering that for a home located within a community with a commuter rail station, variations in driving times to the station would in all probability be minimal since several kilometers of driving distance may translate into only several minutes of driving time. The greater part of the total trip time occurs on the mainline portion of the trip from the station to the CBD. Therefore, total origin-destination travel time for all properties in the community would essentially be approximately the same, resulting in an approximately equivalent increase in property values across the entire community. This 6.7 percent increase is also consistent with earlier findings by Voith (13) in an analysis of commuter rail-service in the Philadelphia region that found premiums associated with accessibility to commuter train service of 6.4 percent of average census tract median house value (13).

Regional accessibility, as represented by the RAIL2 variable, provided by commuter rail service does have a consistently statistically significant appreciative effect on single-family residential property values. The coefficient of $-.137$ on InRAIL2 can be interpreted to imply that for every 1 percent increase in travel time from the CBD by rail, single-family residential property values depreciate, on average, by 0.137 percent, or a little over 1/10th of 1 percent.

Another variable of primary interest to this analysis is the (0/1) dummy variable FT400, indicating a location within the average estimated commuter rail generated 55Ldn contour of the Fitchburg Line commuter rail line. This variable consistently exhibits a coefficient that is significantly different from 0 at the .05 level using a one-tailed test of significance. In Model 2 the estimated parameter indicates a depreciation in the value of single-family residential properties of approximately 20 percent as a result of being located within 122 m (400 ft) of the Fitchburg Line right-of-way. However,

TABLE 4 Model 2 Variable Definitions

<u>Dependent Variable</u>	
lnSLPRIC	- the natural log of the sales price (fair market property value) in thousands of dollars
<u>Structural Attribute Variables</u>	
lnBEDS	- the natural log of the number of bedrooms in the residence
lnBATHS	- the natural log of the number of bathrooms in the residence
lnAGE1	- the natural log of the age of the home as of 1990. If age=0, it was changed to 1 before taking the natural log.
AGE100	- a dummy variable indicating that the home is 100 years of age or older, and therefore classified as antique by the local assessor
MODERN	- structural style is modern/contemporary (0/1 dummy variable)
lnSTRYS	- the natural log of the number of stories the residence has
GAR0	- if the home has no garage capacity, then this variable takes the value 1, otherwise this variable takes the value 0 (0/1 dummy variable)
lnGARG0	- if the home has garage capacity for one or more vehicles, then this variable takes the value of the natural log of that value.
<u>Site Attribute Variables</u>	
lnLTSQFT	- the natural log of the lot size, as measured in square feet
<u>Local Service Provision and Cost Variables</u>	
lnPUPIL	- the natural log of expenditure per pupil, measured as an integrated student cost (1989)
lnVCRIME	- the natural log of the number of violent crimes per 1,000 population (1989)
lnTXRATE	- the natural log of the residential property tax rate per \$1,000 of assessed valuation (FISCAL year ending June 30, 1990)
<u>Locational and Accessibility Variables</u>	
lnAUTO1	- the natural log of the estimated travel time in minutes from the residence to the nearest limited access highway interchange
lnAUTO2	- the natural log of the actual travel time in minutes from the preferred highway interchange to North Station
lnRAIL1	- the natural log of the estimated travel time in minutes from the residence to the nearest Fitchburg/Gardner line commuter rail station (includes a 5 minute transfer time at station)
lnRAIL2	- the natural log of the actual travel time in minutes from the preferred Fitchburg/Gardner line commuter rail station to North Station
lnWLKTIM	- the natural log of the walking time from homes within one mile of a commuter rail station to the station (at a rate of 82 meters ¹ per minute)
STATN	- the municipality in which the residence is located has an MBTA commuter rail station within its corporate border (0/1 dummy variable)
<u>Local Environmental Impact Variables</u>	
FT400	- the residence is within 122 meters (corresponds to the 55 Ldn commuter rail noise contour) of the Fitchburg/Gardner commuter rail line (0/1 dummy variable).

¹ 1 meter = 3.28 feet

it is surmised that since the Fitchburg Line operates freight service as well as commuter rail service, this variable represents the impact of proximity impacts generated by freight service as well as commuter rail service. The fact that both freight rail service and commuter rail service operate on the Fitchburg Line makes it difficult if not impossible to accurately differentiate between the two separate sources of proximity impacts. Therefore, the findings concerning the effects of commuter rail-generated proximity impacts, independent of freight rail-generated proximity impacts, are inconclusive.

CONCLUSIONS AND POLICY IMPLICATIONS

It appears that there are indeed property value impacts on single-family residential properties resulting from commuter rail service. At the regional level access to the CBD provided by commuter rail service has an appreciative impact on property values. Even more

notable is the finding that single-family residences located in communities that have a commuter rail station have a market value that is approximately 6.7 percent greater than that of residences in other communities.

From the perspective of property value losses sustained as a result of proximity to the commuter rail right-of-way, the findings are inconclusive. Although a statistically significant property value loss of about 20 percent was identified for properties within 122 m (400 ft) of the right-of-way, it is impossible to differentiate between the loss attributable to commuter rail service proximity impacts and that attributable to freight rail service proximity impacts.

These findings suggest that some type of compensatory policy for property owners affected by negative right-of-way proximity effects could be appropriate in the case of new commuter rail facilities operated along new or long-abandoned rights-of-way if any of the negative proximity effects identified in this study could be attributed to commuter rail service. Such a policy would be in

TABLE 5 Model 2 OLS Regression Results

Variable	Coefficient	Std. Error	t-ratio
lnBEDS	0.18664	0.04948	3.772 ^{†††}
lnBATHS	0.24227	0.04286	5.653 ^{†††}
lnAGE1	-0.05173	0.01247	-4.149 ^{†††}
AGE100	0.11864	0.05985	1.982 ^{††}
MODERN	0.21267	0.05904	3.602 ^{†††}
lnSTRYS	0.09769	0.04385	2.228 ^{††}
GAR0	-0.01700	0.03378	-0.503
lnGARG0	0.22586	0.05060	4.464 ^{†††}
lnLTSQFT	0.10008	0.01967	5.088 ^{†††}
lnPUPIL	0.75894	0.11310	6.711 ^{†††}
lnVCRIME	-0.04741	0.01224	-3.873 ^{†††}
lnTXRATE	0.56672	0.11090	5.109 ^{***}
lnAUTO1	-0.03085	0.03683	-0.838
lnAUTO2	-0.02926	0.01434	-2.040 ^{††}
lnRAIL1	-0.04565	0.04794	-0.952
lnRAIL2	-0.13734	0.03233	-4.248 ^{†††}
lnWLKTIM	0.07157	0.05235	1.367
STATN	0.06778	0.03780	1.793 ^{††}
FT400	-0.20398	0.10490	-1.944 ^{††}
Constant	-3.18970	1.09000	-2.928 ^{***}

†††,††,† denote coefficient significantly different from zero at the 1%, 5%, and 10% level of significance (one-tailed test).

***,**, * denote coefficient significantly different from zero at the 1%, 5%, and 10% level of significance (two-tailed test).

addition to current practice regarding the partial mitigation of proximity impacts by means of application of noise treatments and construction of noise barriers, and could possibly be financed with a limited value capture policy by using special assessments to capture a portion of the communitywide increase in property values indicated in this study. Alternatively, possible reductions in public opposition as well as potential reductions in project cost and increases in project benefits resulting from the timely implementation of proposed commuter rail facilities may justify such a compensatory policy independent of any value capture policy.

A compensatory policy such as the one described above could have the potential for fairly compensating those residential property owners located within close proximity of the new commuter rail facility, but not within the right-of-way. Properties within the right-of-way are, of course, already compensated through negotiated purchase or eminent domain acquisition. An extension of these existing compensatory policies to include residential properties within close proximity of the right-of-way, but not within the right-of-way, could serve to reduce public opposition to needed transportation improvements and would also result in a more equitable outcome for all involved. From a social benefit-cost perspective, compensatory payments made to the affected property owners can be viewed as a transfer rather than a net loss or cost to society, since

the actual cost to society is the cost imposed on negatively affected property owners in proximity to the right-of-way. A methodology similar to the one used in the present study could be employed in an attempt to quantify impacts on individual property owners, with the prospect of even more accurate estimates of potential impacts, considering the large amount of machine-readable assessors' data compiled by and accessible to each community.

The potential for the practical application of such a policy, however, is somewhat doubtful, given the legal impediments that have been met in the use of similar computer-aided techniques, such as the estimation of assessed property values, and the potential for various institutional impediments as well. The use of computer-aided valuation techniques by local assessors' offices to update property valuations has in the past been met with some opposition by various aggrieved parties attempting to appeal valuations. Many of these techniques are based on the use of multiple regression models in some ways similar to the one used in this analysis. However, even though the legal validity of these techniques appears to be undecided, the general trend appears to be toward acceptance of these techniques as admissible evidence in a court of law. In addition the cooperation of the various local communities served by the commuter rail line would be required, leading to the potential problem of institutional impediments to the application of such a policy.

Given the inconclusive findings of the present study concerning the proximity effects of commuter rail service, future considerations for related analyses should include further attempts to differentiate and quantify property value impacts resulting from commuter rail service on both shared and dedicated rights-of-way. In addition the possible time series effects of the planning, construction, and operation of new commuter rail facilities is another area of possible future study. Such analyses may yield further insights into the effects of commuter rail facilities on residential areas, such that the relationship between transportation planners and the public will continue to become one that is less adversarial, resulting in a more effective and less costly transportation planning process as well as improved transportation services.

ACKNOWLEDGMENTS

The author wishes to acknowledge with gratitude Robert D. Ballou, John R. Mullin, Paul W. Shuldiner, and George I. Treyz of the University of Massachusetts at Amherst for their guidance, technical support, and patience throughout the development and completion of the manuscript that served as the basis for this paper. The Volpe National Transportation Systems Center, U.S. Department of Transportation, is also gratefully acknowledged for allowing the author to use their computer facilities. Persons from various local, state, federal, and private agencies and organizations with whom the author has had countless conversations and meetings, too numerous to mention separately, are also gratefully acknowledged.

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The views expressed in this study are those of the author and are not necessarily shared by the individuals and agencies who have contributed to this report. The author assumes sole responsibility for the contents and use of the material presented and for any errors or omissions herein.

Publication of this paper sponsored by Committee on Transportation and Land Development.