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# Evaluating the effects of the M6 Toll Road on industrial land development and employment

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## Abstract

This paper reports the first evaluation of the wider economic effects of the M6 Toll, the UK’s first toll motorway. Methodologically, it contributes to the literature evaluating the economic effects of new transport infrastructure by exploiting a new source of data, applying fresh econometric techniques, and triangulating quantitative results with interview data. We conclude that the M6 Toll has caused a positive development effect at the sub-regional level. In addition, we advance reasons why the development potential of new road infrastructure may be amplified rather than reduced by tolls.

## Keywords:

M6 Toll Motorway; transport infrastructure; industrial land development; wider economic benefits; evaluation; additionality and displacement.

**JEL classification:** R11; R33; R42.

## Introduction

The M6 Toll is the UK's first toll motorway. The explicit aim of the M6 Toll is illustrated by its former name, the Birmingham Northern Relief Road. The aim of the road is to cut congestion around the Birmingham area and to facilitate inter-urban travel by providing a new 27 mile route. However, although the explicit aim was to facilitate through transport, the development potential of the scheme became an issue for political debate. As a through route there is little justification for a high density of junctions. However, in its final form the M6 Toll has eight junctions that have had a major impact on the accessibility and hence development of industrial land sites in the surrounding area.

This paper reports an evaluation of the impact of the M6 Toll on economic development in the southern Staffordshire sub region. (Figure 1 shows the route of the M6 Toll together with the six districts that comprise southern Staffordshire.) This paper's wider contribution is to evaluating the potential economic impact of toll roads, which may be the future form of motorway development in the UK. In the UK, the need for such evaluation has been highlighted in discussions on the M6 Toll by the House of Commons Select Committee on Transport (2005, Paragraphs 89-90): 'These impacts must be fully evaluated ... before other projects of this sort are undertaken'. This paper also contributes to a wider policy debate initiated by the Scottish Executive's Transport Research Planning Group: '... the potential ability of transport infrastructure investments to produce transport benefits ... is not questioned. The debate is over whether there are additional benefits from these investments' (GVA Grimley, 2004, p.3; also p.65). For reasons of space, this paper does not directly address the broader literatures and policy debates surrounding the economic impact of

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3 infrastructure – especially roads - and public investment policy (Gramlich, 1994),  
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5 road infrastructure and regional development (OECD, 2002), or wider land use  
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7 changes, social inclusion and ecological impacts (Spellerberg, 1998). Yet, by  
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9 reporting an ex post study of the wider economic effects of a new road, this paper  
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11 does contribute to the evidence base of these broader literatures and contentious  
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19 We contribute to the understanding and measurement of the additional economic  
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21 benefits of transport infrastructure by applying econometric techniques not previously  
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23 used in this literature to analyse previously neglected “before” and “after” data on the  
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25 development of industrial land sites in the M6 Toll corridor. In addition, we  
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27 “triangulate” the quantitative analysis with interview data and present a simple  
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29 method for calculating the present value of development associated with the M6 Toll.  
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31 Data limitations mean that attention is restricted to the development impact of the M6  
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33 Toll on industrial land sites in southern Staffordshire (see Figure 1).<sup>1</sup> Moreover, this  
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35 paper does not address environmental or social exclusion agendas and thus takes no  
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37 account of potential negative externalities caused by the M6 Toll. Accordingly, this  
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39 paper focuses only on positive externalities and is thus just one contribution to a  
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41 comprehensive evaluation of M6 Toll effects.  
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51 The paper proceeds as follows. The next Section reviews the literature, considers the  
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53 implications of toll charges for the development effects of new roads, and explains  
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55 our empirical methodology. Section 3 describes the data, the model and the  
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57 econometric methods. Section 4 reports and discusses the estimated M6 Toll effects  
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59 on industrial land development and translates these into employment and output  
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effects. Section 5 investigates the validity of our econometric results. Section 6 concludes.

**Figure 1: The M6 Toll and industrial land (development) sites in the southern Staffordshire sub region**

Source: Crown Copyright; GVA Grimley (2003) for site drivetimes

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## Literature review and methodology

Analytic and empirical research on the additional economic benefits of transport infrastructure is dominated by North American studies, while the smaller evidence base from UK and European studies is weakened by less frequent use of time series data for “before and after” studies (GVA Grimley, 2004, p.9; see also Llewelyn-Davies et al., 2004, pp.2 and 24, and SACTRA, 1999, p.214). Indeed, according to SACTRA (1999, pp.223 and 225), most assessments of transport projects in the UK are ‘*ex-ante* ... undertaken on a commercial basis for scheme promoters and are not typically in the public domain’; there are few ‘good examples of *ex-post* evaluation studies which would reveal the economic impacts of transport interventions’. In particular, the ‘state of the art’ of ‘specific local studies ... is poorly developed and the results do not offer convincing general evidence of the size, nature or direction of local economic impacts’ (SACTRA, 1999, p.7). Moreover, the literature concerning the impact of major roads is still narrower (GVA Grimley, 2004, pp.66-68 and 106) and results are ‘disputed’ (Llewelyn-Davies et al., 2004, pp.21; Holvad and Preston, 2005, p.18). More than 30 years ago, Dodgson (1974, p.76) reviewed cost-benefit analyses of inter-urban road investments and concluded that ‘the techniques for

measuring the benefits to traffic of such investments have been continuously extended and sharpened’. However,

when we come to consider the effects of inter-urban road investment on regional development ... it is far from clear how these benefits, other than those in the form of traffic benefits to residents of such regions, can be measured.

More than 20 years later, Linneker and Spence (1996, p.79) concluded similarly that ‘there is no general agreement on the relevant framework or appropriate methodology for evaluating the economic development implications of major road investments’.

In a recent literature review on the additional economic benefits of road projects, Holvad and Preston (2005, p.19) conclude that ‘the most realistic studies so far have been ex-ante appraisals’ and ‘suggest that an alternative approach might be an ex post evaluation of the economic impacts of a major transport infrastructure’. Holvad and Preston (2005, pp.16-17) identify 22 ex post studies that examine links between road infrastructure and local economic development. Nine are from the UK, and date back as far as 1973.<sup>2</sup> Of these, six studies summarise the effects on employment or other substantive development measures as “small” (or similar descriptor) and two as “substantial”. Of these six, Linneker and Spence (1996, p.89) is representative in finding that ‘the construction of the M25 (pure road effect on accessibility) is positively related to demand for labour’. However, Holvad and Preston (2005) find that there are still no studies of the long-term additional economic benefits of UK motorway infrastructure.

Most narrow in the literature is published empirical analysis of the economic impact of toll roads, which is limited to a single study of two toll roads in Orange County, California: Boarnet and Chalermpong (2001, p.600) find that construction of these roads ‘created accessibility premiums that are reflected in home sales prices’.

This brief literature review suggests that the present paper is slightly unusual in that it examines both a new infrastructure investment and one that is being delivered in a different way from earlier examples in the UK, namely through a user pays toll. This raises questions about the separation of the infrastructure effect from the toll effect and, hence, about the generality of the results. There are insufficient comparable studies to enable an empirically based identification of toll effects separately from infrastructural effects. Consequently, we apply some theoretical reasoning to address both this issue and the associated issue of drawing wider implications from this study.

From the law of demand, we deduce that as the price (toll) rises so commercial road use and associated development benefits fall. (At the limit, as tolls rise, use and development effects must eventually fall to zero.) Yet, the adverse effects of congestion imply that decongestion, through increasing reliability with respect to journey times and costs, may have a positive effect on commercial road use and associated development. In this case, tolls reduce road use, increase reliability and so favour development. Accordingly, we hypothesise that tolls give rise to offsetting effects on commercial users and, hence, on development: a directly negative price effect; and an indirectly positive decongestion or “reliability” effect. This observation has implications for our ability to generalise the results of this study. *If congestion is not an issue* then indirect reliability effects are not economically significant, in which



case a toll-free motorway will maximise transport and wider development benefits. Conversely, *if congestion is an issue* then reliability effects suggest that a toll may increase transport and wider development benefits so long as the marginal cost of the toll is outweighed by the marginal benefit of reliability. Because of offsetting direct and indirect effects, theory cannot determine whether the transport and wider development benefits of a toll road are more or less than those of a non-toll road. The corollary is that we should be cautious in generalising the results of this study, especially to non-toll road developments. However, we can set out some principles.

If congestion is not an issue, then development effects estimated from a toll road study are likely to *understate* the potential development effects of a similar non-toll road. Conversely, congestion implies reliability effects, in which case tolls may have a positive development effect. Hence, if congestion is an issue, development effects estimated from a toll road study may *overstate* potential development effects if generalised to a similar non-toll road. Accordingly, because the possibility of significant congestion on the new road is suggested both by the particular experience of the M6 (House of Commons Select Committee on Transport, 2005, paragraph 84) and by evidence that new roads in general “induce” traffic (Noland and Lem, 2002), tolls may well have increased development relative to the counterfactual of the new road being conventionally toll free.

Where land is readily available for development, it is easy for developers to bring new land to market after an increase in demand (Federal Reserve Bank of San Francisco, 2001). Accordingly, adjustment to improved location and correspondingly increased demand occurs not only through price change but also through quantity change. The

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implication for empirical strategy is that we expect to see locational improvements created by the M6 Toll reflected both in property prices and in the pace of physical development. In this evaluation, because there is no suitable price data for commercial property or land, we exploit data on the physical development of industrial land sites.

Our empirical approach is to treat the M6 Toll as a “natural experiment” (Wooldridge, 2002, p.129). We distinguish a *treatment* group (sites whose accessibility is hypothesised to be changed by the M6 Toll) and a *control* group (sites whose accessibility is unchanged). We can then identify and measure the impact of the announcement or completion of the M6 Toll by analysing site development for both groups in periods *before* and *after* this M6 Toll “event”.

To test the maintained hypothesis that the M6 Toll has a positive effect on the development of industrial land sites, together with the alternative hypotheses that the M6 Toll has either an indeterminate or a negative effect, we need data on the developments of industrial land sites

1. for two periods, *before* and *after* the M6 Toll, and
2. for two groups, a *control* group and a *treatment* group.

Unfortunately, neither theory nor the small empirical literature gives precise guidance for defining either periods or groups (i.e., geographic zones defined in relation to the M6 Toll). The rest of this Section discusses how we operationalise these crucial distinctions.

To define before and after periods, we have to hypothesise a “threshold period”, before which there are no M6 Toll effects and during and/or after which such effects become apparent. The history of the M6 Toll is outlined in Figure 2.

**Figure 2: History of the development of the M6 Toll Motorway**

Periods before and after the M6 Toll cannot necessarily be separated by the time of completion/opening. In theory, anticipation of the M6 Toll may affect property markets via speculative motives. Moreover, there is empirical evidence for such “expectation effects” (SACTRA, 1999, p.224; Boarnet and Chalermpong, 2001). Accordingly, the “before” period must not only be one during which the M6 Toll did not exist but also one in which it was not definitely happening. In any case, the threshold period cannot be determined by theoretical reasoning; rather, it is chosen by a mixture of investigating the history of the M6 Toll, consultation with practitioners in local authorities and the business community, and our own empirical results (use of the latter to refine choice of the threshold period follows Boarnet and Chalermpong, 2001). Legal challenges to the M6 Toll were finally rejected by the Appeal Court in 1999, uncertainties over construction finance and the compulsory purchase of land were resolved during 2000, and construction began in 2001. Moreover, without exception, practitioner opinion was that actual development decisions were undertaken only *after construction began* in 2001. However, both decisions and implementation occurred with lags. Accordingly, our preferred “threshold period” excludes data from April 1<sup>st</sup> 2000 to March 31<sup>st</sup> 2002 from both the “before” and “after” periods.

Neither is the definition of control and treatment areas straightforward (GVA Grimley, 2004, p.87). In principle, these correspond to geographic areas in which the M6 Toll has no or negligible influence on property markets and others in which the M6 Toll does exert a significant effect. Control and treatment areas must be chosen to be as similar as possible in all respects other than the influence of the M6 Toll. Here we have a trade-off between the need to achieve the strongest possible contrast in M6 Toll effects, which can be achieved by comparing locations close to and distant from the M6 Toll, and the need to achieve the greatest possible similarity between the locations in other respects, which suggests choosing areas that are close to each other. We deal with the trade-off between separation and similarity by grouping developments into “zones”, defined by increasing drivetime from access to the M6 Toll (Boarnet and Chalermpong, 2001; Cervero and Duncan, 2002).<sup>3</sup> We follow the practitioner convention of grouping development sites within the M6 Toll Corridor into those within 5-minutes, 10-minutes and 15-minutes drivetime of an M6 Toll junction (*InStaffs*, 2003; GVA Grimley, 2003). This weights the terms of the trade-off between variable distance to the M6 Toll and closeness, hence similarity, of the bands towards the criterion of closeness. By maximising the similarities between sites in all respects other than the influence of the M6 Toll, we minimise the possibility that results are biased by unobserved systematic - confounding - influences. This procedure also tends to increase the difficulty of finding systematic differences between developments in the three bands and thus tends to bias our results away from our maintained hypothesis rather than towards it.

# Data, model and method of estimation

## The data

We investigated the whole population of industrial land sites within the Staffordshire part of the M6 Toll corridor. Our source of data on these 18 sites is Staffordshire County Council’s annual *Staffordshire Employment Land Availability Survey* (henceforth, *Survey*) published continuously from 1994 to 2004 and detailing the situation on March 31st of the year of publication.<sup>4</sup> This source enabled compilation of a longitudinal (panel) dataset on the development of each of the 18 sites over an 11 year period, which enables a clean separation of our “before” period (1994-2000; i.e., data from April 1<sup>st</sup> 1993 to March 31<sup>st</sup> 2000) from our “after” period (2003-2004; i.e., data from April 1<sup>st</sup> 2002 to March 31<sup>st</sup> 2004). Altogether, the dataset contains 197 observations (i.e., 18 sites × 11 years minus one site lacking data for 1994). Each year contains data on the variables in our model (see below). Unfortunately, the *Survey* contains no value - price or rental - data.

## The model

The following model sets out the variables required to implement the natural experiment methodology described in the previous section (Wooldridge, 2002, pp.129-30). The 18 industrial land sites are indexed by subscript *i* (*i*=1,..., 18); and the 11 years in the sample period are indexed by subscript *t* (*t*=1994,..., 2004).

$$\begin{aligned} Development_{it} = & Intercept + \sum Year\_DVs + \sum District\_DVs \\ & + 5\ min\ Zone_{Before} + 5\ min\ Zone_{After} \\ & + 10\ min\ Zone_{Before} + 10\ min\ Zone_{After} \\ & + 15\ min\ Zone_{Before} + 15\ min\ Zone_{After} + (u_i + \varepsilon_{it}) \end{aligned}$$

The dependent variable ( $Development_{it}$ ) is actual development in hectares on site  $i$  in year  $t$ . The model relates actual development to a constant term (*Intercept*) and to the following independent variables.

- $\Sigma Year\_DVs$  denotes dummy variables for each year, 1995-2004. These control for period-specific influences that do not vary between locations. Hence, these control for general but time-specific influences on development such as the property cycle, changes in economic conditions within southern Staffordshire, and changes in the planning regime.
- $\Sigma District\_DVs$  denotes dummy variables that control for influences specific to each of five districts of southern Staffordshire relative to Cannock (the reference district). These variables control for district-specific influences that do not change substantially over time, including different patterns of economic development and/or structure and differing mixes of greenfield and brownfield sites (*Survey*, 1998, p.14 and *Survey*, 2004, p.17).
- Six dummy variables for all sites in the three drivetime zones in both “before” and “after” periods: “before” ( $5MinZone_{Before}$ ) and “after” ( $5MinZone_{After}$ ) M6 Toll effects in the 5-minute zone; “before” ( $10MinZone_{Before}$ ) and “after” ( $10MinZone_{After}$ ) M6 Toll effects in the 10-minute zone; and “before” ( $15MinZone_{Before}$ ) and “after” ( $15MinZone_{After}$ ) M6 Toll effects in the 15-minute zone.
- $(u_i + \varepsilon_{it})$  is a composed error term. The  $u_i$  control for unobserved site-specific heterogeneity.  $\varepsilon_{it}$  is the usual white-noise error term.

In addition, we follow conventional practice and augment these required variables with additional covariates. Total land available (*total*) controls for variations in the size of the site. Supply-side factors influence development at the time of decision

making rather than during the period of construction or completion. Accordingly, this variable is lagged by two years. Land readily available (*readily*) - i.e., ‘no major off-site access, drainage or service impediments to development’; *Survey*, 1994, p.4 - controls for supply constraints that may be both site specific and time specific. This variable is also lagged by two years, for the same reason as “total”. Finally, we included a dummy variable to control for ownership of the site (i.e., whether private or public sector).

Our variables of interest are the six dummy variables for all sites in the three drivetime zones in both “before” and “after” periods. According to the design of our natural experiment, estimates of all three “before” dummy variables should indicate zero M6 Toll effects.<sup>5</sup> Conversely, the three “after” variables measure the effect of the M6 Toll in 2003 and 2004 on the quantity of industrial land developed within the 5-, 10-, and 15-minute drivetime zones respectively. If the hypothesised positive M6 Toll effect is present in the data, then we expect a positive and statistically significant effect within the 5-minute zone and successively smaller effects - if any - in the 10- and 15-minute zones.

We estimate two slightly different versions of our model. In Variant 1, two dummy variables are included for the Stafford district (“stafford”): one for the period “before” the M6 Toll (1994-2000) (*Stafford<sub>Before</sub>*); and one for the two years “after” the M6 Toll (2003-04) (*Stafford<sub>After</sub>*). All three of the Stafford sites are within five minutes drivetime of Junction 14 on the M6 Motorway, which continues northwards from the M6 Toll (see Figure 1). Moreover, the rationale for the M6 Toll was to relieve congestion on the M6 (House of Commons Select Committee on Transport, 2005,

paragraph 84). Accordingly, the M6 Toll and the M6 are not independent, which precludes use of the M6 corridor as a “control corridor”. Unfortunately, no suitable control corridor exists within southern Staffordshire. Instead, Variant 1 allows us to test a supplementary hypothesis; namely, that the M6 Toll may exert positive *indirect* effects on sites located along roads with which it is continuous. Moreover, by estimating both Variant 1 and Variant 2, which includes “before” and “after” dummy variables for *all* sites in the 15-minute drivetime zone, we can compare the “before” and “after” M6 Toll effects in the Stafford sites with those in the 15-minute drivetime zone generally. Positive effects in the former and zero (or, at least, smaller) effects in the latter would be consistent with the supplementary hypothesis of *indirect* M6 Toll effects (on such indirect benefits, see Rand Europe, 2004).

### *Method of estimation*

Developers do not necessarily bring sites to market in each period, while potential clients require new sites only at infrequent intervals. Accordingly, the market outcome of this behaviour for development at particular locations is often zero, but when development does take place its extent varies. On the 18 sites in this study, from 197 possible observations on the dependent variable, 145 are zero; the 52 observations of construction range between 0.14 and 20.68 hectares. For a dependent variable with this structure, we require a “tobit” model (Wooldridge, 2002, pp.518-19; see also Greene, 2003, p.778).

In our tobit model, the estimated coefficients reveal whether the independent variables affect the dependent variable positively or negatively. However, these relationships are best quantified by two “marginal” effects (Wooldridge, 2002, pp.520-21). In our model, for changes in the values of the independent variables, “conditional” effects



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3 estimate changes in the expected (or predicted) value of construction *for those sites on*  
4 *which construction is observed*; and “unconditional” effects account, in addition, for  
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6 the effect of changing values of the independent variables on *the probability that*  
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8 *development will take place at all* (i.e., will change from zero to positive and thus  
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10 observable). Unconditional effects should be larger than conditional effects, because  
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12 they account both for changes in the conditional expectation of construction on sites  
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14 where it is observed and for changes in the probability that construction will take  
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16 place at all.<sup>6</sup>  
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25 To exploit the full potential of our panel data, we first estimated our model by  
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27 random-effects (RE) tobit regression. RE estimation not only exploits the full  
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29 potential of the panel dataset, by taking into account both between-site variation and  
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31 within-site variation over time, but also controls for unobserved site-specific  
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33 influences that do not change substantially over time. Among such unobserved  
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35 influences might be accessibility with respect to labour and suppliers; density and  
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37 type of surrounding land use; neighbourhood quality; and whether the site is  
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39 greenfield or brownfield. Together with the selection of sites and dummy variables for  
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41 district effects and time effects, the structure of the econometric model thus helps to  
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43 control for potentially confounding influences.  
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51 Our estimation method does not control for the possibility that site developments in  
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53 each of our three drivetime zones are spatially correlated with developments in other  
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55 zones. Accordingly, we risk attributing the effects of spatial dependency to our  
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57 independent variables, thereby overestimating our M6 Toll effects. Unfortunately,  
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59 even in the spatial econometrics literature, tobit estimation in the presence of spatial  
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dependency has been ‘relatively neglected’ (LeSage and Pace, 2004, p.128; see also Flores-Lagunes and Schnier, 2004). However, recent experimental evidence (LeSage and Pace, 2004, p.117) suggests that in the context of tobit estimation even ‘strong spatial dependence’ typically inflates coefficient estimates by no more than 20 percent. Accordingly, we acknowledge the possibility of a small upward bias in our estimated M6 Toll effects.

## Results

This section reports quantitative estimates of M6 Toll effects on industrial land development. The first subsection explains how we implemented tobit estimation to obtain the results set out in Tables 1 and 2; the second interprets these estimates; and the third uses these estimates to calculate the employment effect of the development associated with the M6 Toll.

### *Implementation*

The model is estimated in two variants: Table 1 reports Variant 1 with “before” and “after” dummy variables for the Stafford sites; and Table 2 reports Variant 2 with “before” and “after” dummy variables for all sites in the 15-minute drivetime zone (i.e., including the Stafford sites).

Random effects estimates are reported for both variants of the model. However, in both cases a likelihood ratio test overwhelmingly supports the null hypothesis that the random effects are not significant ( $\sigma_u = 0$ ) (Gutierrez, et al., 2001; StataCorp, 2003, p.234). Because unobserved site-specific heterogeneity is not a significant influence on the dependent variable, the tobit panel estimator is not different from the tobit pooled estimator (StataCorp, 2003, p.234). Although the pooled estimator does

not control for unobserved site-specific heterogeneity, it does enable us to exploit our panel data by estimating both dynamic effects (by lagging variables) and “before and after” effects for the same sites (Wooldridge, 2002, pp.129 and 169-170). Accordingly, we report the estimated coefficients from the pooled estimator together with the unconditional and conditional marginal effects for both Variant 1 and Variant 2.

We followed the standard “testing down” procedure. First, for both Variants 1 and 2, we estimated a model with all possible variables suggested by theory and available in the dataset. Secondly, we deleted insignificant variables: the estimated time effects (year dummy variables) proved statistically insignificant both individually and jointly ( $p=0.68$  for the test of joint significance); and the ownership of sites (i.e., public or private sector) proved not to be a significant influence.<sup>7</sup> Accordingly, we arrive at the parsimonious models reported in Tables 1 and 2.

**Table 1: Variant 1**

**Table 2: Variant 2**

***Interpretation of the results***

Tables 1 and 2 report estimated coefficients and marginal effects. The pattern of statistically significant results suggests the following quantitative conclusions.<sup>8</sup>

1. Strictly, “Total land” availability (i.e., the size of the site) is not a statistically significant influence on the development of industrial land. However, the estimated coefficients and marginal effects consistently achieved “borderline”

levels of significance (just outside 10 percent). The marginal effects suggest a very small positive effect of the size of the site on its development.

2. The quantity of land “readily available” on a site is a statistically significant influence: an increase in available land of one hectare increases - on average - development by one-twenty fifth of a hectare. As expected, the more readily available land on the site, the less the supply-side constraint and the more development.
3. Many district effects achieve borderline statistical significance. However, we restrict our attention to districts with consistently significant effects. On average, in comparison with Cannock, Lichfield has benefited from a significantly higher level of development of industrial land over the period 1994-2004 (in Variants 1 and 2, respectively, the unconditional effects are 2.69 and 2.61 hectares). Results for East Staffordshire also suggest an advantage in relation to Cannock.
4. “Before” the M6 Toll, in the period 1994-2000, there are no significant variations in development caused by location in any of the three drivetime zones (or by location in the Stafford portion of the M6 corridor).
5. “After” the M6 Toll, in the period 2003-04 (i.e., from April 1<sup>st</sup> 2002 to March 31<sup>st</sup> 2004), there is: a robust and statistically significant increase in development in the 5-minute drivetime zone (the unconditional effects are both significant at the highest level); a statistically significant increase in the 10-minute drivetime zone (again, the unconditional effects are both significant at the highest level); and no statistically significant change in the 15-minute drivetime zone.

From comparison of “before” and “after” effects in the three drivetime zones, we conclude that the M6 Toll stimulated development of industrial land. The estimated unconditional effects suggest that, in the period from April 1<sup>st</sup> 2002 to March 31<sup>st</sup> 2004, location within 5-minutes drivetime of an M6 Toll junction was associated with increased industrial land development of a little over three hectares (3.01 and 3.09 in Variants 1 and 2, respectively). In addition, location within 10-minutes drivetime was associated with increased industrial land development of about 1¼ hectares (1.24 and 1.23 in Variants 1 and 2, respectively). However, location within 15-minutes drivetime of an M6 Toll junction had no such effect. Together, these results support the hypothesised locational benefits of the M6 Toll. They *suggest positive development effects on sites that have easy access to the M6 Toll and that these effects diminish with drivetime.*

Table 1 (Variant 1) compares “before” and “after” effects for the three Stafford sites along the “M6 corridor”. All three of the Stafford sites are within five minutes drivetime of a junction on the M6 Motorway, which continues northwards from the M6 Toll (see Figure 1). Hence, particularly because the rationale for the M6 Toll was to relieve congestion on the M6, we expect an *indirect* M6 Toll effect on the Stafford sites. The results for the Stafford M6 corridor sites do suggest a positive indirect effect (1.44 hectares) for sites that are within close proximity of the M6. However, in both absolute and relative terms the effect is much smaller than for those sites within close proximity of the M6 Toll: in the “after” period (2003-04) 1.44 hectares was 11.74 percent of the industrial land “readily available” in the M6 corridor sites; in comparison, the estimates of direct M6 Toll effects (3.01 and 1.24 hectares) constituted, respectively, 22.43 percent and 33.42 percent of such land in the 5-minute

and 10-minute drivetime zones. This *evidence is consistent with indirect M6 Toll effects on the Stafford sites*. Moreover, this small positive effect in Variant 1 contrasts with the zero effect of location within the 15-minute drivetime zones generally that is displayed in Table 2 (Variant 2). This *contrast is consistent with the hypothesis of an indirect M6 Toll effect enhancing the benefits of proximity to nearby parts of the motorway network*. However, in contrast to the highly robust direct M6 Toll effects, this indirect M6 Toll effect is supported by only one estimated coefficient, which is significant at the lowest conventionally acceptable level; moreover, it is not supported by results from the three different specifications of our model referred to below. Accordingly, *the evidence for indirect M6 Toll effects is weaker than the evidence for direct M6 Toll effects*. Finally, an alternative hypothesis is that Variant 1 is detecting the effects of proximity to the M6 motorway, rather than indirect effects of the new M6 Toll. However, this is unlikely. There is no reason to think that a general motorway proximity effect would be time varying in just the right way to account for the “before and after” effects that we interpret as indirect effects of the M6 Toll.

### ***Employment and development effects***<sup>9</sup>

We combined our estimate of 4¼ hectares of additional industrial land development (from Table 1 - comprising 3.01 and 1.24 hectares, respectively, in the 5- and 10-minute drivetime zones) with a local estimate of employees per hectare (from Staffordshire County Council, 2003a, pp.26-28; and Arup Economics, 2001, pp.6-7) to obtain an estimate of additional jobs. Then we combined this estimated number of new jobs with average wage data for Staffordshire’s six southernmost districts (from the *New Earnings Survey*, 2002) to obtain an estimate of the overall development or wealth creation effect. Accordingly, the employment effect of the M6 Toll up to March 31<sup>st</sup> 2004 in southern Staffordshire was 265 new jobs in excess of those created

to operate the M6 Toll, which implies additional annual earnings in excess of £5 million.<sup>10</sup> Discounted to a present value at an annual interest rate of five percent (i.e., “capitalised” at a risk-free rate), this suggests a development effect in current values of around £100 million. Given that the asset value of the M6 Toll on 31<sup>st</sup> December 2004 was £1090m (based on net present value calculations) (Macquarie, 2005), this estimate is in line with the view expressed by SACTRA (1999, p.213) that, ‘on average’, the ‘ratio of total net benefits to transport net benefits ... appears unlikely to differ from unity by a very large margin’.<sup>11</sup>

**Discussion of the results**

In this section, we discuss the validity of our results from three perspectives: robustness; “additionality” and displacement”; and the implications of various limitations of our study.

We discuss robustness of our quantitative results with respect to statistical assumptions, different model specifications, an alternative hypothesis, and triangulation with qualitative evidence.<sup>12</sup> First, the whole available range of diagnostic tests and checks suggests that the underlying statistical assumptions of tobit estimation are appropriate for our data. Secondly, we estimated three additional models in which we redefine both the “After” and “Before” periods and the dependent variable. The direct M6 Toll effects reported above are robust to these different specifications. However, the Stafford “M6 corridor” effect is not stable across different specifications. Hence, the indirect M6 Toll effect should be regarded as indicative rather than robust.

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Thirdly, we consider the alternative hypothesis that time-varying changes in other economic conditions within southern Staffordshire - i.e., apart from the M6 Toll - might explain the quantitative changes in development detected by our estimates. Theoretically, this is unlikely, because the location of the drivetime zones is independent of pre-existing patterns of economic or administrative activity that could determine, at just the right time, the pattern of diminishing effects in our findings. Moreover, the results of a natural experiment depend on adequate specification of both “before” and “after” periods and “control” and “treatment” groups rather than on the model having high explanatory power (Wooldridge, 2003a, p.31).<sup>13</sup> Accordingly, the specification of the models reported in Tables 1 and 2 is designed so that time-varying changes in conditions other than those associated with the M6 Toll would affect all three drivetime zones in the “after” period, which would refute the hypothesised M6 Toll effects. In addition, the previously noted individual and joint statistical insignificance of the estimated time effects is also inconsistent with this alternative hypothesis.

Our final approach to robustness was to triangulate our quantitative research with semi-structured interviews with four senior practitioners involved in industrial land development within the M6 Toll corridor. For reasons of space, we refer here only to the most relevant interview evidence; our qualitative analysis is presented fully in Pugh (2005, pp.58-63). Two respondents referred - independently - to the ‘ripple’ effect of the M6 Toll, meaning that development effects diminished with drivetime distance, which is consistent with our main quantitative finding. Moreover, according to one of these respondents, there is an M6 Toll effect on the Stafford sites: it is



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3 'indirect, but its there'. This is the "indirect" development effect of the M6 Toll  
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6 working further along the motorway network.  
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11 Our second approach to validity is to assess the extent to which the quantitative  
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13 development effects identified by our natural experiment might have occurred even in  
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15 the absence of the M6 Toll (hence, are not "additional") and/or reflect reduced  
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17 development elsewhere (hence, are mere "displacement" effects). SACTRA (1999,  
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19 p.213) defines the "additionality" of transport projects as the benefits and costs  
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21 'additional to the transport benefits/disbenefits'. Accordingly, by assuming that the  
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23 transport benefits of the M6 Toll are reflected in the toll revenue, we define all the  
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25 development effects reported above as *potentially* "additional".<sup>14</sup> To evaluate the  
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27 *actual* degree of development additionality associated with the M6 Toll, we first  
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29 consider whether or not the development effects we identify as associated with the M6  
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31 Toll would have occurred in its absence (following Department of Trade and Industry,  
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33 2000, pp.18-20). According to this criterion, the results of our natural experiment  
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35 suggest that the development effects quantified in Tables 1 and 2 are additional  
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37 benefits. If the developments on sites in close proximity to the M6 Toll had been  
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39 unrelated to the M6 Toll, then they could have occurred at any time; hence, would  
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41 have been just as likely to occur in our "before" as in our "after" period. Conversely,  
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43 additionality is suggested by our findings that developments were systematically more  
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45 likely in the "after" period on sites in close proximity to the M6 Toll, and that the  
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47 strength of this relationship diminishes with drivetime distance. Moreover, this  
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49 inference of additionality is consistent with our interview evidence (Pugh, 2005,  
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51 pp.61-63).  
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According to SACTRA (1999, p.55; also DTI, 2000, p.20), to evaluate additionality also requires assessment of “displacement” effects.<sup>15</sup> In the present context, assuming a regional perspective, this means assessing the extent to which developments in the M6 Toll corridor are merely relocations from elsewhere in the region. To this type of direct displacement effect may be added the possibility that increased development might cause existing local firms to contract, which is an indirect displacement effect. With respect to direct displacement effects, the interview evidence suggests that, in terms of floor space, most development is accounted for by investment from outside of the region; while, with respect to indirect displacement effects, the impact on existing local businesses has been either neutral or positive (Pugh, 1995, pp.60-61).

Two limitations of our quantitative study may bias our results, but in opposite directions. On the one hand, we have acknowledged that ignoring spatial dependence, which is the conventional response to the limitations of existing techniques (Wooldridge, 2002, p.6), entails the possibility of a small upward bias in our estimated M6 Toll effects. On the other, according to SACTRA (1999, p.224), ‘both theory and evidence indicate that responses build up over a prolonged period after the intervention’. The latest data available for our quantitative analysis covers the period ending March 31st 2004, only a little more than three months into the operating period of the M6 Toll. Accordingly, quantitative results in this study capture mainly “anticipation” effects and an incomplete adjustment process. In this case, we have estimated short-run effects that are likely to be smaller than the final, long-run effects of the M6 Toll.

The evidence presented in this section suggests that our quantitative results are robust; that the development effects of the M6 Toll are additional; and that biases inherent in our methodology are neither large nor unidirectional.

### Conclusions

This paper evaluates the impact of the M6 Toll on economic development in southern Staffordshire. Primarily quantitative analysis is “triangulated” with qualitative analysis of interview data, which is in line with methodological recommendations in a recent report on evaluating the wider economic effects of transport infrastructure (GVA Grimley, 2004, p.1).

Our quantitative methodology embodies other best practice recommendations from authoritative sources (SACTRA, 1999; and GVA Grimley, 2004). The data provided annual observations on the development of the population of southern Staffordshire industrial land sites within the M6 Toll corridor (defined by 15-minutes drivetime from an access point), in a standard form and continuously from 1994 to 2004. Accordingly, we were able to treat the advent of the M6 Toll as a “natural experiment” (Wooldridge, 2002 and 2003b) and so analyse “before and after” accessibility effects on sites at varying drivetime distances from the new road. This procedure provided methodological solutions to the ‘treatment of time’ and to the linking of ‘accessibility changes and distance’ within suitable ‘catchment areas’ (GVA Grimley, 2004, p.1; see also SACTRA, 1999, p.224).

Our quantitative results are consistent with both the small empirical literature (Boarnet and Chalermpong, 2001; Holvad and Preston, 2005) and the expectation of

SACTRA (1999) that additional economic benefits arising from new transport infrastructure, even if large in absolute terms, are likely to be small in relation to directly measured transport benefits (see above). The main results are as follows.

1. The M6 Toll has stimulated development of industrial land. We estimate that, in the period April 1<sup>st</sup> 2002 to March 31<sup>st</sup> 2004, location within 5-minutes drivetime of an M6 Toll junction was associated with increased industrial land development of 3.01 hectares; and location within 10-minutes drivetime was associated with increased industrial land development of 1.24 hectares. However, location within 15-minutes drivetime of an M6 Toll junction had no such effect. Together, these results are consistent with the hypothesised locational benefits of the M6 Toll. They suggest development effects on sites that have easy access to the M6 Toll and that these effects diminish continuously with drivetime.
2. Results for the Stafford “M6 corridor” suggest a positive *indirect* effect (1.44 hectares) for sites within close proximity of the M6 motorway, which continues northwards from the M6 Toll. However, in both absolute and relative terms, this indirect effect is much smaller than the *direct* M6 Toll effects on those sites within close proximity of the M6 Toll. Also, the statistical evidence for this indirect effect is less robust than for the direct effects.
3. The direct M6 Toll effect of an additional 4.25 hectares of industrial land development implies 265 new jobs in excess of those created to operate the M6 Toll and a development effect in current values of around £100 million.

Qualitative data from interviews with development practitioners uniformly supported the primary finding that direct M6 Toll effects are significant on nearby sites but

diminish rapidly with drivetime distance. In addition, the interviews yielded more limited support for the secondary finding of “indirect” development effects of the M6 Toll working further along the motorway network. The conclusion is that *the M6 Toll is associated with a positive development effect in excess of benefits reflected in toll revenue*. These are short-run effects that are likely to be smaller than the final, long-run effects of the M6 Toll.

We can be only tentative in generalising our results to future road investments and in commenting on possibly different effects of toll and non-toll roads. Of previous studies, only Dodgson (1974, p.88) offers a directly comparable quantitative result, although this arises from an entirely different and ex-ante methodology: ‘... a maximum additional increase in employment of about 2,900 per annum in a region with a total employed population of 3,400,000’. Our estimate of 265 new jobs compares with 288,000 total resident workers in the much smaller southern Staffordshire sub-region (Staffordshire County Council, 2003b). Hence, both estimates suggest employment effects from new road projects of less than 0.1 percent. Dodgson (1974, p.75) acknowledged that his results gave only a ‘very tentative indication’ and, above, we acknowledge limitations that qualify our own quantitative results. Nonetheless, there is consistency between the findings of these two studies, separated by more than 30 years, and the “small” additional economic benefits suggested by Holvad and Preston’s (2005) survey. This very limited evidence base suggests that our quantitative results reflect infrastructural effects. However, in our study these are combined with toll effects.

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3 In Section 2 above, we set out principles for assessing the contribution of toll charges  
4 to development effects. Unfortunately, theoretical reasoning does not uniquely predict  
5 the relationship between tolls and the development effects of new roads. However, the  
6 greater the likelihood of congestion on a new road, the more likely it is that tolls, via  
7 decongestion and reliability effects, will promote commercial use and development.  
8 Current and anticipated congestion on UK roads (Department of Transport, 2004 and  
9 2006) suggests that the development potential of new road infrastructure may be  
10 amplified rather than reduced by tolls.  
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35 suggestions from the anonymous referees and journal editors. All remaining  
36 shortcomings are the responsibility of the authors.  
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Notes

<sup>1</sup> Staffordshire County Council’s ‘industrial land survey includes land in the industrial, office, warehousing and distribution sectors’ (*Survey*, 2003, p.5). Of the 27 development sites within the M6 Toll corridor (Instaffs, 2003), 18 are in Staffordshire, five in North Warwickshire and four in Birmingham.

<sup>2</sup> In our view, one of these (Dodgson, 1974) is an ex ante study.

<sup>3</sup> Tolls ensured that traffic on the M6 Toll was “free flowing” throughout the period investigated. Hence, differential access time to the M6 Toll is the key to its effects at different locations. On the use of drivetime rather than distance or compound “cost” measures, in addition to the references in the text, Holvad and Preston (2005, p.18) conclude from their review of studies on the additional economic benefits of road projects that ‘results are more consistent if travel time is used as a measure of accessibility rather than travel distance’; see also Linneker and Spence (1996).

<sup>4</sup> Archive copies were kindly supplied by the Development Services Department, Staffordshire County Council, Riverway, Stafford. ST16 3TJ.

<sup>5</sup> Significant non-zero “before” effects could indicate either that the threshold period was incorrectly defined or that the three drivetime zones had characteristics that systematically influenced development independently of the hypothesised M6 Toll effects.

<sup>6</sup> For analysis, estimation and interpretation of these marginal effects, see Greene (2003, pp.764-66); Wooldridge (2002, pp.521-24); Wooldridge (2003, pp.567-69); and Cong (2000).

<sup>7</sup> We do not delete variables whose estimated coefficients are statistically non-significant when these are required for comparison within “sets” of variables: this applies to variables for total land available (comparison with total land readily available); all “before” and “after” effects; and the district dummies.

<sup>8</sup> The intercept term is included to ensure that the estimated residual in the tobit model satisfies the assumption of a zero mean (Greene, 2003, pp.765 and 771; Wooldridge, 2002, p.520). However, ‘the intercept should *not* be relied on for purposes of analysis or inference’ (Studenmund, 1992, p.242; see also pp.96-98 and 240-242).

<sup>9</sup> For further detail on the calculations in this Section, see Pugh (2005, pp.55-57).

<sup>10</sup> These calculations take no account of potential multiplier effects (i.e., the extent to which spending additional income leads to further job creation). Although typically local multipliers are very small (around 1.05-1.11; SACTRA, 1999, p.219), the existence of wards in Cannock that are both close to the M6 Toll and eligible for EU Regional Development Funding suggests the presence of under-utilised resources consistent with positive multiplier effects.

<sup>11</sup> The ratio of total net benefits to transport net benefits is defined as

$$\frac{(\text{Transport benefits} - \text{Transport costs}) + (\text{Additional economic benefits} - \text{Additional economic costs})}{\text{Transport benefits} - \text{Transport costs}}$$

<sup>12</sup> These tests and checks on robustness are fully reported in Pugh (2005, pp.51-54), but are omitted here for reasons of space.

<sup>13</sup> Indeed, the low “pseudo R-squared” measures reported in Tables 1 and 2 are typical of this type of regression (Wooldridge, 2002, p.529; Wooldridge, 2003a, p.31).

<sup>14</sup> As we noted in the Introduction, we do not account for potentially negative externalities associated with the M6 Toll. Hence, we have nothing to say about “additional disbenefits” (detrimental impacts).

<sup>15</sup> SACTRA also recommends taking account of multiplier effects. This becomes particularly relevant when we consider employment effects; see note 10.



References

Arup Economics (2001) *Employment Densities: A Full Guide*. English Partnerships and the Regional Development Agencies. London.

Boarnet, M. and Chalermpong, S. (2001) New Highways, House Prices, and Urban Development: A Case Study of Toll Roads in Orange County, CA.. *Housing Policy Debate*, 12(3), 575-605.

Cervero, R. and Duncan, M. (2002) Transit's Value-Added: Effects of Light and Commuter Rail Services on Commercial Land Values. *Transport Research Board, 81<sup>st</sup> Annual Meeting presentation* (January 2002).

Cong R. (2000) Marginal effects of the tobit model. *Stata Technical Bulletin*, 56, 27-34.

Department of Trade and Industry (2000) *Guidance on Preparing Evaluation Plans*. London: DTI, Central Evaluation Team.

Department of Transport (2004) *The Future of Transport*. HMSO. Available online (as of 26/03/2007): <http://www.dft.gov.uk/about/strategy/whitepapers/fot/>

Department of Transport (2006) *Transport Trends*. HMSO.

Dodgson, J. (1974) Motorway Investment, Industrial Transport Costs, and Sub-Regional Growth: A Case Study of the M62. *Regional Studies*, 8, 75-91.

Federal Reserve Bank of San Francisco (2001), Natural Vacancy Rates in Commercial Real Estate Markets, *Economic Letter 2001-27*; October 5, 2001. Available online (as of 26/03/2007): <http://www.frbsf.org/publications/economics/letter/2001/el2001-27.pdf>

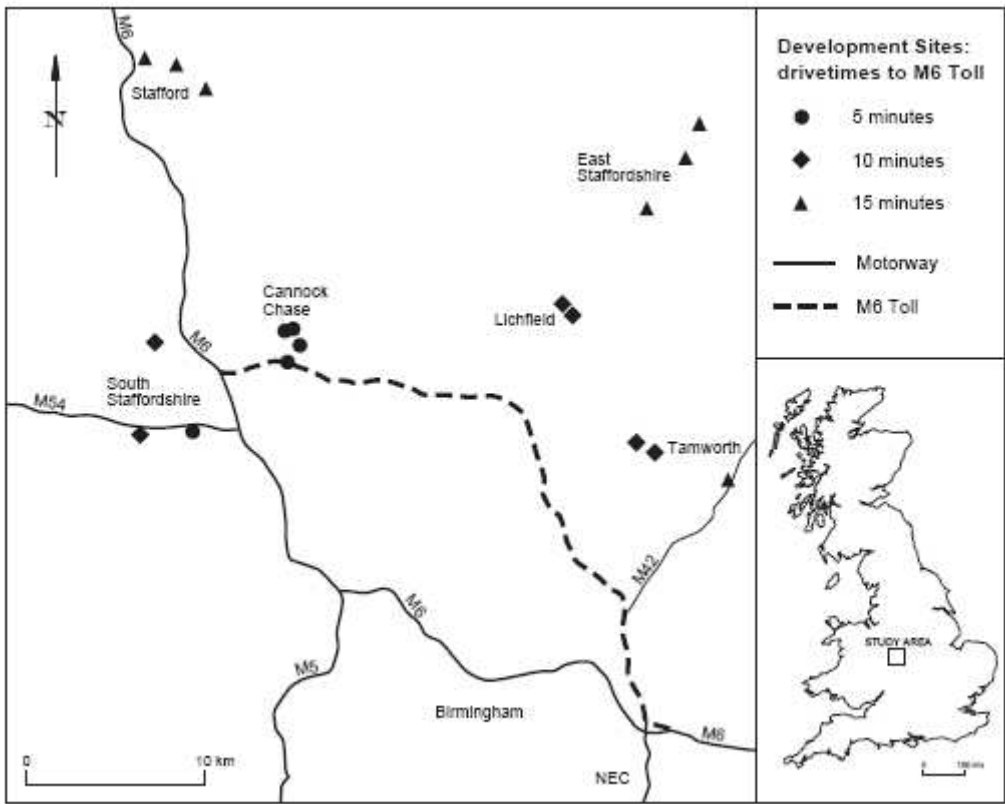
Flores-Lagunes, A. and Schnier, K. (2004) Estimation of Sample Selection Models with Spatial Dependence. University of Arizona, Department of Economics

- (mimeo: December 2004). Available on-line (as of 26/03/2007):  
<http://www.econ.uiuc.edu/~roger/seminar/flores.pdf>
- Gramlich, E.M. (1994) Infrastructure investment: a review essay. *Journal of Economic Literature*, 32, 1176-96.
- Greene, W. (2003; 5<sup>th</sup> Ed.) *Econometric Analysis*. Prentice Hall, New Jersey.
- Gutierrez R., Carter S. and Drukker D (2001) On boundary-value likelihood ratio tests. *Stata Technical Bulletin*, 60, 15-18.
- GVA Grimley (2003) *M6 Toll: The Wider Picture* (2003) - consultancy report by Mott MacDonald and ECOTEC Research in association with GVA Grimley.
- GVA Grimley (2004) *Developing a Methodology to Capture Land Value Uplift around Transport Facilities*. Scottish Executive, Transport Research Planning Group: Transport Research Series (November 2004). Available online (as of 26/03/2007): [www.scotland.gov.uk/planning](http://www.scotland.gov.uk/planning)
- Holvad, T. and Preston, J. (2005) Road Transport Investment Projects and Additional Economic Benefits. Presented at the 45<sup>th</sup> Congress of the European Regional Science Association (ERSA conference papers ersa05p522). Available online (as of 26/03/2007): [http://www.feweb.vu.nl/ersa2005/final\\_papers/522.pdf](http://www.feweb.vu.nl/ersa2005/final_papers/522.pdf)
- House of Commons Select Committee on Transport, *Seventh Report* (March 2005).
- InStaffs (2003) *M6 Toll Road: Commercial Development Opportunities* (published by InStaffs on CD).
- LeSage, J. and Pace, R. (2004) Using Matrix Exponentials to Estimate Spatial Probit/Tobit Models. In: Getis, A., Mur, J. and Zoller, H. (2004) *Spatial Econometrics and Spatial Statistics* (Basingstoke: Palgrave Macmillan).
- Linneker, B. and Spence, N. (1996) Road transport infrastructure and regional economic development. *Journal of Transport Geography*, 4(2), 77-92.

- Llewelyn-Davies, Banister, D. and Hall, P. (2004) *Transport and City Competitiveness: Literature Review*. London: Department for Trade and Industry.
- Macquarie (2005) *Macquarie Infrastructure Group: Interim Financial Report 31 December 2004*. Available online (as of 26/03/2007):  
[http://www.macquarie.com.au/au/mig/acrobat/full\\_concise\\_sixmonth\\_results\\_2004.pdf](http://www.macquarie.com.au/au/mig/acrobat/full_concise_sixmonth_results_2004.pdf)
- New Earnings Survey (2002): from NOMIS, included in Staffordshire County Council (2003) *Monitoring Social Inclusion in Staffordshire*. Development Services Department. For availability, see Note 4.
- Noland, R. and Lem, L. (2002) A Review of the Evidence for Induced Travel and Changes in Transportation and Environmental Policy in the United States and the United Kingdom. *Transportation Research Part D: Transport and Environment*, 7(1) (January), 1-26. Available online (as of 26/03/2007):  
<http://www.cts.cv.imperial.ac.uk/documents/publications/iccts00244.pdf>
- OECD (2002) *Impact of Transport Infrastructure Investment on Regional Development*. OECD, Paris.
- Pugh, G. (2005) *The economic impact of the M6 Toll on southern Staffordshire: Final Report (June 2005) for the Southern Staffordshire Partnership*. Staffordshire University. Available online (as of 18/03/2007) at  
[http://www.staffs.ac.uk/schools/sciences/geography/links/IESR/downloads/M6\\_Toll\\_evaluation\\_FinalReport%20.pdf](http://www.staffs.ac.uk/schools/sciences/geography/links/IESR/downloads/M6_Toll_evaluation_FinalReport%20.pdf)
- Rand Europe (2004) *M6 Toll Road Stakeholder Depth Interviews*. Rand Europe for the UK Department for Transport, Department for Transport, London.

- 
- SACTRA (Standing Advisory Committee on Trunk Road Appraisal) (1999) *Transport and the Economy*. Department for Transport, London.
- Spellerberg, I. (1998) Ecological effects of roads and traffic: a literature review. *Global Ecology & Biogeography*, 7(5), 317-333.
- Staffordshire County Council (2003a) *Staffordshire Industrial Estates Survey 2002*. Development Services Department. For availability, see Note 4.
- Staffordshire County Council (2003b) *Southern Staffordshire Baseline Indicators*. Development Services Department. For availability, see Note 4.
- StataCorp (2003) *Longitudinal/Panel Data*. StataCorp LP, College Station, TX.
- Studenmund, A. (1992; 2<sup>nd</sup> Ed.) *Using Econometrics*. Harper Collins, New York.
- Survey*: Staffordshire County Council, *Staffordshire Employment Land Availability Survey* (published annually from 1994 to 2004); for availability, see Note 4.
- Wooldridge, J. (2002) *Econometric Analysis of Cross Section and Panel Data*. The MIT Press, London.
- Wooldridge, J. (2003a) *Solutions Manual and Supplementary Materials for Econometric Analysis of Cross Section and Panel Data*. The MIT Press, London.
- Wooldridge, J. (2003b; 2<sup>nd</sup> Ed.) *Introductory Econometrics*. Thomson South-Western, Mason, Ohio.

Figure 1: The M6 Toll and industrial land (development) sites in the southern Staffordshire sub region



Source: Crown Copyright; GVA Grimley (2003) for site drivetimes

Figure 2: History of the development of the M6 Toll Motorway

Year	Event
1980	Proposals for a new publicly funded motorway
1984	Consultation on five route options
1986	Announcement of preferred route
1988	Public Inquiry on publicly funded scheme
1989	Announcement that the road will be built by the private sector
1991	Midland Expressway Ltd (MEL) announced as competition winner
1994	Public Inquiry on MEL scheme
1995	Public Inquiry ends
1997	Final go-ahead from Government
1997	Legal challenges against the scheme (Alliance against BNRR)
1999	Legal challenges cleared
2000	Competition for design and build contract
2000	MEL signs contract with CAMBBA for design and construction. Contract Value (Design and Construction): £905m
2000	MEL signs contract for financing
2001	Construction begins
2003	Toll prices announced; MEL awarded concession until 2054
2003	M6 Toll opens

Table 1: Influences on the development of industrial land sites within the M6 Toll corridor, 1994-2004 (RE and Pooled tobit regressions)

Dependent variable: site development (*Development<sub>it</sub>*) (“Before” period = 1994-2000; “After” period = 2003-04)

Variant 1: Stafford sites “before” and “after” the M6 Toll

			Random Effects	Pooled		
				Marginal effects		
Independent variables			Coefficient	Coefficient	Unconditional	Conditional
Total land available (t-2)	total_lag2		0.03	0.03	0.01	0.01
Land readily available (t-2)	readily_lag2		0.19 ***	0.19 ***	0.04 ***	0.04 ***
5-minute drivetime sites before the M6 Toll	5MinZoneBefore		2.10	2.09	0.57	0.53
5-minute drivetime sites after the M6 Toll	5MinZoneAfter		6.74 **	6.75 **	3.01 ***	2.31 ***
10-minute drivetime sites before the M6 Toll	10MinZoneBefore		1.58	1.60	0.41	0.39
10-minute drivetime sites after the M6 Toll	10MinZoneAfter		3.67 *	3.70 *	1.24 ***	1.04 **
Stafford sites “before” the M6 Toll	StaffordBefore		-0.27	-0.27	-0.06	-0.06
Stafford sites “after” the M6 Toll	StaffordAfter		4.01	4.02	1.44 *	1.18
Tamworth	tam		3.14	3.15	0.93	0.83
Lichfield	lich		6.35 *	6.38 *	2.61 ***	2.05 ***
South Staffordshire	sstaffs		0.68	0.67	0.16	0.16
East Staffordshire	estaffs		5.26	5.32	1.88 **	1.55 *
Stafford	stafford		3.25	3.28	0.98	0.87
Intercept term	Intercept		-9.82 ***	-9.85 ***	-2.18 ***	-2.25 ***
Variance components						
Panel-level variance ( $\sigma_u$ )	sigma_u		0.34			
Overall variance ( $\sigma_e$ )	sigma_e		4.73 ***			
Contribution (%) of the panel variance component	rho		0.01			
Diagnostics and “Goodness of Fit”						
Likelihood-ratio test of ( $H_0$ : $\sigma_u = 0$ )	chibar2(01)		0.32 †			
Log likelihood			-174.55	-174.71		
Likelihood Ratio Test (against $H_0$ : joint significance)	chi2(13)		47.41 †	47.93 †		
Estimated standard error of the regression	_se			4.76		
Pseudo R2				0.12		
Conditional moment test against $H_0$ : normal errors				14.19 †		

\*\*\* Significant at the one-percent level or better; \*\* Significant at the five-percent level or better; \* Significant at the ten-percent level or better; † Null not rejected at the five-percent level or better

Observation summary:  
45 uncensored observations; 116 left-censored observations; 0 right-censored observations

Table 2: Influences on the development of industrial land sites within the M6 Toll corridor, 1994-2004 (RE and Pooled tobit regressions)

Dependent variable: site development ( $Development_{it}$ ) (“Before” period = 1994-2000; “After” period = 2003-04)

Variant 2: All sites in the 15-minute drivetime zone “before” and “after” the M6 Toll

		Random Effects		Pooled	
				Marginal effects	
Independent variables		Coefficient	Coefficient	Unconditional	Conditional
Total land available (t-2)	total_lag2	0.03	0.03	0.01	0.01
Land readily available (t-2)	readily_lag2	0.18 ***	0.18 ***	0.04 ***	0.04 ***
5-minute drivetime sites before the M6 Toll	5MinZoneBefore	2.19	2.18	0.60	0.55
5-minute drivetime sites after the M6 Toll	5MinZoneAfter	6.87 **	6.87 **	3.09 ***	2.36 ***
10-minute drivetime sites before the M6 Toll	10MinZoneBefore	1.57	1.58	0.40	0.39
10-minute drivetime sites after the M6 Toll	10MinZoneAfter	3.67 *	3.68 *	1.23 ***	1.04 **
15-minute drivetime sites before the M6 Toll	15MinZoneBefore	-0.86	-0.86	-0.18	-0.19
15-minute drivetime sites after the M6 Toll	15MinZoneAfter	0.91	0.91	0.22	0.22
Tamworth	tam	3.44	3.45	1.05	0.92
Lichfield	lich	6.51 *	6.52 *	2.69 ***	2.11 ***
South Staffordshire	sstaffs	0.77	0.76	0.18	0.18
East Staffordshire	estaffs	5.72	5.75	2.10 **	1.71 **
Stafford	stafford	4.71	4.73	1.60 **	1.34
Intercept term	_cons	-9.99 ***	-10.01 ***	-2.23 ***	-2.29 ***
Variance components					
Panel-level variance ( $\sigma_u$ )	sigma_u	0.27			
Overall variance ( $\sigma_e$ )	sigma_e	4.80 ***			
Contribution (%) of the panel variance component	rho	0.003			
Diagnostics and “Goodness of Fit”					
Likelihood-ratio test of ( $H_0$ : $\sigma_u = 0$ )	chibar2(01)	0.19 †			
Log likelihood		-175.43	-175.52		
Likelihood Ratio Test (against $H_0$ : joint significance)	chi2(13)	45.66 †	46.30 †		
Estimated standard error of the regression	_se		4.82		
Pseudo R2			0.12		
Conditional moment test against $H_0$ : normal errors			15.27 †		

\*\*\* Significant at the one-percent level or better; \*\* Significant at the five-percent level or better;

\* Significant at the ten-percent level or better; † Null not rejected at the five-percent level or better

Observation summary:

45 uncensored observations; 116 left-censored observations; 0 right-censored observations