Improving the political case for transport investment: an ex-post evaluation of the external economic benefits of the Nottingham Express Transit LRT Scheme

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1 Introduction

The case for transport investment, and its acceptability to politicians, would be strengthened if we had a better understanding of the wider economic impacts that past schemes have delivered.

Taking Nottingham Express Transit (NET) Line One as a case study, this paper demonstrates ways in which the wider economic benefits actually achieved can be assessed. In particular, the paper recommends the use of easily obtainable and improving data sources for ex-post economic scheme assessments, thereby enabling us to build a credible data base of past scheme performance. Government decisions about investment in transport infrastructure to support economic growth could then take proper account of the evidence of past performance.

The remainder of this paper is set out in the following sections:

- Background;
- Case study area context and control area selection;
- Results and discussion;
- Monetary evaluation of benefits;
- Strengths and weaknesses of the approach; and
- Conclusions and message to Government.

2 Background

2.1 The Economic Impacts of Transport and their Valuation

The 2006 ‘Eddington’ study, since endorsed by the Department for Transport, established firmly in the UK the economic imperative of transport infrastructure. Investment drives economic growth and has a critical role in facilitating competitiveness, from the town to regional level and beyond (Eddington, 2006; Knowles & Febrache, 2014). Eddington acknowledges several types of economic impact, first set out by SACTRA (1999):

- Extension of labour market catchment areas;
- Stimulation of inward investment;
- Unlocking previously hard to reach sites for development;
- Reorganisation or rationalisation of production, distribution and land use; and
- Triggering fresh growth through elimination of significant transport constraints.

There is also a long history of debate and development around the need to forecast such benefits ex-ante and the suitability of travel time savings to represent them. In 2005 the Department for Transport (DfT) released a discussion paper seeking to improve the modelling of further indirect impacts of transport schemes (on GDP) by including agglomeration economies, increased competition benefits due to imperfect markets and tax benefits due to changes in labour supply. They were piloted on the appraisal for Crossrail in 2005 and these ‘Wider Impacts’ are now part of standard WebTAG appraisal methodology in the UK (DfT, 2005).

Furthermore, land and property value increases are not estimated explicitly in traditional ex-ante appraisal, although ‘willingness to pay’ for transport user time savings may in part account for land value uplift. Land Use and Transport Interaction (LUTI) models attempt to forecast this effect directly, but accounting for this is not part of WebTAG requirements.

As important decisions are based on appraisal forecasts, there is a clear need to assess the economic impacts ex-post. The National Audit Office (2011) highlighted the importance of evaluation for ensuring transparent and accountable decision making, and the DfT (2012) have updated guidance reflecting this.

However, a mismatch exists between the requirements for ex-ante appraisal to choose between schemes, and the level and quality of ex-post assessment of transport scheme effects used to justify such decisions. As a result, we have only a limited understanding of the extent to which transport investment is delivering the claimed economic benefits. A recent meta-analysis of local scheme evaluation commissioned by the DfT found that:

Little evidence was presented in evaluation reports to demonstrate the delivery of longer term objectives such as economic, environmental and social impacts.

(Atkins, 2014)

The DfT has recently produced guidance for evaluation to improve on this, which is sound and commendable. However, little detail is given around appropriate methods, metrics or data sources which might be used to gain a consistent standard of assessment (DfT, 2012). It is therefore clearly important that ex-post scheme evaluation is conducted and I therefore present a case study attempting to evaluate scheme benefits given currently available data.

There are however many difficulties when evaluating the economic impact of schemes both before and after opening, not least the risk of double counting or comparing like with like. Attributing inward investment or other wider impacts to a particular scheme - the problem of 'Additionality' – is the most significant problem to effective evaluation (ONS, 2010). Multivariate approaches are the most powerful here, but are resource and data hungry (Gibbons & Overman, 2007; Chesterton, 2000). And even then, it may be virtually impossible to account for all of the effects at play.

Where such methods are not feasible, those employed in the Jubilee Line Extension Impact Study are a practical alternative. By carefully selecting 'control' or control areas which are assumed to have similar properties to the scheme area – less the new infrastructure – an assumption can be made that background effects are allowed for. Here systematic and selection biases may be a problem as other factors are not accounted for explicitly and we rely on the appropriateness of the control area as a comparator 'deadweight' scenario. However they give us a means of estimating an order of magnitude of effects against a range of indicators given the assumptions made, and for substantially less cost than a full multivariate study.

Other researchers (Hasiak & Richer, 2013), recommend a combination of quantitative and qualitative approaches, stressing the importance of knowledge of local spatial and planning constraints in order to gain a good appreciation of scheme impacts.

Most authorities will have a budget for evaluating scheme benefits on the order of £10,000 rather than £100,000. Based on the trade-off between confidence in estimation of 'additional' benefits, resources and data availability, a hybrid approach with a mix of empirical multivariate and control area comparisons, as well as qualitative research of the planning and spatial environment, seems most appropriate to obtaining balanced, consistent, cost effective and robust scheme evaluations. The NET case study demonstrates each of these elements. Minimising risk by using national datasets and using clearly set out assumptions in order to reach evaluation conclusions is also important.

2.2 Availability of data for scheme evaluation

Obtaining adequate measured variables of interest, at suitable levels of spatial disaggregation and over the right time periods, is a perennial problem in transport scheme evaluation. What is encouraging though are continuing improvements in available data, and the current government's commitment to 'unleashing the potential' (Cabinet Office, 2012). Their Open Data policy facilitates several advances which could be helpful to transport practitioners, and is already making data more readily and widely available for the evaluation of scheme impacts. Some advantages are:

- Encouragement to private enterprise to make data available (which may help with access to real estate data).
- New datasets are being released frequently (core accessibility indicators; ONS origin-destination matrices), and they will become increasingly useful as the available time series grow.
- Plans to centralise many existing datasets and make them accessible (such as planning portal data for all Local Authorities on Data.gov.uk).
- Existing datasets are also becoming more consistent, seeing longer time series develop without discontinuity or major update (ABI employment data).

I first conducted a research exercise to investigate the availability of datasets which might be used to evaluate the economic impact of transport investments ex-post. A requirement for this exercise was that the data be available at 2001 Lower Super Output Area (LSOA) level to enable effects to be investigated at an appropriate level of spatial disaggregation.

Table 2.1 shows the indicators identified as being easily available for use in ex-post evaluations, under the broad economic headings derived from the Jubilee Line Extension Impact Study (University of Westminster, 2004). Details of time series availability, continuity, cost and levels of aggregation are summarised.

Table 2.1: Available Evaluation Indicators

Indicator	Continuity	Source	Aggregation	Cost
Controls/Demographic				
Population	1998-present	ONS	LSOA	-
Standard Area Measurement	1998-present	ONS	LSOA	-
Index Multiple Deprivation	2004, 2007, 2010 (every 3 years)	ONS	LSOA	-
Planning and Development				
Planning Applications	2001-present	Nottingham City Council	Individual property Individual property postcode	-
Land Value and Property				
Rateable Value	2000-present	Valuation Office Agency	LSOA	FOI request
House Price Paid	1995-present	Land Registry	Postcode	-
Labour Market				
Employment (ABI/BRES)	2003-2005, 2006-2008, 2009+	NOMIS	LSOA	£60 incl VAT
Jobseekers claimants (as proxy for Unemployment)	2000-2012	NOMIS	LSOA	-
Productivity (IDBR)	2001-2007, 2008-2009, 2010-present	IDBR	Firm-level	Approved researcher status

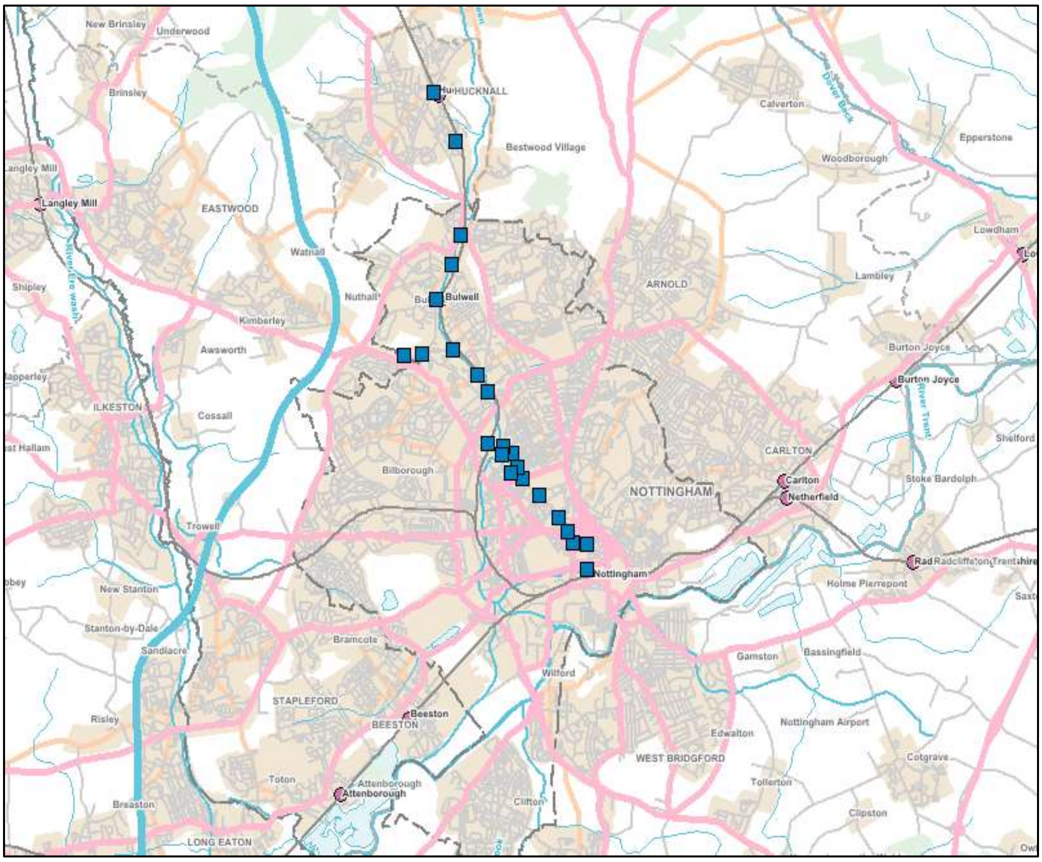
While most of these datasets are currently too short in continuous time series for longer term impacts to be examined, the improving quality of datasets is likely to mean such impacts will be increasingly open to examination in the future. Evaluations could be applied at intervals in the short, medium and longer terms.

3 Case Study - NET Line One Short Term Evaluation

3.1 Study Context

The NET line, opened in March 2004, runs from Hucknall village to the north of the city, through the northern built up area and into the city centre. The introduction of the tram offered significant additional journey time and reliability benefits to users over and above bus network improvement, especially into the city centre from residential areas. Figure 3.1 shows the Nottingham built area, together with the location of the NET Line One tram stops.

Figure 3.1: Nottingham Built up Area with NET Line One Stop Locations



I decided at an early stage that the Nottingham Central Business District (CBD) south of the Forest stop should be excluded from the analysis as the LSOAs comprising the city centre were fairly few in number using the 2001 categorisation (this has been improved with the new 2011 Census categorisation due to a growth in resident population in the centre). Furthermore, the majority of bus and tram routes also converge within the CBD, and so study and control area catchments are likely to overlap. Other studies have also investigated, qualitatively, the stimulated development seen in the central areas due to the tram, where we might expect the majority of employment and retail benefit to be seen (SDG, 2005). Therefore the results of this study will be additional to impacts seen in the CBD.

Separately, the village of Hucknall was excluded, as no appropriate comparator areas were found. Increased property development in Hucknall has also been explored qualitatively in detail (NDE Consultants, 2007). The defined NET corridor for the present study therefore extends only as far south as the Forest stop and as far north as the boundary of the City of Nottingham.

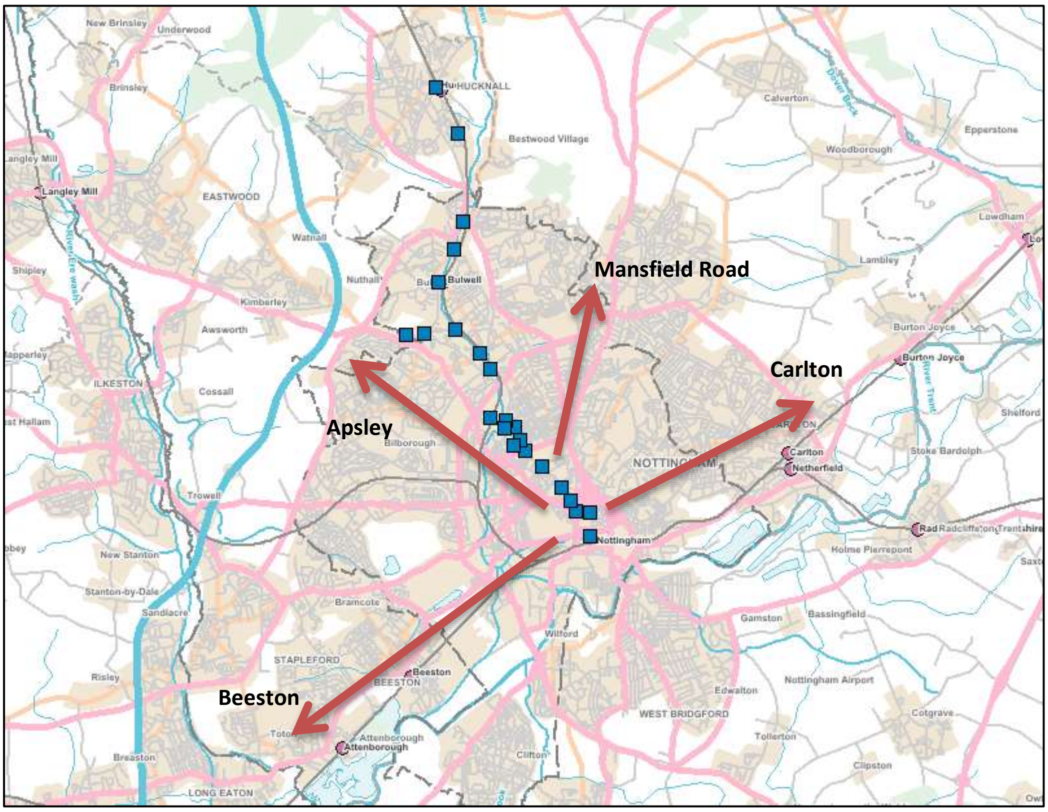
For the purposes of the current research, an evaluation period of 2002-2005 (1 year after opening) was taken. Moving to 3 or 5 years post opening would mean taking account of significant macroeconomic effects of the stock and housing market crashes and subsequent recession, and this was beyond the scope of the present work.

While the Nottingham city centre economy is thought of as buoyant pre-recession, it is surrounded by pockets of quite serious deprivation (NCC, 2006).Therefore, the selection of this sub-corridor offers the potential to investigate the ability of the tram to break down (transport) barriers to employment and reduce unemployment in areas of particular concern to local decision makers.

3.2 Control Area Selection

Four potential corridors were examined and compared in order to identify a suitable study control area. They are shown in Figure 3.2.

Figure 3.2: Potential Control Corridor Locations



Only radial corridors were considered, terminating in the city centre, with established bus corridors pre-scheme. Corridors were compared using index of multiple deprivation (IMD) scores, population density, employment and unemployment levels. The results of the sifting exercise are summarised as:

- **Mansfield Road Corridor (NE)** – Parallel and close to the NET corridor in more central areas. Lower IMD and population densities than the NET corridor.
- **Beeston Corridor (SW)** – Markedly different characteristics. Low IMD, large university campus and business parks make this corridor unsuitable as a control area.
- **Carlton Corridor (E)** – Similar IMD and population density to the first two thirds of the NET corridor. Also runs into the town centre from a different direction. Eastern sections of CBD labelled as regeneration areas and suitable for redevelopment.
- **Apsley Road Corridor (NW)** – Parallel and close to the NET corridor for the more central areas of route make this section unsuitable as a control corridor. However, further from the city centre, characteristics of deprivation, population density and business land uses are similar to the Bulwell

end of the NET corridor (especially the deprived areas of Broxtowe and Hyson Green, respectively) and make this outer part suitable for comparison purposes (NCC, 2006).

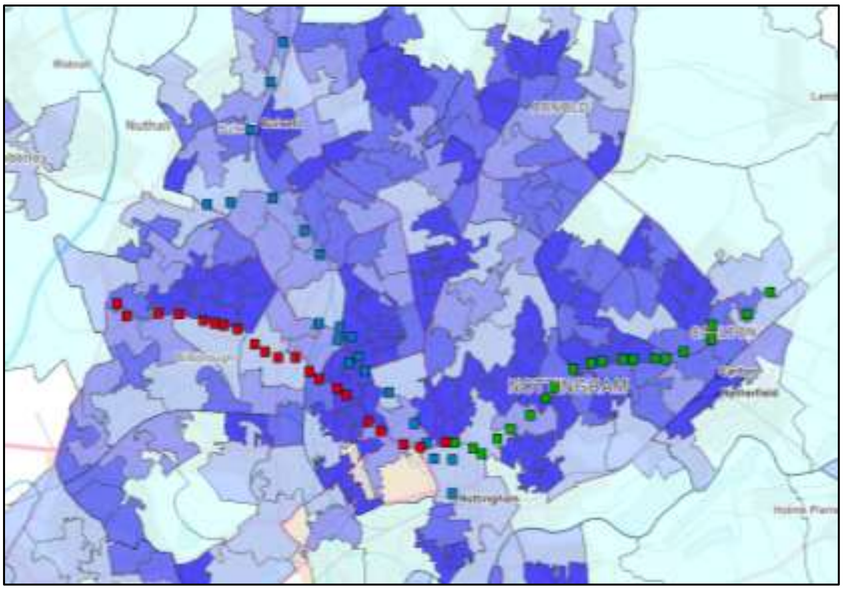
Based on the characteristics observed, there was an intuitive appeal to combining the more peripheral section of the Apsley Road corridor with the Carlton corridor in order to create a control area similar in overall makeup to the NET corridor. As can be seen in the table below, the aggregated control area was similar in population, density, employment and unemployment to the NET corridor in 2002, as well as possessing the shared IMD and residential density characteristics seen in Figures 3.3 and 3.4. We therefore have a reasonable comparator baseline against which to examine the short term post opening economic impact of NET Line One, Nottingham City Council suggested the Apsley Road and Carlton corridors were the the most appropriate controls from their perspective when consulted.

Table 3.1: NET Corridor versus Apsley Road/Carlton Control area - Key Characteristics Comparison - 2002

	Population	Population Density (ppha)	Claimants per head of Population	Total Employment (2003)
Control area	75,202	46.2	0.14	7,873
NET Corridor	78,341	46.5	0.14	8,152

Figure 3.3: Nottingham Built Area - IMD 1999-2002 Comparison (darker indicates higher IMD score)

Figure 3.4: Nottingham Built Area - Population Density Comparison (darker indicates higher population density)



3.3 Catchment Definition

The study areas were defined as all LSOAs having their population weighted centroid falling within the following radii around stops along the corridor:

- 1km – for all generator or resident based indicators; and
- 400m - for all attractor or employment based indicators.

These buffers were chosen based on prior research suggesting the majority of residential- and employment-based effects occur within those radii (SDG, 2005). The resulting selected catchment areas can be seen in Figures 3.5 and 3.6.

Figure 3.5: 1km NET Line One Corridor and Control area Catchments (Residential)

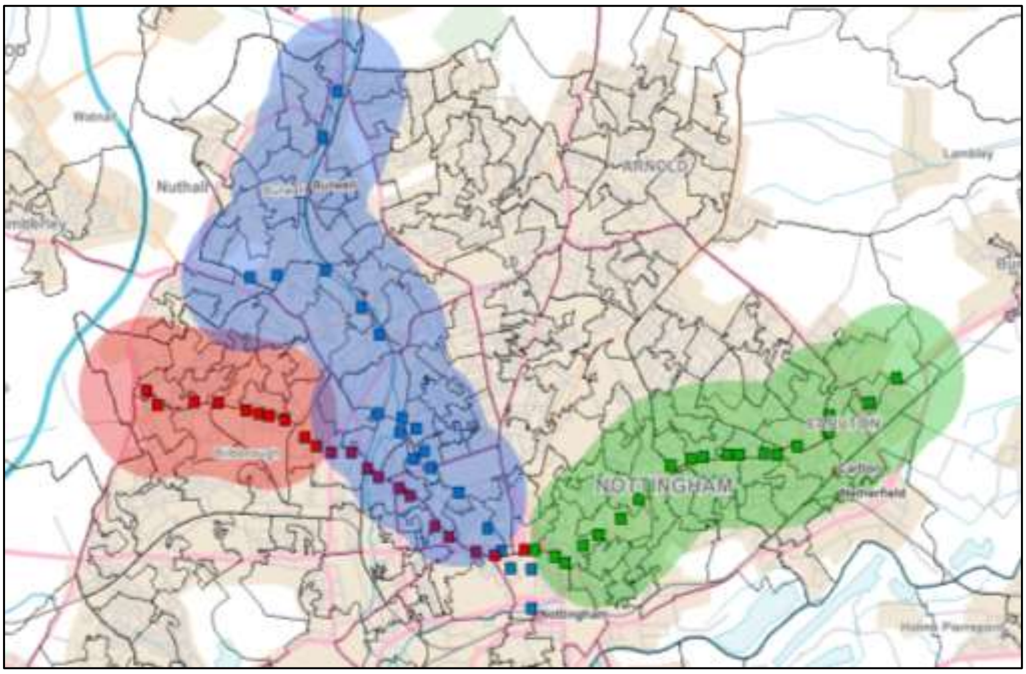
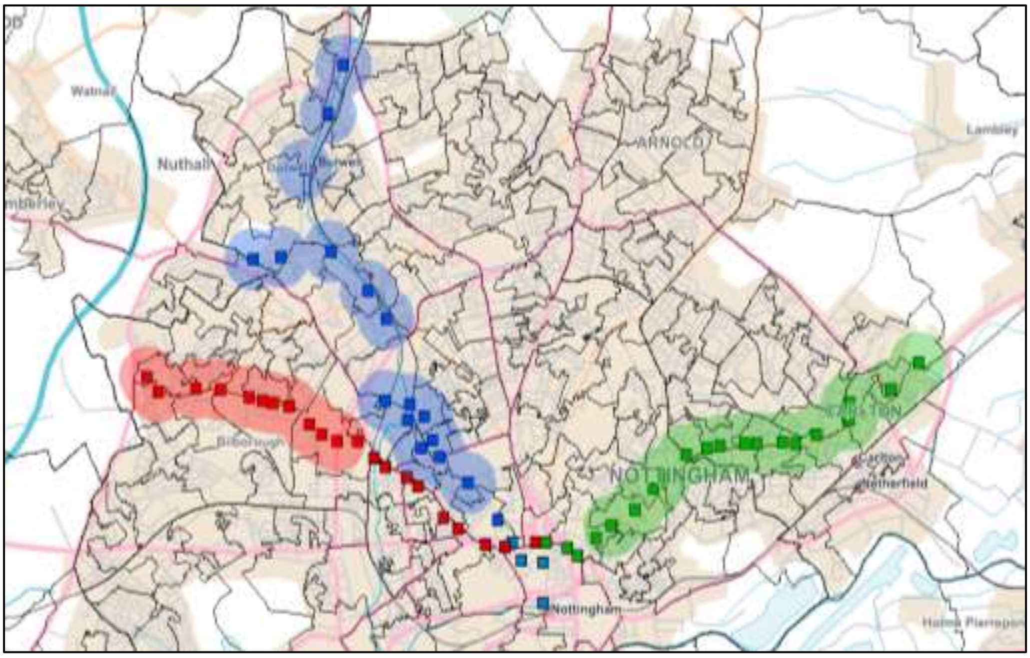


Figure 3.6: 400m NET Line One Corridor and Control area Catchments (Non-residential)



4 Results and Discussion

4.1 Labour Market

4.1.1 Employment

Table 4.1 below shows the number of employees working within 400m of a stop on the NET and control area corridors in 2003 and 2005.

Table 4.1: Change in Employment Comparison by Industry 2003-2005

400m Control area										
	Agricul ture	Energy and water	Manufactu ring	Constr-uction	Distribution, hotels and restaurants	Transport and comms	Banking, finance and insurance	Public Sector	Other services	Total
2003	4	1	383	949	1,907	205	667	3,344	413	7,873
2005	4	0	389	404	1,920	123	844	3,965	370	8,019
Diff	**0**	**-1**	**6**	**-545**	**13**	**-82**	**177**	**621**	**-43**	**146**
%	**0.0%**	**-100.0%**	**1.6%**	**-57.4%**	**0.7%**	**-40.0%**	**26.5%**	**18.6%**	**-10.4%**	**1.9%**
400m NET Corridor										
	Agricul ture	Energy and water	Manuf-acturing	Constr-uction	Distribution, hotels and restaurants	Transport and comms	Banking, finance and insurance	Public Sector	Other services	Total
2003	0	0	898	470	2,811	412	920	2,291	350	8,152
2005	1	0	869	438	3,121	474	997	2,814	385	9,099
Diff	**1**	**0**	**-29**	**-32**	**310**	**62**	**77**	**523**	**35**	**947**
%	**-**	**-**	**-3.2%**	**-6.8%**	**11.0%**	**15.0%**	**8.4%**	**22.8%**	**10.0%**	**11.6%**

There was markedly more labour market growth within 400m of a tram stop versus the control area between 2003 and 2005, with relative growth of 9.8% overall. This was driven in the first instance by higher growth in the distribution, hotels and restaurants sectors.

Transport and communications sectors (which at the time included IT industries) also see a large net increase compared to the control area. It should be noted that a major driver attenuating employment change in the control area is in the construction sector, where nearly 60% of employment has been lost.

Some changes might be due to the relocation or trading status of just one larger firm, which may or may not be independent of the tram. However, even excluding changes in construction employment, the tram corridor performs better than the control area. The results are therefore encouraging in that areas close to tram stops received a net increase in employment growth compared to the control area, which indicates an economic benefit.

It is likely that some of the increase in jobs is redistributed from other areas of Nottingham. As such, in the monetary evaluation in Section 5 I have assumed that only 50% of the increase is a genuine benefit to Nottingham.

4.1.2 People moving into and out of work

The level of Jobseekers allowance claimants was also examined as a proxy for unemployment. The NET corridor outperforms the control area, with a net reduction in unemployment of 1.7% seen between 2002 and 2005 over the control area (Table 4.2, overleaf). This indicator offers a broad comparison for the labour supply indicator ‘people moving into work’ from WebTAG Wider Impacts.

Table 4.2: Change in Number of Jobseekers Claimants 2002-2005

	2002	2005	Diff	Percent
Control area	10,865	10,790	-75	-0.7%
NET Corridor	10,660	10,400	-260	-2.4%

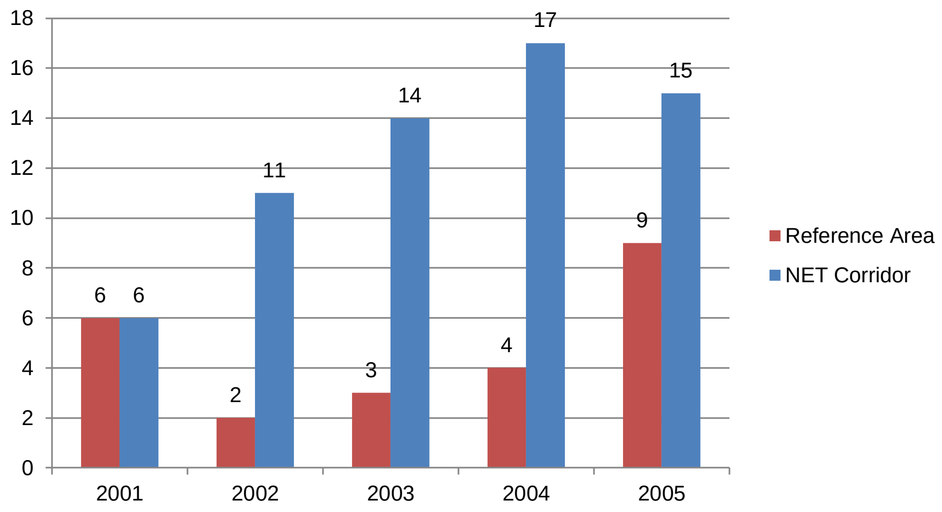
Again, while not all decreases can necessarily be directly attributed to the presence of the tram, it is particularly encouraging given the deprivation seen in areas outside of the city centre on the tram route.

4.2 Planning and Development

4.2.1 Major Residential Development

Figure 4.1 shows the number of planning applications submitted under the 'Major Dwellings' (10+) categorisation on the NET corridor and control area between 2001 and 2005. There appears to be consistently higher residential developer interest on the NET corridor in the years just prior to and immediately after scheme opening. While this may be in part due to a higher availability of developable land for residential purposes, it is suggestive of significant interest in inward investment and opening of new areas for development on the corridor, as a result of the tram scheme.

Figure 4.1: 1km Catchment Major Residential Development Applications Received 2001-2005

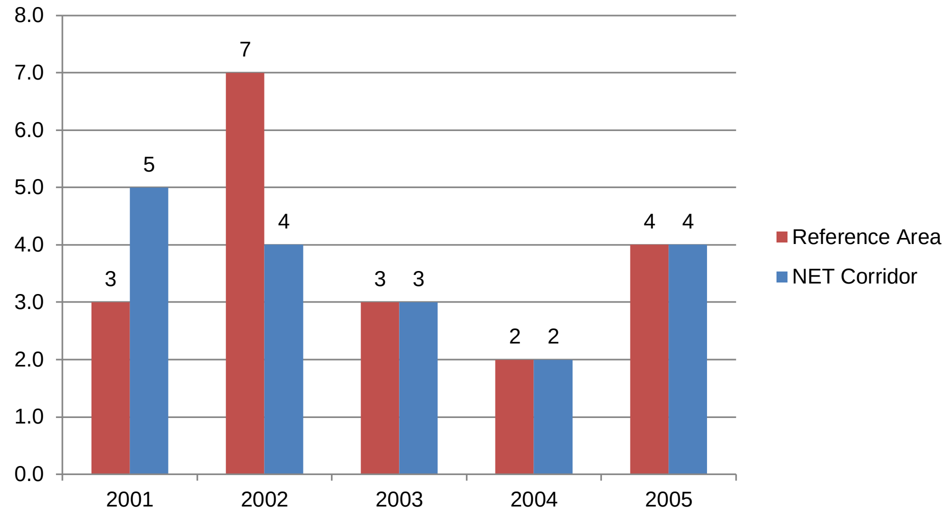


Prior qualitative analysis suggests that the tram had a critical determining impact on the decision to proceed with investment (NDA Consultants, 2007). A logical next step (with further resources) could be to investigate the number of completed properties produced as a result of this flurry of activity around the NET route.

4.2.2 Non-Residential Major Development

While the residential evidence is convincing, there is not a great difference in other (industrial, retail and other) major development (1km^2 or over) applications received over the observed construction/opening scheme period. Figure 4.2 demonstrates the similarity between the NET and control areas year by year.

Figure 4.2: 1km Catchment Non-Residential Major Development Applications Received 2001-2005



The large number of major residential development applications in the NET corridor may have suppressed the number of other major development application. In addition, interest in larger retail development might be more expected in central areas, such as Lace Market area which reportedly saw increases to retail and mixed use development (SDG 2005). Again, more detailed local knowledge, which is beyond the scope of this developmental case study, would be of value here.

4.3 Land Value and Property

4.3.1 Rateable Value

In the control area, the real total rateable value in the control area between 2002 and 2005 shows a slight reduction of 0.4%. While 'Other' purposes business space value increases sharply, Office space reduces in value. In addition, retail and industrial space values stagnate over the time period in real terms.

In the NET corridor, while industrial total rateable value similarly stagnates slightly, which makes intuitive sense given the backdrop of structural employment changes to service industries in the East Midlands, Retail, Office and Other uses all see comparatively robust growth in real rateable value.

Table 4.3: Total Rateable Value Comparison – NET Corridor versus Control area

400m Control area					
	Retail	Office	Industrial	Other	**Total**
2002	2,974	682	1,598	243	5,498
2005	2,914	519	1,577	466	5,475
Diff	**- 60**	**- 163**	**- 22**	**222**	**- 23**
%	**-2.0%**	**-24.0%**	**-1.4%**	**91.4%**	**-0.4%**
400m NET Corridor					
	Retail	Office	Industrial	Other	**Total**
2002	7,542	805	4,820	662	13,828
2005	7,702	906	4,737	798	14,142
Diff	**160**	**101**	**- 83**	**136**	**314**
%	**2.1%**	**12.6%**	**-1.7%**	**20.5%**	**2.3%**

While this data represents the total rateable value available, and not just in use, the differences seen between the NET corridor and control areas appear large. Caution should therefore be used in attributing the net increase entirely to the opening of the NET tram along the corridor. Derelictions or changes in use of significant sites could have large effects on changes in the totals, independent of the tram. Given more resources, further comparisons might be made at the business unit level which may allow any outliers to be investigated.

But there are indications that the opening of the tram in 2004 coincided with increases in business property values. It is also an important recommendation that this initial assessment is not conducted in isolation, but should be combined with measurements in the medium and longer terms in order to gain a full appreciation of the situation over time.

4.3.2 House Prices

A house price model was developed to examine the available evidence of an uplift or otherwise in the value of residential properties within a 1km catchment of a tram stop in the short term, controlling for other factors. Full details of the methodology can be found in Appendix 1.

The natural logarithm of change in average real property price paid at LSOA level was examined as the dependent variable, in three year intervals between 1996 and 2005. It is intuitive that house prices in cheaper or more expensive areas respond to other effects in proportional increments as opposed to in absolute values.

A panel dataset of all LSOAs within 1km of a tram or bus stop on the NET corridor and control area was examined. With 87 LSOAs and 352 total observations (in 1996, 1998, 2002 and 2005), it was felt that this presented a reasonable statistical basis for modelling. A first differences model was calibrated which looked at the change in average LSOA house prices between periods. This method also controls for time invariant unobserved variables.

The following explanatory variables at LSOA level were investigated for potential inclusion in the model:

- ‘Within 1km of a tram stop in 2005’ dummy variable.
- Proportion of new builds.
- Proportion of detached, semi-detached, terraced and flats house types.
- Proportion of lease/freeholds.
- IMD scores – multiple, living environment and crime.
- Population density.
- Bank lending base interest rate.

It was decided that only one of the house type proportion variables would be included due to concerns over multicollinearity. Additionally, the IMD scores were excluded due to their non-stationary nature over time (i.e. the presence of a stochastic trend in the data which can give rise to spurious regression models). All other variables were taken forward and tested in a series of calibrated first difference models. This model form was chosen to eliminate non-stationarity in the dependent variable. Significance of parameter estimate t-tests and overall model fits were used as a guide for the inclusion of variables. A lagged dependent variable was also included as a control for the effect of past changes in house prices.

The following final model was estimated, applicable to LSOAs on both the NET corridor and control area:

∆(Ln Average price paid) = 0.426 + 0.051*∆(within 1km of a tram stop) + 0.499*∆(Proportion of detached houses) + 0.262*∆(Proportion of new builds) – 0.124*∆(Ln Average price paid in previous time period)

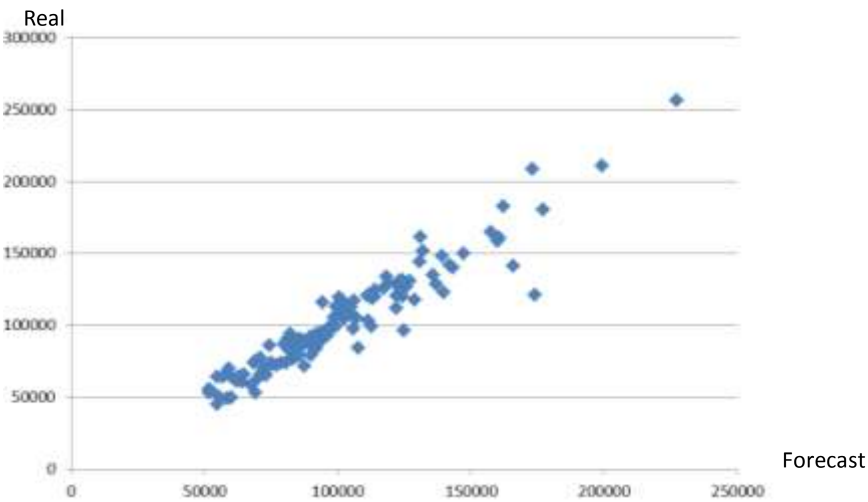
∆ = Change between time=t and time=t-1

The tram variable of this equation indicates that the average price of properties sold in LSOAs within 1km of a tram stop received a 5.1% uplift in price paid post opening, holding all else equal. This is an encouraging result, and supports prior evidence that the 'tram must add a "few percentage points" to the value of property in close proximity' (NDE Consultants, 2007).

Similarly if the proportion of detached houses sold increases by 10 percentage points, then the average price increases by 4.99%. Similarly an increase in the proportion of new builds sold of 10% would equate to a 2.62% increase in average prices. These results appear intuitive. The lagged dependent variable introduces a slight suppression proportional to the extent of growth in the previous period within the time series examined.

Figure 4.3 shows a graph of actual average price paid against the values predicted by the model, which shows a reasonable level of prediction accuracy.

Figure 4.3: Real versus Forecast House Prices – Final Model



This modelling therefore gives an initial indication of changes in average house prices in Nottingham in proximity to the tram. Applying this average increase in value to all properties within 1km of a tram stop on the defined corridor should enable us to estimate a simple order of magnitude of added value to the Nottingham housing market as a result of the scheme.

While the results are encouraging that the tram had a positive initial effect on the housing market, a short term evaluation cannot guarantee that market uplift is permanent. A time series analysis over a longer period would be required to draw conclusions about the medium to long term impacts.

The housing market, by all reports, became quite distorted during the recession. However, there is evidence to suggest that uplifts due to transport schemes and the connectivity they bring lie 'dormant' during times of economic stagnation, only to have a recurrent impact in the longer term when the macroeconomic environment is more favourable. This has been seen in Manchester Metrolink in the late 1990s, as has the corollary that a buoyant national and/or regional economy appears to be a precondition for local development growth (Mejia-Dorantes & Lucas, 2014). Therefore further analysis is recommended on NET post-recession.

5 Monetary Evaluation of Benefits

These investigations allow an estimate to be constructed, giving an order of magnitude of short term benefits of the NET Line One scheme, under some simplifying assumptions.

Government guidance provides standard multipliers which allow the level of additional employment benefit, less displacement and deadweight effects to be estimated from the gains found on the NET corridor in Section 5. This study assumes that the control corridor provides a deadweight scenario, while 50% of employment gains are assumed to be due to displacement.

It should be noted that there is no inclusion of agglomeration benefits or people moving to more or less productive jobs in this evaluation, which are a feature of WebTAG Wider Impacts ex-ante assessments.

The assumptions for average productivity per worker used are shown in Table 5.1.

Table 5.1: NET Evaluation Average Productivity per Worker Assumptions 2005

Nottingham GVA NUTS3 2005 (£m 2012 prices)	8,668
Nottingham Total Employment SOC 2005	122,800
GVA per worker 2005 (£ 2012 prices)	70,583

Source: ONS

Table 5.2 sets out the estimate calculation. These estimates exclude Hucknall and CBD effects.

Table 5.2: NET Short Term Evaluation

Added Value	Net Increase	Estimate (£m 2012 prices)	Jobs
<u>Multivariate</u>			
Property Market			
Housing Land Value (5.1% tram proximity uplift; 2001 census Nottingham pop/households = 2.30; NET corridor pop 2005– 79,929; implied households – 32,705; Avg NET corridor price paid 2005 - £143,138)	5.1%	240	
Multivariate Total		**<u>240</u>**	
<u>Control Area Comparisons</u>			
Labour Market			
New Employment Added Value 2005 (50% assumed redistributed from Nottingham)	9.8%	30	400
- Of which people moving into work (assumed 100% benefit to Nottingham)	1.7%	10	180
Property Market			
Business Rateable Value	2.7%	370	
Control Area Comparisons Total		**<u>400</u>**	

Total Short Term Evaluation Added Value Estimate		**640**	

The monetary evaluation of scheme impacts demonstrates property and labour market economic benefits of up to £640m. Based on a total scheme cost of £259m in 2012 prices, even if total benefits came out to be, say, half the estimated value, the impact of the scheme would be favourable. This estimate excludes further investigation into outliers for the rateable value comparison. On the other hand, several factors which are more difficult to measure, such as agglomeration benefits (which could be explored through further multivariate modelling), and those moving to more or less productive jobs are not represented here, which would likely provide further positive benefits.

While I do not have an estimate of forecast user benefits and there is uncertainty in this evaluation, the overall conclusion is that the wider economic benefits of NET Line One are significant compared with the scale of transport investment involved.

6 Assessment of Methodology

The methodology employed in this study has several fundamental strengths such as being:

- A transferable and consistent methodology.
- Use of control area comparisons are cost effective assuming that the level of systematic and selection biases can be minimised.
- A combined approach – combining quantitative and qualitative techniques with local knowledge in order to arrive at the best understanding and estimation of scheme impacts while minimising analysis costs.
- The methodology can be applied repeatedly to build up a picture of the economic impacts over time, which can then be considered within their macroeconomic context.

However further refinement is also possible and care must be taken to avoid a number of potential pitfalls such as:

- Sensible selection of control areas is essential to minimising systematic biases.
- Data quality issues. Care must be taken to select a time series without survey methodology discontinuities
- There remain things that are not easily evaluated due to the absence of appropriate measured variables (e.g. WebTAG move to more/less productive jobs).
- There is also the perennial problem of Additionality or attribution of effects. The assumption of control studies is that net benefits observed are additional. It is very difficult in practice, even when using a multivariate approach, to say for sure what would have happened were the transport investment not made in the first place.
- This methodology is not directly comparable with WebTAG estimates.
- Complex multivariate models require significant expertise and resource. This is where the trade-off between resources and analysis detail comes in to play.

7 Conclusions and Message to Government

This study presents a practical example of how an ex post evaluation of wider economic impacts might be conducted using available data sources, and employing a methodology that attempts to minimise the possibilities for bias. My conclusions are as follows:

1) Transport investment can create substantial wider economic benefits, probably in excess of the traditional user benefits and in excess of the wider economic benefits calculated by WebTAG.
2) I have demonstrated a basic methodology using readily available data sources for estimating the key wider economic benefits of any transport scheme.
3) If this type of methodology were to be applied to other schemes and over several time periods, we would build up an empirical data base of the wider economic benefits of transport investment.
4) This data base could be used to help refine the ex-ante scheme assessment process specified in WebTAG.
5) An enhanced understanding of the wider economic impacts of transport investment would assist Government, helping them to make more robust investment decisions, based on an improved understanding of the contribution to economic growth from transport infrastructure.

As a result of my study conclusions, my final message to the Government is as follows:

1) Pay more attention to understanding the wider economic effects of transport investment from as many schemes as possible; applying effort here would be well worthwhile.
2) There is increasingly detailed and available data to help assess these impacts which should be capitalised on.
3) Scheme impacts should be measured at every opportunity in order to help us understand these effects and guide future transport investment decisions.

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Appendices

Appendix 1 – House Price Model Methodology

A.1 Introduction

An econometric modelling exercise was conducted using available data averaged at LSOA level. Constructing the dataset as a (pseudo) panel would enable the use of techniques that would assist in accounting for time invariant missing variables. If a premium on house prices in proximity to the tram (once in operation) could be seen, this would enable inferences to be made on the housing market as a whole in the tram vicinity.

A.2 Study Area

All LSOAs whose population weighted centroid falls within a 1km radius of a tram stop on the defined NET study corridor or bus stops on the Apsley/Carlton control area were taken as the set of zones. This gave 87 LSOAs in total. Time series data was selected at a three year period to provide consistency with the short term evaluation period and covered 1996, 1999, 2002 and 2005.

The natural logarithm of Average real LSOA house prices was selected as the dependent variable. This has the advantage of enabling interpretation in percentage point changes which is more intuitive and arguably a more realistic response. The data was loaded as an unbalanced panel into eViews 8 (unbalanced as not all LSOAs in 1996 have houses sold and so there were some empty fields).

The following variables were investigated:

- Within 1km of a tram stop in 2005 dummy
- Proportion of new builds
- Proportion of detached, semi-detached, terraced and flats.
- Proportion of lease/freeholds
- IMD indices – living environment and crime
- Population density
- Bank lending base interest rate

A.3 Multicollinearity

A matrix of pairwise Pearson correlations is shown in Table A.3.1 below. House type proportions are highly correlated with one another as might be expected (all above 0.4). Deprivational indices also correlate highly with the proportion of detached and terraced houses, which is also an intuitive result. The possible effects of including these potentially multicollinear variables in a single model should therefore be taken into account.

Table A.3.1: Pearson Correlation Matrix of Independent Variables

Covariance Analysis: Ordinary
Date: 11/18/14 Time: 21:12
Sample (adjusted): 1996 2005
Included observations: 352 after adjustments
Pairwise samples (pairwise missing deletion)

Correlation Probability	1KM TRAM	DETACHED	FLAT	SEMI	TERRACED	NEW BUILD	POP DENSITY	CRIME IMD	LIVING ENV IMD
1KM TRAM	1.000000								

DETACHED	-0.120898	1.000000							
	0.0502	-----							
FLAT	0.030987	-0.091501	1.000000						
	0.6169	0.1389	-----						
SEMI	0.011226	0.064502	-0.253241	1.000000					
	0.8562	0.2973	0.0000	-----					
TERRACED	0.061324	-0.690215	-0.211052	-0.622881	1.000000				
	0.3218	0.0000	0.0006	0.0000	-----				
NEWBUILD	0.070190	0.040767	0.473862	-0.099327	-0.172089	1.000000			
	0.2567	0.5104	0.0000	0.1080	0.0051	-----			
POPDENSITY	0.015983	-0.383232	-0.060628	-0.322360	0.513570	-0.109286	1.000000		
	0.7960	0.0000	0.3274	0.0000	0.0000	0.0769	-----		
CRIME_IMD	0.233846	-0.564814	0.128033	-0.125478	0.399859	0.088469	0.114987	1.000000	
	0.0018	0.0000	0.0913	0.0980	0.0000	0.2443	0.1286	-----	
LIVING_ENV_IMD	-0.078405	-0.554860	0.045290	-0.334591	0.581887	-0.072449	0.458536	0.577345	1.000000
	0.3010	0.0000	0.5517	0.0000	0.0000	0.3407	0.0000	0.0000	-----

A.4 Stationarity and Autocorrelation

Each variable was tested for temporal non-stationarity using correlograms in eViews. Both IMD indices were found to be non-stationary. At this point it was decided to exclude the multiple deprivation indices from further analysis as panel data techniques for non-stationary explanatory variables were too time intensive for this study. As might be expected from price data (even though basic price inflation had been accounted for), the dependent variable was also non-stationary. This can be seen in the large partial autocorrelations between time periods in Table A.4.1.

Table A.4.1: Ln_Houseprice Correlogram

Date: 10/12/14 Time: 01:33						
Sample: 1996 2005						
Included observations: 302						
Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
.|** |	.|** |	1	0.339	0.339	35.024	0
*|. |	**|. |	2	-0.116	-0.26	39.111	0
.|. |	.|* |	3	-0.059	0.096	40.171	0

First differences were therefore taken in an attempt to 'difference' out the non-stationary element. As can be seen from the correlogram outputs in Table A.4.2, the partial autocorrelations disappear and the Q-test statistic is no longer significant against a null hypothesis of no autocorrelation.

Table A.4.2: Ln_Houseprice First Differences Correlogram

Date: 10/12/14 Time: 01:31						
Sample: 1996 2005						
Included observations: 213						
Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
*|. |	*|. |	1	-0.11	-0.11	2.5949	0.107
.|. |	.|. |	2	-0.052	-0.065	3.1878	0.203

Therefore a first differences model form was taken forward in preference of pooled ordinary least squares or fixed/random effects approaches, with a lagged dependent variable term included. First differences models have the advantage of cancelling out all time invariant factors, which it was hoped would go some way towards accounting for some unobserved effects. A lagged dependent variable was also included as a control for the effect of past changes in house prices.

A.5 Heteroskedasticity

PCSE weights were used to ensure standard errors were robust to heteroskedasticity.

A.6 Modelling Results

Several models were then calibrated, and all non-significant variables removed. Signs of collinearity between house types (parameter values changing drastically) meant only the single most significant house type variable was retained. The removal or addition of other variables saw no coefficients change drastically: this was encouraging, indicating no obvious further presence of multicollinearity. The eViews output of the final model is shown in Table A.6.1 below.

Table A.6.1: Average Change in Ln_Houseprice Final Model

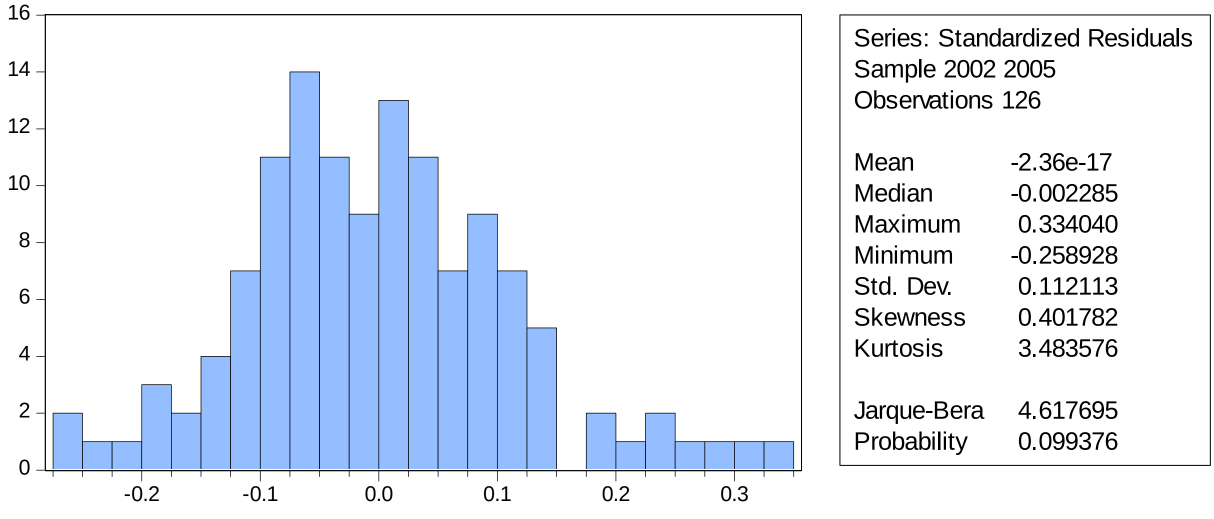
Dependent Variable: D(LN_PRICEPAID)		

Method: Panel Least Squares				
Date: 10/12/14 Time: 01:18				
Sample (adjusted): 2002 2005				
Periods included: 2				
Cross-sections included: 87				
Total panel (unbalanced) observations: 126				
Cross-section weights (PCSE) standard errors & covariance (d.f. corrected)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(_1KM_TRAM_Corridor)	0.050701	0.017788	2.850237	0.0051
D(DETACHED)	0.498407	0.119402	4.174206	0.0001
D(NEWBUILD)	0.261549	0.075675	3.456232	0.0008
D(LN_PRICEPAID(-1))	-0.12368	0.052595	-2.35164	0.0203
C	0.42559	0.015364	27.70101	0
R-squared	0.378363	Mean dependent var		0.40398
Adjusted R-squared	0.357813	S.D. dependent var		0.121231
S.E. of regression	0.097151	Akaike info criterion		-1.78624
Sum squared resid	1.142027	Schwarz criterion		-1.67368
Log likelihood	117.5328	Hannan-Quinn criter.		-1.74051
F-statistic	18.41184	Durbin-Watson stat		1.668016
Prob(F-statistic)	0			

This model has a fairly reasonable adjusted R^2 value; it explains 35.8% of variation seen. As can also be seen, LSOAs on the tram corridor see an increase of 5.1% to the increase in average house prices from 2002 to 2005. This is significant to the p<0.01 level. A higher proportion of new build housing also results in higher house prices. Detached housing is also, as expected, significantly more expensive than other housing types on average. The lagged dependent variable introduces a slight suppression proportional to the extent of growth in the previous period within the time series examined.

Residuals were also tested for normality and the Jarque-Bera test p-value of 0.1 means we cannot reject the null hypothesis of zero skewness and zero excess kurtosis at the 5% level. Normally distributed residuals are a key assumption for unbiased parameter estimates.

Figure A.6.1: Normality Test – Final Model



A.7 Forecasting

Lastly, a forecast of house prices was compared with actual average price paid data, giving a reasonably small mean absolute prediction error of 7.6% as can be seen in Table A.7.1. Forecast versus actual house prices are also plotted in Figure A.7.1 below where we can observe an acceptable level of prediction accuracy.

Figure A.7.1: Real versus Forecast House Prices – Final Model

Real

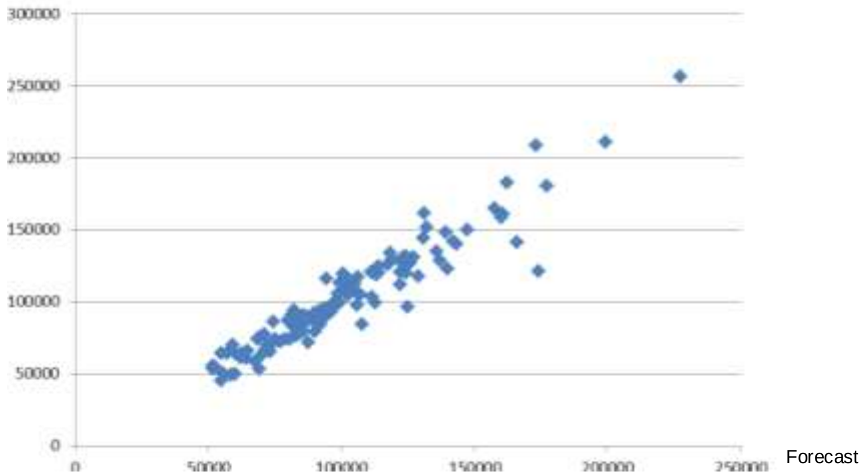


Table A.7.1: Final Model Forecast Outputs

Forecast: LN_PRICEPAF	
Actual: LN_PRICEPAID	
Forecast sample: 1996 2005	
Adjusted sample: 2002 2005	
Included observations: 126	
Root Mean Squared Error	0.099908
Mean Absolute Error	0.076108
Mean Abs. Percent Error	0.663806
Theil Inequality Coefficient	0.004348
Bias Proportion	0.000731
Variance Proportion	0.057235
Covariance Proportion	0.942033