PACIFIC RIM PROPERTY RESEARCH JOURNAL
2019, VOL. 25, NO. 3, 217–227
https://doi.org/10.1080/14445921.2019.1693323

The value of a tram station on local house prices: an hedonic modelling approach

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ABSTRACT

There are many drivers of house prices. In urban locations, public infrastructure is considered one of the leading determinants. To explore this relationship, an Hedonic house pricing model was applied to an established Birmingham, the UK working class residential area which is serviced by the Metro Midland tram line. The selected Wednesbury Great Western Street station provides ease of access for the local residents to Birmingham and Wolverhampton City Centres plus there has been recent sale evidence of 100 properties within close proximity to the station. Independent variables consisted of a range of typical physical, locational and neighbourhood attributes for the Hedonic house pricing model input data.

Based on the preferred linear Hedonic model, the findings from the recent 100 Wednesbury house sales showed property type, bedrooms, floor area, ambience and distance to the tram station were key explanatory factors in relation to pricing levels. On the evidence provided, property price increased by £16,878 for every km closer to the tram stop. However, when examining properties within defined distance bands with smaller datasets, the location to the tram station was not a significant statistical driver. This suggests that proximity to a public transport access point alongside key housing characteristics should form part of the housing decision making process as they are significant predictors of local house prices.

ARTICLE HISTORY
Received 28 June 2019
Accepted 12 November 2019

KEYWORDS
House prices; public transport infrastructure; hedonic pricing model; property features; Wednesbury Great Western Street Station

1. Introduction

Sustainability and the environment are important aspects to consider for urban locations. To many, a key environmental component to a sustainable urban strategy is a convenient and reliable public transport system. The benefits public transit offers are a relatively inexpensive transportation cost especially for the low income and disabled population alongside providing lower energy consumption and emissions compared to the current main form of transport; privately own cars (Dunbaugh, 2008; Ong & Houston, 2002; Richardson, 1999)

In recognising the societal and economic advantages of public transport to the wider community, transit impact studies are generally based on the hypotheses that improved accessibility will create a spatial interaction with increased land values adjacent to

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infrastructure developments (Alonso, 1964). Whist many studies have found positive relationships between real estate values and the proximity to developed public transport systems (see detailed literature reviews by Bartholomew & Ewing, 2011; Debezion, Pels, & Rietveld, 2007; Duncan, 2011; Hess & Almeida, 2007; Mulley, Ma, Clifton, Yen, & Burke, 2016; Sirmans, Macpherson, & Zietz, 2005), this UK study applies the cross-sectional approach to an established dense working class location with defined light industrial and residential boundaries supporting an ethnically and culturally diverse population.

In this study, we are interested in evaluating whether house buyers are willing to spend more money when purchasing residential property located in proximity to public transport facilities, in this instance, Wednesbury Great Western Street tram station. Wednesbury is a working-class market town in England's Black Country, and is a recognised Birmingham suburb with a population of approximately 19,340 with 85% born in England and an average age of 40. The top occupations listed by people in Wednesbury covers the traditional skills of process, plant and machine operatives, skilled trades and administrative services.

Wednesbury is served by the Midland Metro rail (tram) system, with stops at Great Western Street and Wednesbury Parkway. The tramline links Wolverhampton and Birmingham city centres, and the line has a proposed extension to Brierley Hill. A map of Wednesbury, house sale locations and the metro station can be seen in Figure 1.

A case study strategy selected a Wednesbury suburb, specifically postcode WS10, as the catchment area to look at the impact of the Wednesbury Great Western Street Metro Station (tram stop) on surrounding recent house sales. This location offered similar dwellings in a relatively narrow price range alongside public transport serviced by an accessible tram line and to a lesser extent local bus services which appear to be restricted to busy main thoroughfares due to residents' cars parked on both sides of local residential roads.

The methodology sourced secondary data from the Rightmove website, UK's largest online real estate portal and property website. As they create a simpler and more efficient property marketplace, researcher can access extensive residential sales data, offering a big data approach for analytical analysis. In this instance, as an exploratory study, sales data were extracted for 100 recent residential property transactions within 4.5 km distance to the selected tram station. This information provided the input data to perform the hedonic modelling which is based on regression analysis that can use panel variables or dummy variables assigned to individual or group of characteristics, see Sirmans et al. (2005) and Malpezzi (2003) for literature on hedonic modelling methodology and past categories of independent house price determinants. For Wednesbury, several independent determinants were sourced including property type, number of bedrooms, floor area, off-street parking, garage, location beside busy road, location in modern area and distance to the metro station.

Following this introduction, Section Two provides a literature review covering public infrastructure and property pricing determinants. Section Three details the selected methodology and associated data. Section Four provides the empirical findings and housing implications and the last section provides concluding comments.

2. Literature review

In this section, the review of literature covers two key areas, public infrastructure development in metropolitan areas and determinants of property values. This approach is

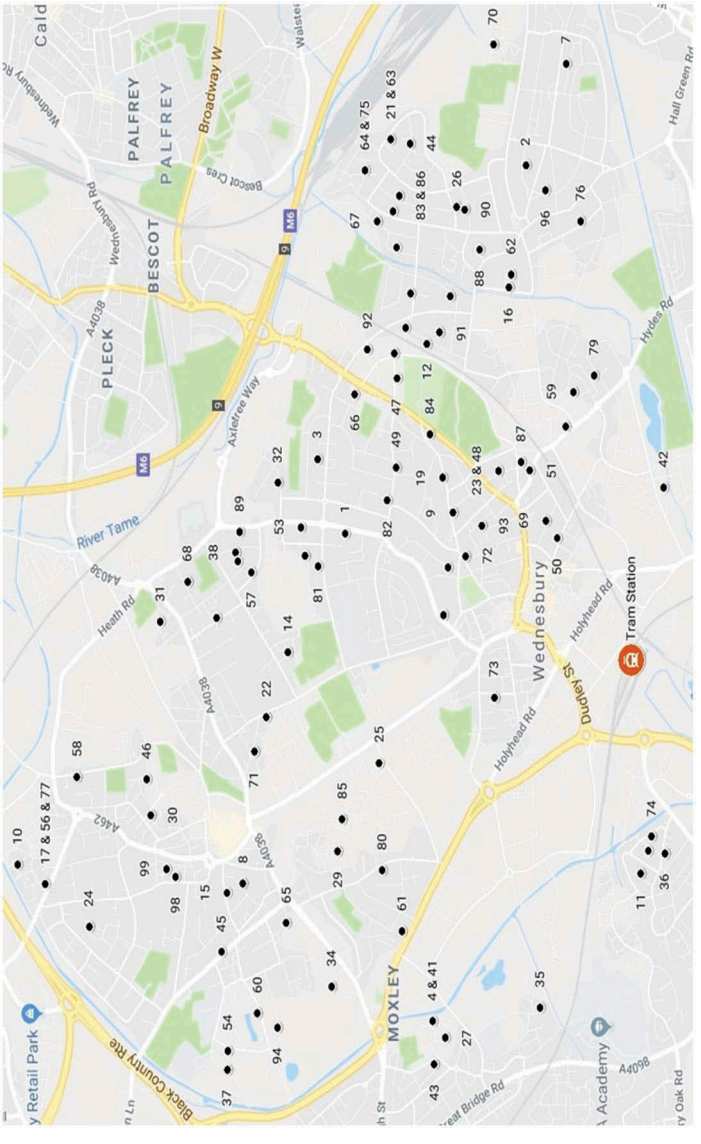

Figure 1. Map of Wednesbury, West Midlands.
Source: Author, 2018

supported by Ratcliffe, Stubbs, and Shepherd (2004) where a study on the dynamic growth of urban areas detailed that 10% of the world population lived in cities at the beginning of the twentieth century, whereas, this rate exceeded 50% at the end of the century. This figure is estimated to increase to 60% by 2030. Currently, almost 90% of the population in England live in urban areas.

2.1. Public infrastructure development in metropolitan areas

Urban area growth and the increase in supporting populations can lead to more public infrastructure needs. As the prevailing role of the urban areas in economic and social life of the nation, "nodal" development was proved to be a system that makes people less reliant on private car use. To encourage people to use public transport rather than private cars, the scheme was changed to be based on nodes (like bus/train/tram stops, shops, schools, parks) which were located within 500-m radius or 5 min walking distance of residential properties (Ratcliffe et al., 2004).

Similarly, Elburz, Nijkamp, and Pels (2017) highlighted the importance of public infrastructure, especially transport infrastructure, as a policy instrument to endorse growth of developed and developing locations. They further focused on the economic impacts of public transport infrastructure as a tangible contribution to environmental and sustainability considerations. Therefore, better planned public transport infrastructure should be embedded and integrated within city planning systems to promote people to reduce the usage of private cars.

Daido and Tabata (2013) conducted a study on the economic development through the interactions between political decisions about public infrastructure and economic decisions on nations and businesses. They specified that economic growth effects of public infrastructure projects are through several factors such as effects on private investment, and production of health and education services. Similarly, Pardo-Bosch and Aguado (2016) developed a multi-criteria decision-making tool called the "Sustainability Index of Infrastructure Projects" (SIIP) in which, they approached the feasibility of investment and the priority of an infrastructure project by considering four main parameters of sustainability, social, economy, and environment.

2.2. Determinants of property values

Major factors affecting property values from the viewpoint of urban locations were covered extensively by Alonso (1964), Ratcliffe et al. (2004), and Sirmans et al. (2005) and included rental income or sale price, investment yield for capitalization, gross building size, net lettable area, construction costs, fees, cost of finance, land cost, required profit, development period, construction period, acquisition and disposal costs, contingency sum, and void periods.

Likewise, Baum and Crosby (2008) looked at the value of the properties from an investment point of view and discussed appraisal methods and techniques. They considered property value financial factors for the investor, and that these could include the tax situation, rate of capital loans, the total capital required, the size and type of the property being appraised, and cashflow implications of leases.

Gwamna, Yusoff, and Ismail (2015) reviewed and descriptively analysed 12 previous empirical research studies on land use and property value from Malaysia, the USA, and Nigeria. They considered the major determinant factors under three attributes of property as "structural", "locational", and "neighbourhood". By integrating bid rent theory and monocentric city models, they concluded that proximity to central business districts can have positive impacts by reducing transportation costs, but negative ones as crowd and traffic, together with smaller lots and spaces.

Kolowe (2014) utilized hedonic price modelling to analyse determinants of urban land prices in Rwanda. He divided the variables into three categories, i) variables related to housing structural characteristics, ii) variables related to environmental and household amenities, and iii) variables related to neighbourhood characteristics. Each category was further broken down to different groups, each including a number of detailed factors. He considered a total of 35 factors in the model and provided recommendations for policy makers for improvements.

In the UK, Du and Mulley (2007) considered how the introduction of a rail transit system can lead to land value changes using the extension to Sunderland of the Tyne and Wear Metro as a case study. They noted changes in land values benefits from public infrastructure in urban locations and that property value drivers can include physical, locational and social attributes.

In summary, across different geographic locations, hedonic property price models have highlighted a range of determinants that cover broad categories around physical, social and locational factors. This research looks to add to the body of knowledge, by modelling house price determinants in a defined working class, multicultural location serviced by a tram station offering access into Wolverhampton and Birmingham city centres.

3. Methodology

Derived from Lancaster's (1966) consumer demand theory, the Hedonic Price Model (HPM) is based on the idea that property prices can differ with respect to various characteristics such as property type, number of bedrooms, house size, proximity to specific locations, etc. To reveal the empirical relationship between the property price and these characteristics, regression analysis is adopted as the primary research tool. For more information, Malpezzi (2003) provides a detailed explanation on single equation hedonic house pricing models.

Considering the different classification of determinants within the literature on housing characteristics (such as lot size, number of bedrooms etc.), neighbourhood (like proximity to city centre) and locational amenities (such as ambience, off street car parking, etc.), the price function of a property can be demonstrated (see Xiao, 2017):

$$y_i = \int(\mathrm{D}, \mathrm{H}, \mathrm{L}, \mathrm{N})$$

where sales price (y) is a function of D, which presents the proximity of properties to tram station; H, housing characteristics; L, locational amenities; and N, Neighbourhood characteristics.

In order to conduct appropriate statistical analysis and explore the interrelationship with property prices, key determinants were selected, and their relative information were collected. These selected determinants can have direct impact on property prices. Table 1 shows the directional impact of the determinants on property prices. This will be later investigated and proven with reference to appropriate statistical analysis.

Table 1 implies that property price will increase by additional number of bedrooms, larger floor area, availability of off-street parking, a garage, and being located in a modern area. It also suggests an increase in value by the property type from terraced to semi-detached to detached house. Property prices are assumed to be inversely proportional to the distance to the metro station and a location beside busy road.

Required data were extracted primarily from Rightmove (2018) website (Rightmove sales data and individual property sale brochures) which provided the research input data.

4. Results

Descriptive statistics describe the features of the research data by providing simple summaries about the sample property sales and evidence of measurements (variations to the mean, measure of central tendency and the shape of the data set). A summary of the descriptive statistics for the data used in the hedonic price modelling study is presented in Table 2.

Table 2 illustrates Wednesbury average property sales price for the period November 2017 to May 2018 was £138,812 and ranged from £115,872 for a terraced to

Table 1. Impact of selected determinants on property prices.

Determinant	Impact on Price
Property type (terraced, semi-detached, detached)	+
Number of bedrooms	+
Floor area (m^2)	+
Off-street parking	+
Garage	+
Location beside busy road	-
Modern area (attractive location)	+
Distance to Wednesbury Metro Station (Kms)	-

Table 2. Descriptive statistics.

	Analysed Property Sales			
Sale Price	Complete	Terraced	Semi-detached	Detached
Number of data points	100	30	58	12
Mean	£138,812	£115,872	£134,711	£220,250
SD	£48,189	£39,027	£28,298	£63,270
SD+2	£235,191	£193,925	£191,307	£346,790
SD-2	£42,434	£37,818	£78,115	£93,710
Median	£128,000	£109,000	£130,000	£233,000
Kurtosis	3.23	9.56	−0.26	−1.11
Skewness	1.64	2.59	0.39	0.11
Range	£265,000	£211,000	£126,500	£195,000
Min	£65,000	£65,000	£80,000	£135,000
Max	£330,000	£276,000	£206,500	£330,000

£220,250 for a detached house. The standard deviation data showed semi-detached house sales (£28,298) had a narrow price spread compared to detached house sales range (£63,270). This slightly differed to the Kurtosis reading where terraced properties have a high reading of 9.56 compared to – 1.11 reading for detached properties. This showed that while terraced properties sales were generally close together in value, there were some noticeable outliers, whereas detached properties were more evenly spread along the normal deviation bell curve.

Following Malpezzi (2003), the linear regression analysis was used to find the relationship between property sale prices and the explanatory determinants. For building type, a control variable (terrace) was nominated and two dummy variables (semi-detached and detached) were selected. The results of the linear regression analysis is presented in Table 3.

The results of linear regression analysis presented in Table 3 illustrated that property prices (as the dependent variable) has a very strong direct relationship with property type, number of bedrooms, floor area and modern area location of the property. There is a strong inverse relationship with distance to the tram station. The panel data sets were separately tested for multicollinearity, which provided evidence of data sets correlations for three of the determinants namely off-street parking, garage and being located beside a busy road and so were removed from further analysis because of similar levels of correlation to that of an attractive modern location. Looking at the P-values of the explanatory factors showed that there is a low probability and that these results occurred randomly. Coefficients illustrated that having one more bedroom will increase the property price by £19,807 and on the other hand, being 1 km further from the metro station will reduce the property price by £16,878.

As part of the analysis, the data were converted to natural logs (including: semi-log, log-log) to examine if non-linear data provided a better regression reading to the above linear regression analysis. As the best non-linear regression reading is $R^2 = 0.64$, being lower than the linear regression reading and with the same explanatory variables, the linear data regression analysis was preferred and used for the rest of the study.

Second classification for data analysis was based on property distance to Wednesbury Great Western Street Metro Station. Regression analysis was performed under three different categories:

Table 3. Linear regression analysis.

Regression Statistics:	R Square 0.70	Standard Error 37,900	Observations 100	
Explanatory Variables	*Coefficients*	*Standard Error*	*t Stat*	*P-value*
Intercept	35,092	21,524	1.63	0.11
Semi-detached	15,714	7,039	2.23	0.03
Detached	50,754	11,450	4.43	0.00
Bedrooms	19,807	5,820	3.40	0.00
Floor Area	562	174	3.23	0.00
Off-street Parking	10,063	8,948	1.12	0.26
Garage	4,514	6,818	0.66	0.51
Busy Road	-5,861	8,831	-0.66	0.51
Modern Area	17,234	6,596	2.61	0.01
Distance to tram stop	-16,878	6,372	-2.65	0.01

(i) properties within 2 km distance to metro station
(ii) properties between 2 and 3 km to metro station
(iii) properties above 3 km (3–4.5 km) to metro station

This analysis on property sales by distance can highlight if sales prices changes by proximity to a public transport node.

4.1. Properties within 2 km distance to tram stop

Of the 100 properties plotted, 25 properties were located within 2 km distance to the metro station. Linear regression analysis results for these properties are presented in Table 4.

Table 4 shows the R square value ($R^2 = 0.84$) for this category with a satisfactory chi-square goodness of fit test between actual and calculated property sales prices. On the other hand, looking at the explanatory factors, floor area is found to have the highest impact and is a significant factor on property prices within 2 km distance to the metro station. Interestingly, there was no other evidence of key statistical drivers on house prices close to the metro station which may primarily relate to the reduced dataset.

4.2. Properties between 2-3 km to tram stop

A total of 46 residential sale properties were located within 2-3 km distance to the metro station. Regression analysis results for these properties are presented in Table 5.

Table 5 details the determinants in this category have less correlation with property prices ($R^2 = 0.57$) compared to the first category ($R^2 = 0.84$). Unlike the properties within 2 km distance to the metro station, property type and number of bedrooms and modern

Table 4. Regression analysis results for properties within 2 km distance to the tram station.

Regression Statistics:	R Square 0.84	Standard Error 38,914	Observations 25	
Explanatory Variables	Coefficients	Standard Error	t Stat	P-value
Intercept	−106,228	79,423	−1.34	0.20
Semi-detached	17,935	24,577	0.73	0.47
Detached	28,561	29,792	0.96	0.35
Bedrooms	22,328	19,529	1.14	0.27
Floor Area	1,144	536	2.14	0.05
Modern	22,239	20,050	1.11	0.28
Distance to tram stop	48,959	38,306	1.28	0.22

Table 5. Regression analysis results for within 2-3 km distance to tram station properties.

Regression Statistics:	R Square 0.57	Standard Error 23,383	Observations 46	
Explanatory Variables	Coefficients	Standard Error	t Stat	P-value
Intercept	48,488	42,363	1.14	0.26
Semi-detached	16,162	7,679	2.10	0.04
Detached	55,168	15,294	3.61	0.00
Bedrooms	13,559	7,146	1.90	0.07
Floor Area	462	279	1.66	0.11
Modern	25,091	7,815	3.21	0.00
Distance to tram stop	−5,522	14,193	−0.39	0.70

Table 6. Regression analysis results for properties above 3 km distance to tram station.

Regression Statistics:	R Square 0.82	Standard Error 23,300	Observations 29	
Explanatory Variables	Coefficients	Standard Error	t Stat	P-value
Intercept	13,338	54,653	0.24	0.81
Semi-detached	23,022	11,394	2.02	0.06
Detached	60,458	19,556	3.09	0.01
Bedrooms	29,872	10,485	2.85	0.01
Floor Area	186	181	1.03	0.31
Modern	12,452	10,134	1.23	0.23
Distance to tram stop	−1,602	14,851	−0.11	0.92

location were the determinants having the highest influence on prices among the properties within 2-3 km distance to the metro station.

4.3. Properties above 3 km (3-4.5 km) to tram stop

The remaining 29 properties were located within 3–4.5 km distance to Wednesbury metro station. Linear regression analysis results for these properties are reported in Table 6.

Properties within 3–4.5 km distance to the metro station showed the highest reading between actual and calculated property prices (R^2 = 0.82). Similar to properties within 2-3 km distance to the metro station, property type and number of bedrooms have the highest impact on property prices in properties beyond 3 km distance to the metro station. The only difference is that in the former, property type had the highest impact and in the latter, number of bedrooms has the highest influence on property prices. Again, the critical explanatory factors may be effected by the reduced data sets.

5. Conclusion

Residential property markets can be influenced by several determinants including physical, social, environmental factors, see Duncan (2011) and Sirmans et al. (2005) coverage of past literature. This study examines key house price factor, specifically the distance to a public transport as a determinant of house prices. Wednesbury, a suburb of Birmingham was selected as the study location as it provided an established working-class location with defined light industrial and residential boundaries supporting an ethnically and culturally diverse population. Wednesbury is served by the Great Western Street Metro Station being part of the Midland Metro Tram network linking Birmingham and Wolverhampton city centres.

Relevant sales data for 100 properties within 4.5 km distance to the tram station were collected from Rightmove's website and categorised as to property type (terraced, semi-detached, detached), number of bedrooms, floor area, off-street parking, garage, location beside busy road and attractive modern area. On sourcing the data, Hedonic house price model was applied to determine the significant factors that impacted on local house prices.

Linear and non-linear regression analyses were carried out over the whole dataset. It was established that both results offered similar outcomes and thus, linear regression was

utilised for the rest of the study. Three of the determinants namely off-street parking, garage and being located beside a busy road were removed from further analysis because of similar levels of correlation to that of an attractive modern location.

Further, the analysis included the distance of the property to the Wednesbury metro station. Properties were categorised under three groups of within 2 km, 2-3 km and beyond 3 km distance to the tram station. Hedonic regression analysis was then performed for each distance band and the results were interpreted and discussed.

The hedonic regression analysis results in respect to the distance to metro station showed compliance with chi-square goodness of fit test between actual property sale prices and the hedonic model explanatory determinants. Property type and number of bedrooms had the highest impact on property prices for properties within 2–4.5 km distance to tram station, where floor area was the dominating determinant for properties within 2 km distance to tram station.

There are several key features evident in this research. Foremost is the relationship linkage between property price as the dependent variable and determinants such as property type, size of the property, number of bedrooms, location of the property and proximity to public infrastructure. Different features of a property can inevitably influence sales prices and therefore they must form part of buying strategy. These features are the same determinants (modern area, number of bedrooms, floor area, and property type) which were proven to have specific impact on property sale prices. The value of infrastructure can be measured on property sales evidence and this was dependent on location. The Wednesbury evidence showed house prices close to public transport (tram station) can increase in value by £16,878 for every km.

This research can assist in improving the knowledge base for property stakeholders and offer policymakers a valuable approach to measure the impact of public transport on local house prices. The analysis highlights the importance of cross-sectional data analysis at a local level as part of the property decision-making process.

Disclosure statement

No potential conflict of interest was reported by the authors.

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