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Transportation, Sorting and House Values

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In this paper, we examine the importance of accessibility to employment and transportation system attributes for residential location choice, car ownership and house values. Using the 1980 Census of Housing and Journey to Work data merged with transportation system data, we find strong evidence of residential sorting based on employment location. We find that suburban areas with good commuter rail access to the CBD have significantly greater fractions of their labor force working in the CBD, own fewer cars and have higher house prices than similar neighborhoods and houses in census tracts without service. The house value premium is over 6.4%.

INTRODUCTION

Traditional urban economics has stressed accessibility to employment as a major factor determining location choices and house values. Monocentric models pioneered by Muth [17] and Mills [16] simplify the notion of accessibility by assuming that the only concentration of employment is in the central business district (CBD) and transportation costs per mile to the CBD are the same from all suburban locations. These assumptions led to the well-known predictions that rents and density should fall with distance from the CBD and that in the presence of decentralized employment, residential location choices should minimize commuting distance.[1]

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[1]The results of the monocentric model generally hold in the presence of decentralized employment, but not with multiple employment centers.

While the prediction of decreasing density has received some empirical support (see McDonald [15] for a review of the density literature), there has been little consistent evidence of a declining rent gradient. Examples of studies finding either positive or insignificant relationships between distance from the CBD and rents or house values include Cropper and Gordon [4], Blackley and Follain [2], and Heikkila et al. [11]. (See Jackson [12] for a review of earlier studies.) Recent studies by Hamilton [10], Blackley and Follain [12], and White [24] have further shown that the monocentric model generally predicts locations that are significantly closer to the CBD with shorter commutes than are observed. As suggested by White [24], the underlying model of location based on accessibility is reasonable, but the assumptions of monocentric cities and ubiquitous transportation are not.

In a multicentered region with heterogeneity in transportation, we would not expect to observe rent and density gradients that are related to distance from the CBD because individuals' residential bid-rent functions depend on their employment locations (White [25]).[2] Rather, we would expect to see individuals who work in the same job location to concentrate in residential locations that have comparative advantages in transportation *to their place of employment.* Thus we should observe residential sorting according to place of employment. By examining the distribution of employment locations for all residential locations (census tracts) of a metropolitan area, White [24] and Gordon et al. [9] provide general evidence that people do, in fact, sort themselves into residential locations that are convenient to work locations. Contrary to Hamilton [10], White finds very little excess commuting, in light of the multicentered nature of employment locations. Similarly, Cropper and Gordon [4] find substantially less excess commuting than Hamilton when taking into account preferences for amenities than can differ across locations.

Rent differences should only arise if a locale has accessibility advantages when individuals can choose both employment and residential locations.[3] Locations that have specific transportation advantages that cannot be duplicated elsewhere, such as proximity to a freeway or commuter train should have higher rents than locations of similar distances to employment centers. Unfortunately, these transportation cost-related house price

[2]See Steen [20] for a model of bid-rents with nonubiquitous transportation.

[3]As noted by White [23], only 25% of urban travel is for work commuting, so that accessibility to employment is only one factor in a locale's overall accessibility.

gradients are difficult to observe empirically because they require detailed geographic and transportation data at a level that is seldom available.[4]

Even if it does not lead to rent gradients, the extent of locational sorting is important to consider when evaluating the consequences of policy changes that affect accessibility. The attributes and size of a locale's population are likely to change if the locale's accessibility changes. For example, a change in transportation prices may result in larger than expected changes in demand if sorting is strong (Voith [22]). The sorting process should be reflected in average household transportation investments as well; households in locations with better public transportation should, on average, own fewer cars.

In this paper, we examine residential sorting on the basis of employment location and transportation accessibility in the Philadelphia metropolitan area. Though employment in the Philadelphia region is fairly decentralized with multiple centers, the region provides a natural test for the sorting hypothesis because it has a commuter rail system that is specifically designed to bring suburban workers to the CBD. In particular, we attempt to explain the fraction of people in any suburban census tract that works in the CBD as a function of the tract's accessibility to the CBD and to other locations. In doing so, we can obtain evidence of the importance of accessibility to employment in the residential location choice, as well as direct evidence on the effects of transportation system attributes on residential location and rents. We expect that locations with commuter rail service would have a greater fraction of CBD workers and own fewer cars per household. Locales with service should enjoy house value premiums if the commuter rail system is an attractive alternative to the highway. Further, we expect the extent of sorting to increase with increases in transit service quality.

Using the 1980 Census of Housing and Journey to Work data merged with Southeastern Pennsylvania Transportation Authority (SEPTA) and Port Authority of Pennsylvania and New Jersey (PATCO) commuter rail service data, we find strong evidence of residential sorting based on employment location. We estimate that the percentage of a census tract's labor force working in the CBD is 12.0% higher for tracts with commuter rail service nearby, other things held constant. In these tracts,

[4]Heikkila et al. [11] provide evidence on the rent gradients to subcenters in Los Angeles.

auto ownership is 4.5% lower as well. Further, we find that the strength of sorting depends on the quality of service. In particular, the relative time advantage of the train compared to the auto for a trip to the CBD and the frequency of the train positively affect the fraction working in the CBD. As one would expect, we also find that the fraction of a tract's labor force working in the CBD falls as highway commute time to the CBD increases and falls with the tract's accessibility to alternative work sites.

We find surprisingly strong evidence that the value of the commuter rail service is capitalized into house value. Premiums associated with accessibility to train service are quite large and average $5,594 or 6.4% of average house value.[5] In aggregate, the premium in real estate values for the suburban metropolitan area is on the order of $1.45 billion dollars. These findings are consistent with Boyce et al. [3] who find similar house value premiums associated with proximity to Philadelphia's PATCO line in the early 1970s.[6]

GEOGRAPHY AND DATA

The basic sample consists of virtually all census tracts in four Pennsylvania counties and one New Jersey county that had radial rail service to the CBD in 1980.[7] There are a total of 678 tracts in all. Tract data from the 1980 Housing Census and the Journey to Work Census were combined with highway travel time data and commuter rail service data. Data on highway commute time to the CBD were purchased from the Delaware Valley Regional Planning Commission. Service information associated with each commuter rail station for 1980 was assembled from schedules. Commuter rail stations were located on census tract maps, and a list of tracts with stations in or near the tract was compiled.

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[5]All monetary figures are in 1990 dollars.

[6]Others have found house value premiums along rail lines and that values decline with distance from stations in residential areas. See Dewees [6] and Damm et al. [5]. These studies examine central city properties only and do not include measures of highway accessibility. Related evidence is also available in the discrete choice literature, see Anas [1], Lehrman [13], and Quigley [18], for example.

[7]The Pennsylvania counties are Bucks, Chester, Delaware, and Montgomery. The New Jersey county is Camden county. Several census tracts in Camden county are not included. These tracts were excluded because they are associated with employment destination stops in the City of Camden for the train that continues through to Philadelphia.

TABLE 1
Variable Descriptions

Dependent Variables	
%CBD	Percentage of the labor force in each tract working in the CBD.
CARS	Average number of cars per household for each tract.
HOUSEVAL	Median house value for each tract.
Accessibility Variables	
STATION	Dummy variable that is equal to 1 if there is commuter rail service in or near the tract, 0 otherwise.
AUTO-COMMUTE	Travel time in minutes from each tract to the CBD by auto.
COMMUTE	Average length of commute in minutes for each tract, regardless of destination.
PEAK	Number of peak trains serving each tract. This variable is equal to 0 for tracts without service.
TIMEDIF	Difference in CBD commute time between auto and train. A positive value indicates a time advantage for the train. In tracts without service, this variable is equal to −22, the lowest value for a tract with service.
Control Variables	
INCOME	Average household income for each tract.
HHSIZE	Average household size for each tract.
%BLACK	Percent of the population that is Black for each tract.
DETACHED	Percent of the housing stock in each tract that is single family detached housing.
AGEHOUSE	Median age of the housing stock in each tract.
ROOMS	Average number of rooms in a house for each tract.

Census tracts were designated as having service or not having service as follows. In densely populated suburban areas where tracts are geographically small, the census tract where the station is located and immediately adjacent tracts are all designated as having service. In less densely populated areas where census tracts cover much larger areas, only the tract with the station is deemed to have service, except where stations lie on the border of two tracts.[8]

Table 1 displays the variables used in the analysis and their definitions. Table 2 shows the means and standard deviations of the variables for the overall sample as well as for census tracts with stations and for those without stations. The variables fall broadly into three categories: (1) variables that reflect outcomes

[8]We could have used other methods for defining tracts with and without service. For instance, we could have used census data on the fraction of a tract's population using rail transportation to work. However, we believe that this might be a case of "data snooping" as described by Lo and MacKinlay [14] and hence bias the significance of our results upward. The procedure we used may introduce some noise from misassignment, but it is unlikely to be systematic. The overall impact of the resultant noise is to bias the estimates toward zero, so that our estimations are biased against finding sorting effects.

TABLE 2
Variable Means and Standard Deviations

	All Tracts	Tracts With Stations	Tracts Without Stations
Dependent Variables			
%CBD	0.046	0.053	0.041
	(0.043)	(0.044)	(0.04)
CARS	1.63	1.53	1.71
	(0.35)	(0.35)	(0.34)
HOUSEVAL	87455	85777	88695
	(35518)	(38726)	(32946)
Accessibility Variables			
STATION	0.42	1.00	0.00
	(0.49)	(0.00)	(0.00)
AUTO-COMMUTE	53.20	48.46	56.70
	(20.30)	(16.15)	(22.26)
COMMUTE	23.12	22.81	23.35
	(4.39)	(4.35)	(4.42)
PEAK	3.74	8.79	0.00
	(6.55)	(7.53)	(0.00)
TIMEDIF	−10.16	5.87	−22.00
	(14.93)	(8.78)	(0.00)
Control Variables			
INCOME	38853	38907	38812
	(13328)	(15372)	(11610)
HHSIZE	2.88	2.81	2.94
	(0.37)	(0.36)	(0.36)
%BLACK	7.54	10.50	5.36
	(16.80)	(21.05)	(12.36)
DETACHED	57.49	48.86	63.87
	(28.47)	(29.44)	(23.98)
AGEHOUSE	27.29	29.86	25.40
	(12.00)	(12.08)	(11.60)
ROOMS	6.08	6.02	6.12
	(0.93)	(0.96)	(0.90)
Number of Obs.	678	288	390

of the sorting process, including percent working in the CBD (*%CBD*), average car ownership (*CARS*), and median house value (*HOUSEVAL*); (2) measures of accessibility, including existence of a commuter rail station (*STATION*), number of peak trains serving the tract (*PEAK*), difference in CBD commute time between auto and train (*TIMEDIF*), auto commute time to the CBD (*AUTO-COMMUTE*), and average length of all work commutes (*COMMUTE*); and (3) controls for household and house characteristics.

The raw means show that on average, 4.6% of the labor force worked in the CBD, ranging from a low of 0 (nearly 17% reported no workers in the CBD) to a high of 22%.[9] Consistent with expectations, the percent working in the CBD was over 29% higher for tracts with stations than those without, although the difference is not statistically significant. The average car ownership in the sample was 1.63 cars per household. Car ownership was lower in tracts with stations than in tracts without stations. Again, the difference in means is not significant. Median house value averaged $87,455 and was similar for both groups.

Turning to the accessibility variables, Philadelphia area residents commuted an average of 23.1 minutes each way; average commute times are similar across tracts with and without stations. Further, the standard deviation of commute times are small relative to their means.[10] In general, the data are supportive of White's [24] findings in that one would expect relatively equal commute times in a multicentric region (assuming there are sufficient employment centers).

Although average commute times fall within a relatively narrow range, highway travel time to the CBD varies widely and its average is more than twice the average daily commute; further evidence of the multicentered nature of the region. Tracts with train stations have considerably lower highway commute times to the CBD (48.5 minutes) than do those without (56.7 minutes), primarily because the coverage of the commuter service declines with distance from the CBD.

Measures of accessibility of the CBD by train are relevant only for tracts with stations. About 42% of all tracts have train service nearby. For these tracts, there is an average of 8.8 peak trains (one way) per day and the train enjoys an average 5.9-minute advantage in the commute time.[11] Also there is considerable variation in the peak frequency of train service and in the relative time advantage of the train. Thus, it should be

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[9]The CBD maintained its share of metropolitan employment during the period 1976–86 despite rapid suburban growth and overall central city employment decline. For estimates of central city employment see Summers and Linneman [21].

[10]A breakdown of the data on average commute time by county reveals strikingly similar commute times for the five counties ranging from a low of 22 minutes in Chester County and Montgomery County to a high of 25 minutes in Delaware County.

[11]Note that this does not include the time it takes to get to the train nor the time it takes to get to the office after disembarking from the train. This is not important, however, because we are not interested in the levels, but rather the relative attractiveness of the two modes.

possible to identify differences in sorting outcomes based on quality of service.[12]

Finally, we have data that are used to control for differences in the characteristics of households and houses. Income (*INCOME*), household size (*HHSIZE*), and house size (*ROOMS*), are all quite similar for tracts with stations and those without. However, tracts with stations tend to be slightly older (*AGEHOUSE*), have fewer single-family detached dwellings (*DETACHED*), and have higher percentages of the population that are Black (%*BLACK*). These differences are not statistically significant or economically large.

SPECIFICATION, ESTIMATION ISSUES AND RESULTS

In this section, we specify estimating equations for each of the three sorting outcome variables—percentage working in the CBD, household car ownership, and median house value—as functions of accessibility. The equations are similar, though not identical for each dependent variable.[13]

Percentage Working in the CBD

We explain the percentage of the labor force in each tract that works in the CBD as a function of the relative accessibility of employment sites from the tract by either car or train:

$$\%CBD_i = f(A_{ic}, T_{ic}, A_{io}, T_{io}) \quad (1)$$

where:

A_{ic} is accessibility to the CBD by auto;
T_{ic} is accessibility to the CBD by train;
A_{io} is accessibility to other employment destinations by auto;
T_{io} is accessibility to other employment destinations by train.

Increases in accessibility to the CBD should increase the fraction working in the CBD, while increases in accessibility to other

[12]We do not include price train price because it is collinear with travel time to the CBD.

[13]One might argue that the equations for the three sorting outcome variables should be estimated jointly in a seemingly unrelated regression. We have not undertaken that exercise here because the estimation used for the percent working in the CBD is a Tobit and estimation of the system would be practically very difficult in that case.

employment centers should reduce the fraction working in the CBD.

Empirically, we measure accessibility to the CBD by auto by *AUTO-COMMUTE*, the highway travel time from the tract to the CBD. We expect a negative coefficient on *AUTO-COMMUTE* in the estimations. Train accessibility is measured in two ways. The simplest measure is by *STATION*, which is a dummy variable for the presence of a station in or near the tract. We also use another measure which makes train accessibility a linear function of the train's relative travel time attractiveness compared to a car (*TIMEDIF*) and frequency of peak service (*PEAK*):

$$T_{ic} = \alpha_0 STATION + \alpha_1 TIMEDIF + \alpha_2 PEAK. \quad (2)$$

We expect the coefficients on α_1 and α_2 to be positive, and though we have no expectation on α_0 in this formulation, we expect the impact of T_{ic}, when evaluated at the variable means, to be positive.

Auto accessibility to other locations is somewhat problematic, because we do not have direct measures of a census tract's accessibility to other work sites.[14] However, once we control for CBD accessibility by car and train, the average commute time of all residents of the census tract, *COMMUTE*, should provide an indication of its relative accessibility to other sites. Controlling for differences in CBD commutes, higher average commute times should indicate poor accessibility to other employment centers. Thus we expect a positive coefficient on *COMMUTE* in the estimation. Train accessibility to other employment locations is ignored because the only market in which it is competitive is the CBD.[15]

We do not control for differences in demographic characteristics across tracts. These differences are endogenously determined as a result of the joint employment and residential decisions and hence represent outcomes of the sorting process. We also assume that transportation characteristics are not a

[14]Ideally, we would like to use the average commute time for non-CBD workers as a measure of accessibility to other locations; unfortunately, we do not have this data.

[15]Generally, the commuter rail system does not serve suburban employment centers, which tend to be closely tied to freeway interchanges rather than in older suburban towns where rail service is present. The fraction of peak ridership travelling to the city in the morning is nearly 90%, suggesting that the system primarily serves the CBD.

TABLE 3
Percent Working in the CBD
Tobit

	I	II
INTERCEPT	−0.0028	0.046*
	(0.011)	(0.012)
AUTO-COMMUTE	−0.0014*	−0.0014*
	(0.0001)	(0.0001)
COMMUTE	0.0048*	0.0049*
	(0.0004)	(0.0004)
STATION	0.0078*	−0.054*
	(0.0028)	(0.0067)
PEAK		0.0002
		(0.0003)
TIMEDIF		0.0021*
		(0.0002)
Numbers of Obs.	678	678

*Denotes significance at the 5% level; standard errors are in parentheses.

function of individual location decisions, at least in the short run.[16]

We estimated equation (1) using a Tobit because about 17% of the tracts in the sample had no commuters to the CBD.[17] Table 3 reports the Tobit estimates and comparable marginal impacts, evaluated at the variable means are shown in Table 4. Column 1 shows the estimation with only a dummy variable (*STATION*) for train accessibility while column 2 makes train accessibility a function of service quality.

The estimated marginal impacts of the accessibility variables, shown in Table 4, have the expected signs and are statistically and economically significant. Increasing highway travel time to the CBD (*AUTO-COMMUTE*) by 10 minutes, or 19%, reduces

[16]In fact, there was very little highway system change in Philadelphia in the 1970s and virtually all of the commuter rail stations, with the exception of those in New Jersey, have been in existence for over fifty years. The commuter rail service on New Jersey's PATCO line started in 1968. Finally, service levels on the commuter trains have changed little over time.

[17]The data in all estimations are weighted by the size of the labor force in each tract. The results do not change significantly for unweighted estimations. Dickens [7] notes that it may be inappropriate to weight the data if there are large within-group effects. Using tests suggested by Dickens, we found that estimated within group error components are very small compared with individual error components, suggesting that weighting is appropriate.

TABLE 4
Estimated Marginal Impacts on the Percent of the Labor Force Working in the CBD[a]
Tobit

	I	II
AUTO-COMMUTE	−0.0012*	−0.0013*
COMMUTE	0.0042*	0.0044*
STATION	0.0068*	−0.048*
PEAK		0.00015
TIMEDIF		0.0019*

*Derived from coefficients significant at the 5% level.
[a]Evaluated at the sample mean.

the percentage of people working in the CBD by 1.2 percentage points, or 26%. An increase in average commute time (*COMMUTE*, the proxy for accessibility to other employment centers) by 10 minutes, or 43%, results in an increase of 4.2 percentage points, or 91%. The marginal impact of the existence of commuter rail service to a tract (*STATION*) on percent working in the CBD is an increase of 0.68 percentage points, or about a 14.8% increase over tracts without stations.

Because the quality of commuter rail service is not uniform across all tracts that have stations, we estimated equation (1) making train accessibility to the CBD a function of service quality as in (2). The estimated coefficients on *AUTO-COMMUTE* and *COMMUTE* are quite similar to the estimations shown in column 1. The estimated coefficients on *TIMEDIF* and *PEAK* are of the expected sign but only *TIMEDIF* is statistically significant. When evaluated at the mean, these estimates imply effects similar to the corresponding dummy variable model. An increase in the time advantage of the train (*TIMEDIF*) of 10 minutes increases the percent working in the CBD by 1.9 percentage points, or 41%.[18] As we show later, the insignificance of *PEAK* likely results from problems in pooling census tracts from New Jersey and Pennsylvania caused by the dramatic differences in peak service levels across the two systems, rather than the lack of importance of *PEAK* service for accessibility. The negative coefficient on *STATION* coupled with the significant coefficients on the quality measures suggests that poor quality service has little impact on location decisions while high quality service significantly affects location decisions.

[18]Note this really is not that large an increase. Though the mean value for *TIMEDIF* in tracts with service is 5.87, its variance 8.78.

In sum, accessibility factors significantly affect the percentage of people in any given census tract that work in the CBD. Availability of suburban commuter rail service has a significant impact on individuals' joint residential-employment location decision. The magnitude of the public transportation-related sorting impact is tied to the quality of public transportation service, suggesting that changes in the use of public transit services in response to price and quality shifts are likely to grow as longer term location decisions are made.

Auto Ownership

Given the significant effect of the commuter railroad on sorting behavior, we examine whether there is a corresponding negative effect on car ownership among tracts with train service. The model we estimate for average car ownership in a census tract is nearly identical to that for percentage working in the CBD, but we also include controls (D_i), for nonaccessibility-related demand differences across tracts:

$$CARS_i = g(A_{ic}, T_{ic}, A_{io}, T_{io}; D_i) \quad (3)$$

The vector D_i consists of a variable for average household income in the tract (*INCOME*), and average household size (*HHSIZE*). Unlike the estimations for percentage worked in the CBD, there are no unambiguous signs for the coefficients for any of the variables except T_{ic} and D_i. For example, one might think that increasing auto accessibility to the CBD would enhance the attractiveness of owning a car; but on the other hand, less auto accessibility to the CBD increases the attractiveness of the car because there are poor transportation substitutes further from the CBD. We would expect, however that the availability of train service would reduce car ownership, especially as the quality of the substitute increases. Additionally, we expect auto ownership to rise with income and family size.

Table 5 presents two OLS regressions for auto ownership; column 1 includes the dummy variable for train service, while the regression in column 2 makes train accessibility a function of service quality. As expected, *INCOME* and *HHSIZE* are positive and significant in both regressions. *AUTO-COMMUTE* and *COMMUTE* are also positive and significant in both regressions suggesting that the further from work centers that people live, the more attractive or necessary automobiles are.

Households in tracts with train service have lower average car ownership, as is evident in a statistically significant coefficient of

TABLE 5
Household Automobile Ownership
OLS

	I	II
Intercept	−0.17*	−0.18*
	(0.064)	(0.068)
*INCOME*1000*	0.12*	0.12*
	(0.0005)	(0.0005)
HHSIZE	0.33*	0.32*
	(0.019)	(0.020)
AUTO-COMMUTE	0.0060*	0.0060*
	(0.0004)	(0.0004)
COMMUTE	0.0048*	0.0047*
	(0.0018)	(0.0018)
STATION	−0.074*	−0.048
	(0.013)	(0.033)
PEAK		−0.0002
		(0.0013)
TIMEDIF		−0.0010
		(0.0012)
Adjusted R^2	0.740	0.740
Obs.	678	678

*Denotes significance at the 5% level; standard errors are in parentheses.

−0.074 on *STATION* in column 1. In the regression with *STATION, PEAK* and *TIMEDIF*, all have negative coefficients, but only the coefficient on *STATION* is statistically significant. Focusing on the simpler regression, the estimated effect is only a 4.5% reduction from the mean household car ownership in tracts without stations, but it represents a large impact considering only 5.3% of the labor force in tracts with stations commute to the CBD. If we assume that train service is irrelevant for 90% of the people in a given tract and hence service should not affect car ownership, the estimates imply a household car ownership rate among the remaining 10% of only 0.97 cars per household.[19]

House Values

We find that a census tract's accessibility attributes are capitalized into house values based on estimations of models

[19]This value is computed as follows: the mean car ownership for the 90% whose decisions are not affected by the existence of train service is 1.71 and 0.074 is the marginal effect, so the implied ownership of the remaining 10% is ((1.71–0.074)–(0.9*1.71))/0.1 = 0.97.

similar to those above, except for controls for differences in housing and neighborhood, Q_i:[20]

$$HOUSEVAL_i = h(A_{ic}, T_{ic}, A_{io}, T_{io}; Q_i) \quad (4)$$

The housing control vector includes *HHSIZE*, percent of the tract's population that is Black, *%BLACK*, percent of the tract's housing that is single-family detached, *DETACHED*, the median age of the housing, *AGEHOUSE*, and the average number of rooms, *ROOMS*.

House value regressions for both measures of train accessibility are shown in Table 6. The coefficients on the controls are as expected; larger houses in neighborhoods composed of single-family detached dwellings are more expensive, while older houses in neighborhoods with higher Black populations are less expensive. Larger households tend to have less expensive housing, probably reflecting a smaller share of household income spent on housing. Additionally, household size may reflect otherwise unmeasured systematic differences in the tax and amenity package associated with different neighborhoods, which in turn may affect house values.

Turning to the accessibility variables, the positive, significant coefficient on *AUTO-COMMUTE* indicates a positive rent gradient that is at variance with the monocentric model.[21] This result probably reflects preferences for open space and higher levels of housing and land consumption. The coefficient on *COMMUTE* is positive, but insignificant. The lack of significance here is not surprising as there is little variation in average commute times across tracts. Most residential locales appear to be equally convenient to some employment.

The significant effect of the commuter rail system on the joint residential-employment location decision is reflected in house values. The coefficient on *STATION* in (column 1 of Table 5)

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[20]We do not include income because it is endogenous to the sorting process. This is marked contrast to Heikkila et al. [11]. They include the average income of the neighborhood as one of the explanatory variables determining house values. This can be misleading if, for example, a high proportion of workers choose to live in a tract because of its CBD accessibility, and in addition CBD employment is higher wage, then a regression of house value on accessibility and income might yield no premium for accessibility but a high correlation with income. Yet it is the accessibility to a high income job that is leading to the value premium.

[21]This result also differs from those of Edelstein [8]. He finds that house values in suburban Philadelphia's "main line" area decrease with distance from the CBD. His findings are based on data for the late 1960s when the region was more nearly monocentric. Additionally, the main line has traditionally been CBD-oriented because it has enjoyed high quality commuter rail service.

TABLE 6
Median House Value
OLS

	I	II
Intercept	60343*	62560*
	(9352)	(9745)
HHSIZE	−54813*	−55585*
	(3023)	(3091)
%BLACK	−112.52	−94.81
	(56.51)	(57.20)
DETACHED	230.32*	239.69*
	(39.74)	(40.04)
AGEHOUSE	−1076.6*	−1076.9*
	(73.89)	(74.05)
ROOMS	30891*	30936*
	(1235)	(1235)
AUTO-COMMUTE	175.00*	157.58*
	(43.95)	(46.10)
COMMUTE	82.23	107.92
	(217.11)	(217.24)
STATION	5594.4*	7358.6*
	(1479)	(3751)
PEAK		−281.68
		(151.46)
TIMEDIF		25.34
		(136.32)
Adjusted R^2	0.707	0.708
Obs.	678	678

*Denotes significance at the 5% level; standard errors are in parentheses.

indicates that tracts with commuter rail service enjoy house value premiums of $5,594. This premium is 6.4% of the 1980 median house value of $87,455. The coefficients on *PEAK* and *TIMEDIF* are very small and insignificant in the more complex formulation. Evaluated at the mean, the more complex equation predicts similar premiums to those of the dummy variable formulation. Evidence from more disaggregate regressions presented in the next section, which break out the Pennsylvania counties from the New Jersey counties, however, indicate that service levels do matter.

The house value premium associated with census tracts with stations can be used to calculate a net increase in suburban real estate values associated with the commuter rail system. There are a total of 258,437 owner-occupied houses in census tracts that have train service. This implies that the increase in suburban

value associated with the train service is about $1.45 billion.[22] Note that the existing house value premiums can be sustained only if service continues and the CBD maintains an advantage in productivity over alternative locations.[23] The productivity of the CBD and the transportation system are not independent, as one of the major attributes of the CBD is its accessibility to a wide labor pool. However, if other factors such as local taxes, poor services, or crime reduce the CBD's attractiveness, the real estate premiums associated with the commuter rail system are likely to disappear.

SERVICE QUALITY AND SORTING: NEW JERSEY AND PENNSYLVANIA

Separate analysis of Camden County, New Jersey and the Pennsylvania counties provides more conclusive evidence on the role of service quality in sorting. The characteristics of commuter rail service are very different in New Jersey and Pennsylvania. In comparison to the service offered in Pennsylvania by SEPTA, New Jersey's commuter rail service is of much higher quality. Table 7

TABLE 7
Transportation Characteristics by States
Means and Standard Deviations

Variable	All PA	Camden, NJ
STATION	0.468	0.196
PEAK	6.86	33.41
(Tracts with Stations)	(3.06)	(1.47)
TIMEDIF	5.13	15.33
(Tracts with Stations)	(8.58)	(5.23)
AUTO-COMMUTE	49.59	34.10
(Tracts with Stations)	(16.04)	(9.36)
AUTO-COMMUTE	62.59	35.88
(Tracts without Stations)	(20.48)	(14.52)
COMMUTE	22.73	23.78
(Tracts with Stations)	(4.46)	(2.44)
COMMUTE	23.35	23.39
(Tracts without Stations)	(4.55)	(3.94)
Number of Obs.	571	107

[22]This assumes that increases in value near stations are not offset by decreases at areas far from stations.

[23]Richardson et al. [19] note that in Los Angeles, the premium associated with proximity to the CBD in 1970 had diminished to zero by 1980, while premiums associated with proximity to other subcenters increased.

TABLE 8
Estimated Marginal Impacts on the Percent of the Labor Force Working in the CBD by State[a]
Tobit

	All PA	Camden, NJ	All PA	Camden, NJ
AUTO-COMMUTE	−0.0013*	−0.00015	−0.0013*	−0.00033
COMMUTE	0.0037*	0.0025	0.0040*	0.0025
STATION	0.0018	0.035*	−0.062*	0.057
PEAK			0.0020*	−0.0038
TIMEDIF			0.0018*	0.0027*
Obs.	571	107	571	107

[a]Evaluated at the sample mean. Actual Tobit estimates used to derive impacts are available on request.
*Denotes significance at the 5% level.

displays transportation characteristics for Camden county and for all Pennsylvania counties.

Service on the PATCO line in New Jersey is five times as frequent as its SEPTA counterpart, and its time advantage relative to the automobile is three times as great. The higher quality PATCO services should result in greater sorting in Camden county compared to the Pennsylvania counties.[24] Note that there is very little variation relative to the mean in the frequency of the PATCO; this contrasts with the relatively high variance in peak service on the SEPTA system. We therefore expect little explanatory power of frequency within Camden county.

Tables 8–10 display estimations for percent working in the CBD, auto ownership, and median house values, separately for Camden county and the Pennsylvania counties. As expected, the sorting impacts are larger in all cases for Camden county, and we gain precision on the role of service quality. For percentage working in the CBD (Table 8), the simple Tobit estimation indicates that the effect of the PATCO service in Camden is nearly seven times as large as the SEPTA effect in Pennsylvania. The Pennsylvania effect in no longer significant. In the more complex formulation for service we find significant effects for *PEAK* and *TIMEDIF* in Pennsylvania, however, suggesting that

[24]Also Camden county residents receive favorable treatment for the city of Philadelphia's high wage tax; this may result in the CBD being a more attractive employment destination than is the case for the Pennsylvania counties. Hence, the commuter train system may have even greater sorting impacts.

TABLE 9
Automobiles Per Household by State
OLS

	All PA	Camden	All PA	Camden
Intercept	−0.26*	0.69*	−0.22*	0.60*
	(0.070)	(0.17)	(0.074)	(0.20)
*INCOME*100*	0.011*	0.019*	0.012*	0.019*
	(0.0006)	(0.0016)	(0.0006)	(0.0016)
HHSIZE	0.38*	0.045	0.37*	0.031
	(0.020)	(0.051)	(0.021)	(0.053)
AUTO-COMMUTE	0.0055*	0.012*	0.0052*	0.012*
	(0.0004)	(0.0018)	(0.0004)	(0.0018)
COMMUTE	0.0051*	−0.015*	0.0050*	−0.016*
	(0.0020)	(0.0068)	(0.0020)	(0.0068)
STATION	−0.078*	−0.011*	−0.021	−1.38
	(0.014)	(0.40)	(0.038)	(0.84)
PEAK			−0.0085*	0.046
			(0.0035)	(0.027)
TIMEDIF			−0.0001	−0.0067
			(0.0012)	(0.0060)
Adjusted R^2	0.749	0.777	0.751	0.784
Obs.	571	107	571	107

*Denotes significance at the 5% level; standard errors are in parentheses.

in areas of high quality service there is a significant sorting impact. As expected, *PEAK* has no effect in Camden. In terms of auto ownership (Table 9), we also find larger effects for Camden than Pennsylvania. Interestingly, the effect of peak service levels becomes significant in the Pennsylvania estimation, even though it was not for the whole sample.

The SEPTA services and PATCO services result in different house value premiums (Table 10). The higher quality PATCO service has an estimated premium for Camden county houses of $6,707, or 10% of the median Camden county house value, compared with $3,437, or 3.8% of the median value for Pennsylvania houses. Unlike the pooled sample estimations, in the regressions with explicit measures of service quality, the coefficient on *PEAK* is significantly positive and *TIMEDIF* is positive but insignificant in Pennsylvania. *TIMEDIF* is positive and significant in Camden. *PEAK* is insignificant in Camden county as expected, but the dummy for the existence of service is positive and significant for Camden as well. Because SEPTA and PATCO serve the same employment market, these differences in sorting effects likely reflect service quality differentials.

TABLE 10
Median House Values by State
OLS

	All PA	Camden	All PA	Camden
Intercept	78516*	55330*	77533*	74630*
	(10528)	(18103)	(10933)	(19692)
HHSIZE	−57891*	−31922*	−55893*	−32877*
	(3206)	(6522)	(3317)	(6440)
%BLACK	−68.85	−200.64*	−70.90	−132.83
	(67.58)	(85.42)	(67.87)	(89.88)
DETACHED	309.41*	33.33	300.05*	67.91
	(43.18)	(82.93)	(43.18)	(83.88)
AGEHOUSE	−1077.5*	−943.15*	−1013.0*	−904.63*
	(79.64)	(149.39)	(80.81)	(151.19)
ROOMS	30265*	24192*	29712*	24722*
	(1351)	(2567)	(1363)	(2535)
AUTO-COMMUTE	58.59	249.45	82.32	178.99
	(51.36)	(161.73)	(54.42)	(162.00)
COMMUTE	160.51	−942.30	154.96	−829.21
	(240.84)	(608.17)	(240.15)	(600.21)
STATION	3437*	6706.5*	−4642.6	33802.3
	(1626)	(3127.4)	(4487)	(63395.4)
PEAK			1000.46*	−2069.11
			(408.09)	(2058.6)
TIMEDIF			60.24	1061.93*
			(141.26)	(458.34)
Adjusted R^2	0.711	0.826	0.715	0.835
Obs.	571	107	571	107

*Denotes significance at the 5% level; standard errors are in parentheses.

CONCLUSION

This paper empirically documents the role of accessibility in the residential-employment location choice. The findings are consistent with the fact that employment in the Philadelphia metropolitan area is multicentered. Commute times appear to be relatively consistent across residential locations indicating that most residential locations are equally convenient to an employment center, if not the CBD. Despite the multicentered nature of the region's employment, the specific sorting effects of the commuter rail systems are significant. We find higher concentrations of residents working in the CBD and lower auto ownership in tracts with commuter rail service.

We find that part of the value of commuter rail systems is capitalized into the house prices in tracts with service. These

effects are relatively large, over 6% of value or $1.45 billion in aggregate for suburban houses with train service. These estimates suggest that, despite the increasing decentralization of the region, over 40% of the residents of the suburban metropolitan area have a direct interest in the quality of public transportation and economic health of the CBD, regardless of whether they use the service or work in the CBD.

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