Understanding and Modelling Decision-Making for Intra-Regional Demand Management Policies

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ABSTRACT

Demand management policies are contentious. It is argued that the introduction of significant pricing policies or restraints on parking for new development can be politically difficult as they may drive new development to other areas with fewer restrictions. Empirically such propositions remain unproven yet they invite some important questions.

First, if decision-makers do perceive cities to compete, what are their **motivations** and how do they relate to the impacts of demand management policies? Secondly, how could and how have competitive interactions between cities been **modelled** and what are the implications of this work?

This paper provides evidence to answer these questions and to understand the significance of any gaps between what decision-makers look for and what models provide. It begins with a short review which sets the context for considering competition between cities and then the special case of competition with fiscal demand management. A qualitative study of decision-makers in four major city region areas in England is then described which explores the motivations and framings of the problem. Next, a series of modelling exercises that have sought to explore the impacts of different pricing scenarios and assumptions on competition and collaboration between adjacent authorities are presented. These set out some conditions under which competition and collaboration are important. The paper concludes with a discussion of the current gaps we perceive in the understandings which the models produce and the needs of decision-makers. We set out a tentative research agenda for the future.

Keywords: competitive cities, demand management, decision-makers perceptions, modelling interaction

1. Introduction

A substantial body of research maintains that cities and regions increasingly act as distinct and competitive entities (e.g. Agnew 2000; Boland 2007; Peck and Tickell 2002; Ward and Jonas 2004), and there are suggestions that transport is one of the factors which are used to compete (Docherty et. al. 2009; Eddington 2006; Graham et al., 2010). Boland describes claims that economic development is associated with 'economic diversity, connectivity and quality of life' (2007, pp. 1022).

Begg suggests that competitiveness can be conceived either in terms of one area competing with others so that it is 'is essentially about securing (or defending) market-share' or 'equated, usually loosely, with the `performance' of an economy, an absolute measure' (1999, p. 796). Ward and Jonas (2004) argue that competitiveness is manifested as a move to produce supply side conditions which will attract investment and encourage economic development. Lever (1999) lists five potential areas over which cities might compete:

- For mobile investment;
- For economic growth (defined as gross value added);
- For population (linked to income, human capital and political power);
- For public funds at the level of the nation state; and
- For hallmark events or major infrastructure as part of urban place marketing. (p1029)

Following Florida (2005) attention has also been given to how cities can create an attractive built environment in which knowledge-based and creative industries will invest. Florida's arguments are contested, with some doubting the extent of supporting empirical evidence or at least the direction of any causal link between quality of built environment and investment by knowledge based industries (Boland 2007, pp. 1022; Christophers 2008, pp. 2319-2320; Clifton 2008). It is also important to note that, despite the prevalence of claims that cities and regions focus on competition, there are arguments which indicate that this is not an approach taken fully to the exclusion of other motivations including policies of re-distribution (Basolo 2000), and social cohesion (Ranci 2011), and ''politics of collective consumption' beyond political intervention to facilitate competitiveness (Ward and Jonas 2004, p. 2121).

Studies of transport's role in city and regional competitiveness somewhat lag behind the wider political geography literature. Within those broader accounts transport tends to be mentioned as among a number of factors relevant to creating supply side conditions conducive to competitiveness (e.g. Begg, 1999; Ranci, 2011). Doherty et al. (2009) have considered in more depth the potential implications for transport of the literature on city and regional competitiveness. They suggest that limited transport capacity and congestion will harm the 'ability of cities to compete against places with less congestion, and better quality public transport' (Docherty et. al. 2009, p. 323). Further, they describe how transport interventions have function in creating a high quality built environment supposed according to Florida's argument, to attract knowledge based industries. Studies drawing on economic theory have considered potential economic benefits of agglomeration, including Eddington's claim that there are prospects for economic impacts 'over and above direct time savings of a transport intervention currently captured in appraisal' (Eddington 2006, para. 2.33) and

Feldman et al. (2008) who claim that savings in journey to work times made possible by agglomeration economies can be translate into increases in time given to employment. Empirical work on the economic role of transport is characterised by greater uncertainty. There have been studies on specific impacts of particular interventions, such as implemented congestion charges (e.g. Marsden 2006; Quddus et al. 2007; TfL and Mayor of London 2008). Yet claims about the relation between economy and transport intervention leave open significant questions 'as to whether there is an implied causality, whether any economic development is new or merely a transfer from elsewhere' (Banister 2012, p. 1; see also Chatman and Noland 2011).

Studies on transport's role in economic development give an under-determined account of expected impacts of transport provision. More than this they leave an open question about what decision-makers are trying to achieve, as distinguished from the questions about what certain interventions might be expected to achieve. Following the literature, it is plausible to suggest that decision-makers will be motivated by an aim of creating supply side conditions to improve competitiveness. However the literature also indicates that other motivations are plausible (such as policies of re-distribution), and that even if ideas of competitiveness drive decisions, their content might take any of several forms each with different implications for the implementation of congestion charging.

Drawing from all of the literature set out above we suggest different ways in which demand management might feature in notions of competition as shown in Table 1.

Table 1: Ways in which demand management might impact on competition

Factor	**Impacts of demand management**
Creating an attractive built environment (Florida, 2005)	Demand management policies aim to reduce the extent to which urban environments are over trafficked and may therefore be beneficial.
Promoting Economic Growth (Lever, 1999)	Reducing congestion externalities increases user benefits and widens labour markets
Growing public funds (Lever, 1999)	Major demand management policies may bring significant additional investment to make the implementation acceptable. They also generate a revenue stream for future investment.
Competing for population (Lever, 1999)	Demand management policies may impact on the relative attractiveness of some areas relative to others due to charges (or exemptions) both positively and negatively
Competing for mobile investment (Lever, 1999)	Whilst there is potential for reduced congestion to be attractive to industry, demand management policies may also encourage job relocation and deter investment.

This paper sets out to further understand the aims of decision-makers and also the extent to which evidence might be generated to support the questions which they pose. The paper next reviews findings from an empirical study in which city and regional transport, planning and economic officers took part in interviews to explore their economic priorities, perceptions of the economic role of transport, and the way in their view of the potential for congestion charging is influenced by these priorities and perceptions. The second set of questions concern the decision-support tools and evidence that decision-makers can draw on. The

aspect of this question which we focus on is whether transport models can be designed to incorporate what we have discovered to be decision-makers aims and perceptions of the role of competitiveness in decisions on demand management. The paper concludes with some reflections on the significance for demand management policy and also for the future research directions for modelling.

2. The Study: motivations and perception of transport decision-makers

This study sought to understand the motivations of decision-makers and how this relates to the capabilities of decision-support tools. We present the findings related to fiscal demand management tools and, within these, the subset of congestion charging and parking pricing. Competition may also exist over matters such as parking supply and roadspace reallocation. The key questions to be explored in the first part of the study surround motivations and in particular:

- What are decision-makers perceptions of relationship between economy, competitiveness and transport?
- What do decision-makers understand to be the implications for congestion charging of the economic impact of transport decisions?
- Are decisions on congestion charging motivated by objectives of economic competitiveness?
- How, if at all, is transport planning at city and regional level is motivated by non-competitive concerns?

The empirical study involved four English city-regions giving a geographical spread across the country with the exclusion of London and South East.[1] The places involved included major cities within the city regions and smaller towns or cities, and this enabled investigation of how decision-makers viewed neighbours within the region, and well as perceptions of relationships between regions. In all we conducted 20 semi-structured interviews with 21 local and regional officers responsible for transport planning, passenger services, economic development, and town planning (see Table 2). The interviews tool place between November 2010 and March 2011.

The interviews were held in two rounds. The first explored how the participants viewed the role of transport in promoting economic competitiveness and what they understood by this. The second asked detailed discussions around the role of transport investments and demand management policies in promoting competitiveness. In the following discussion we use the symbols (R1, R2...) to indicate which city or region's officers' expressed particular comments. This allows identification of correlations between officer aims and opinions and the type of area in which they are based.

[1] The difference between economies in London and South East as compared to the rest of England suggests that they should be treated separately, but to do so would be beyond the scope of this study.

Table 2: Study Participant Structure

Study Area	Participant	Role (and participation in 1st and/ or 2nd round)
City Region A	R1 - County Wide Integrated Transport Authority	Development Director (1st round); Passenger Services Director (2nd round)
	R2 - Major regional city	Senior Transport Policy Officer (one interview)
	R3 - Smaller city in city region	Senior Transport Planning Officer (1st and 2nd round); Senior Economic Regeneration Officer (1st round)
City Region B	R4 - County-wide Integrated Transport Authority	ITA Officer (1st and 2nd round)
	R5 - Major regional city	Senior Transport Planning Officer (1st and 2nd round) ; Transport Planner (1st and 2nd round)
	R6 - Smaller city in city-region	Transport Planning Manager (1st and 2nd round) ; Economic Development Manager (1st round)
City Region C	R7 - County-wide Integrated Transport Authority	Former officer –Passenger Transport Authority (one interview)
	R8 - Major Regional City	Senior Transport Policy Officer (1st and 2nd round); Senior Economic Development Officer (1st round)
	R9 - Smaller Town in City Region	Transport Policy Manager (1st and 2nd round); Economic Development Manager (1st round); Planning Policy Manager (1st round)
City Region D	R10 - Regional Partnership	Chief Executive (one interview); Head of Transport (one interview)
	R11 - Smaller city in city-region	Planning and Transport Policy Manager (1st and 2nd round); Strategic Transport Projects Manager (1st round); Economic and Business Development Manager (1st round)

3. Study Findings: Competitiveness, economy and transport

The empirical study found officers' priority to be economic growth and competitiveness, primarily manifested as intentions to support private sector employment growth, although other factors including business investment and retail are also prominent. Transport is held to have a central function in supporting these economic aims. In the following subsections we consider first the objectives for employment and business investment, and then the perceived role for a congestion charge in achieving these objectives. Finally we briefly describe the objectives for retail and their implication of demand management through parking.

3.1 Objective of increasing employment and the value of transport investment

Across the areas involved in the study, it is suggested that realising the employment and business investment objectives involves placing a strong focus on gaining transport investment, especially for improving existing public transport, for road improvements in some places, and for delivering major new public transport schemes. Plans to encourage greater

walking and cycling are less prominent although they were discussed by interviewees. This approach might appear to reflect arguments that cities will seek to improve competitiveness by using supply side measures to attract investment and development. Following literature on economy theory and transport, we might expect that this involves economic growth associated with time savings, especially by reducing congestion (cf. Banister 2008; Calthrop et al., 2000).

The idea of seeking to create supply-side conditions for competitiveness plausibly explains much of the decision-makers' approach. Decision-makers are concerned by existing and expected future congestion, and talked about transport investment – especially for public transport - partly in terms of tackling congestion's economic dis-benefits. This is particularly true of the major city centres, and occasionally of other areas with agglomeration economies. Yet despite the presence of concern about congestion, this is not apparently the greatest concern of officers, even in major cities. Further in talking about economic impacts of transport investment, and congestion, the discussion tended not to be framed in terms of time savings (although that was mentioned - R1; R3; R7). Instead the discussion fell into two categories: one concerned with transport's role in creating a high quality built environment which will attract high GVA employment, and the second concerned with connectivity and improving access to travel to work. The first category clearly echoes Florida's arguments. Many of the interviewees consider there to be plausible prospects of encouraging creative and knowledge based industries to invest in their area. Only in one case was there any indication that the emphasis on seeking high GVA employment was based on contingent characteristics of the area. Transport interventions, such as pedestrianisation of town centres, and traffic control to limit environmental dis-benefits, are held to have roles in creating the conditions for this. The second category forms the major concern for transport and economy. All of the interviewees described how transport investment can support access to employment by enabling people to get from residential areas to employment. In particular, there is an emphasis on providing public transport links from residential area to areas of employment, or expected employment growth. There is further emphasis on measures designed to ease passengers use of public transport, for instance, by through ticketing across administrative boundaries.

In discussing use of transport in increasing employment, interviewees indicated that the intention is an absolute increase, and not an increase in some areas at the expense of others. Further it is apparent that cities and towns involved in the study consider their economic interests to involve collaboration across their region. As such they are willing to engage in regional transport planning, and tend to consider travel to work as a regional matter. They are also willing to accept (although not without argument) transport investment decisions made at the regional level, even though some decisions do not bring significant benefits to each constituent town or city. Overall there was relatively little mention of the need to compete with other areas for finite numbers of jobs, although that idea was raised occasionally (including in relation to congestion charging). However this impression may be partially misleading. Although cities and towns will accept collective decisions which they would not greatly benefit from, this can be understood as a strategic loss worth suffering for the greater benefits of collective working as a region.[2]

3.2 Competitiveness and congestion charging

The idea of congestion charging is widely considered an attractive intervention among the study interviewees. The prospect of a charge being implemented in the near future is considered unlikely due to strong political opposition. However this has not prevented officers from considering the role of a congestion charge could have in a different political context, and it is in this hypothetical context that the idea of a charge has currency. The

[2] The situation differs significantly in relation to retail, for which there is strong inter-regional competition which has substantial impacts on transport, especially on parking policy.

primary motivation for supporting the idea of a charge is to get the income for transport investment. This may appear to reflect traditional ideas that the benefit of a charge, in bringing investment and reducing time lost through congestion (Cowie, 2009; Eddington 2006). However the interviewees did not treat a potential charge in this way. While there was enthusiasm for the investment that could flow from income brought by a charge, and for the potential to tackle congestion, this is not the whole story. Instead there is a view that a charge is attractive especially because would bring prior transport investment, which, as discussed above could support economic objectives. Not only do decision-makers find the prospect of prior investment appealing, but for some, it is a necessary pre-condition for a charge which otherwise be a dis-benefit. The timing of benefits and dis-benefits appears relevant to perceptions here. The view that dis-benefit would be offset by future investment made possible by the charge was not raised.

It could be suggested that this support for congestion charging indicates a limit to the supply-side focus described in the literature. However in this case, demand management is being used to create supply side conditions which are considered important for competitiveness. These supply side conditions include those which support increased greater demand for certain types of travel, including travel to work by public transport or walking and cycling. They also include reduced congestion. This is not to deny that interviewees perceive risks to the approach of restricting certain types of demand, especially private vehicles. The risk that a charge would damage retail was raised, and actors discussed measures to mitigate this by setting charges designed to catch only commuters and not shoppers. There are also risks to the attractiveness of a place to inward investment although these are considered to be broadly considered outweighed by the supply side benefits. However actors confidence in this depends in part on the status of their city or town, Generally, the risk is felt more by smaller places, who consider that their overall attractiveness to business investment is relatively weak (R1; R3; R6; R5: R4). In such cases cities and towns would potentially either not adopt or would seek to match or undercut the charges of other weak towns and cities with whom they compete.

In general, the perception that the benefits from congestion charging will overwhelm the risks of deterring inward investment underpins a general willingness among actors to work with intra-regional neighbours in setting a charge. However contingent factors are also relevant. In some cases, the geography of a region, and proximity of cities means that any feasible charge would include areas in more than one city. Decisions to collaborate on charges also go beyond necessity brought by geography, and include pragmatic decisions to share back room costs, and in one case a decision to set identical charges across a poly-centric region in order to avoid any risk of competition to undercut other places on charges. Despite a general willingness and practical necessity to consider joint charging systems, there was a clear local political calculus which examined the extent to which the residents of an area would have to pay a charge relative to the benefits that would accrue to them (this takes us back to the point that while overall collaborative regional decisions may be considered to be in the interests of all members, there remain disputes about their fairness).

3.3 Retail and parking

Opinions on retail and the types of transport policy which could support retail indicate a conceptual approach quite different to that concerning measures to facilitate employment growth. The nature of the approach to retail shows a sharp distinction between those – usually major cities which consider their sufficiently attractive to bring in visitors from outside of their area as well as retaining the custom of their own residents, and places which understand their retail as something that serves more local demand. Those who consider they have retail which will attract people from a wide area, and they tend not to judge themselves as being in competition for retail with their immediate neighbours. However two expressed their view that face competition from large out-of-town shopping centres (R5; R8), and there is some awareness of, and comparison with, the retail available in other large

cities. Among places who consider that their retail is designed for a more local market, there appears a greater sense of competition either with neighbours, as well as with the out-of-town centres. There is a perception of a need to try to supply plentiful parking provision for retail, and also for keeping charges relatively low (with one exception - a historic city with restricted geographical space). As with the measures designed to facilitate employment for both major and smaller cities the emphasis on supply side development by seeking to create conditions in which retail can expand. The difference is in how this is expressed, and in relation to retail there is a strong sense that actors, especially in smaller cities, understand themselves to be engaged in inter-jurisdictional competition.

3.4 Summary of perceptions of demand management policies and competition

Economic priority is focussed on employment growth, and it is considered that Transport can contribute to this economic priority through expanding travel to work areas and creating a high quality built environment. In relation to this objective both local and regional decision makers appear to seek absolute employment growth in their area. These perceptions diverge from assumptions made within decision-support tools used by decision-makers since they do not frame benefits in terms of time saving but instead in terms of the employment outcome. Within this, the type of job also matters, with a preference for high gross value added employment. Further, while cities understand themselves as seeking competitiveness, this is not at odds with a willingness to work collaboratively and plan transport interventions within the region. Congestion charging is held to be attractive for prospects of transport investment which will contribute to conditions for employment growth. In conceptualising the benefits of congestion charging, timing matters and prior investment was considered more important than post investment. Without collaboration, smaller towns and cities might compete with each other on whether to enter the system and on price to seek comparative economic advantage. For retail, the context is different. Parking provision is held to a significant factor in the attractiveness of a city or town's retail, and this is especially so for smaller towns who perceive that they relatively lack other benefits. Where parking provision and retail is at issue then competition between cities, and between cities and out of town shopping centres is much more prevalent. The approaches taken to demand management in contexts assumed to affect retail (parking provision) and those assumed to influence conditions of employment growth (possible congestion charge), and the divergence between these approaches may have implications for the approaches taken in development of transport models.

4. Study Findings: Modelling Approaches

4.1 The Central Planner

Research in the transport literature has focused predominantly on intra-city issues with the decisions being under the control of some 'central planner'. The strong focus in recent years has been on road user charging, economic theory suggesting benefits will accrue to a city from a combination of congestion relief and recycling of revenues within the city (Walters, 1961). Beyond the theoretical benchmark of full marginal cost pricing, the design of practical charging schemes, such as those adopted by English local authorities in recent Transport Innovation Funds (TIF) bids, have generally focused on pricing cordons around single, mono-centric cities (Shepherd et al, 2008). As our own research has demonstrated, it is possible in such cases to design the location and level of charges for a cordon so as to systematically maximise the potential welfare gain to the city (Shepherd and Sumalee, 2004; Sumalee et al, 2005), yet there is an implicit premise here that the city acts in isolation.

Whilst we have found no empirical studies examining competing cities in the transport sphere, a handful of studies address aspects of competition. In the context of toll roads,

several authors have studied the welfare implications of competition between a public and private operator (Verhoef et al, 1996; De Palma & Lindsey, 2000; Yang et al, 2009). The focus in these studies is on the impacts of alternative ownership regimes, and of public versus private control in the form of either monopoly pricing or competitive Nash equilibria. De Borger et al (2007) and Ubbels & Verhoef (2008) studied a more closely related problem of competition between countries/regions setting tolls and capacities, investigating the implications of players adopting two-stage games or different strategies.

In parallel, several pertinent recent studies have appeared on the evolution of city structures and tolls under different assumptions. Levinson et al (2006) and Zhang et al (2007) used an agent-based approach to investigate how networks evolve over time. [Interestingly, the latter study was based on a continuum model of traffic flow rather than a discrete network, which has a similar motivation to the aggregation methods we propose to adopt.] In this area of study, while Mun et al (2005) focused on the development of a non-monocentric, linearised city, others have opted to develop two-dimensional continuum models (solved using finite element methods) capable of representing multiple CBDs (Ho et al, 2005; Ho & Wong, 2007). From the field of Economic Geography, the latest contribution by Anas & Pines (2008) analyses the move away from monocentric models to polycentric ones. In spite of their relevance to the proposed study, none of the above approaches considers direct competition between cities, nor the inter-play between parking charges and road user tolls either within or between cities (for which Marsden, 2009, found evidence).

When we move to a polycentric case - reflecting either neighbouring cities within an authority or neighbouring authorities - then competition between cities and/or authorities may arise as described above. Issues of short-term destination changes and potentially longer term household and business relocation decisions thus need to be considered. The dynamics of this process are further complicated by the interaction over time between the potentially negative income effects and the positive “amenity” effects of ring-fenced spending of the income on improved alternatives to the car (Whitehead et al., 2005). The authorities too are involved in dynamic decisions about whether to instigate a charge, to amend an existing charge or to withdraw it.

In considering competing cities we then have to move away from the ‘central planner’ assumption and instead consider a high level process where there exists more than one high level decision-maker as described next.

4.2 Moving Beyond the Central Planner

In our research, rather than model the central planner alone, the city authorities are assumed to maximise the welfare of their own residents whilst taking advantage of tax export mechanisms by charging traffic from the competing authority. This mirrors at least some of the distributive cost and benefit concerns expressed by the interviewees.

The problem is posed as an Equilibrium Problem with Equilibrium Constraints (EPEC) which is a special form of a Nash game with a hierarchical structure. Figure 1 shows the structure of the problem where city authorities are the leaders, the policy variables are the cordon charges and the users are travelling on the network and are assumed to be resident of one of the cities. In the short term, the users form an equilibrium in terms of route choice at the lower level in response to congestion and changes in tolls while the cities seek an equilibrium at the upper level. In the longer term, other responses such as change of mode, destination or location may also be included in the model.

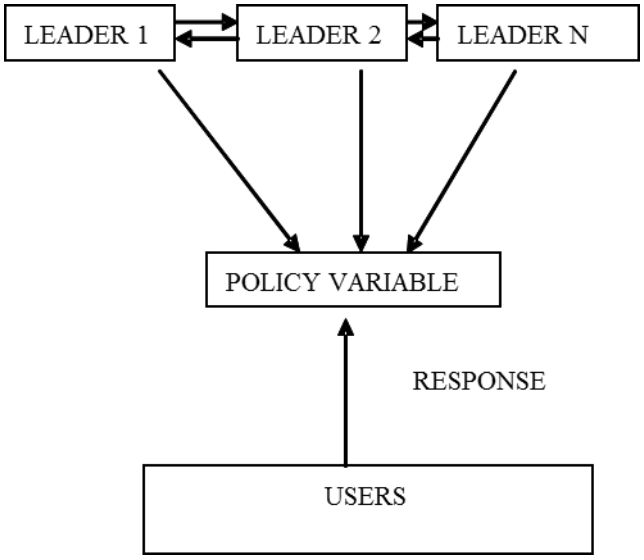

Figure 1 : Basic structure of the EPEC problem

Within the research we have used two forms of model. The first is a traditional network assignment model for private traffic only. This model represents traffic movements for a typical peak hour on a network between two hypothetical cities and is therefore only concerned with short term responses. It includes route choice and an overall demand response (represented by an elasticity of demand), which could be thought of as representing responses such as choice of time period, mode and whether to travel or not.

The second model adapts the Land Use Transport Interaction model MARS (Pfaffenbichler et al, 2010) to model two abstract cities (firstly identical and then representative of Leeds and Bradford in the UK). This LUTI model is a highly strategic model which includes all relevant modes of transport, two time periods/trip purposes and relocation decisions of residents and employers along-side the development of land over a 30 year period. It is therefore capable of investigating the longer term responses to charges set by each city.

4.3 General results from the modelling work

Space precludes a more detailed explanation of each of the modelling approaches. We summarise some of the key findings below, focussing on the differences that occur between symmetric and asymmetric cities, again seeking to capture a key variable of interest to the decision-makers. In order to keep the number of variables simple at this stage some simplifying assumptions were necessary.[3] The modelling exercises compare competition between cities with a coordinated regulator model. In the former, the revenues are assumed to stay within the authority where collected whilst in the latter all revenues may be redistributed among all residents.

Both models looked initially at symmetric cases where it was assumed that the cities were identical and that flows between cities were therefore identical. In both model applications reported in Koh et al, (2011, 2012) and Shepherd et al (2012), Balijepalli et al, (2012) it was found that when cities compete in terms of welfare, then there was the possibility that the outcome of the Nash game was a classic prisoner's dilemma whereby once the game starts

[3] In both model studies we make no assumptions about the use of any revenues raised from a cordon charge. We simply assume that all revenues collected are recycled back to the residents. There is no hypothecation of revenues to transport and we do not model any investment in transport which may arise from toll revenues. Whilst we do not model investment in transport schemes other than the cordon charge, residents and non-residents can benefit from time savings (if they are still travelling) and this would be counted in the welfare gain of their city even for travel on the other city's network.

both may end up worse off. That is to say that allowing competition between the two cities results in residents in both cities being worse off than under the no toll case. In addition the tolls under competition were higher than when only one city applies a toll.

Both modelling studies found that with a higher level regulator in place who is concerned with the overall welfare of both cities, then charges in both cities are lower than under competition and both cities are better off than with no tolls in place. As in this case both cities are assumed to be identical, then both cities have an incentive to co-operate or collude and move from the Nash competitive solution towards the regulated solution. In such cases, there should be no real problem in negotiating a regulated solution.

From the longer term MARS model, we also found that a small proportion of the residents would relocate in response to the tolls. Overall, the residents moved to the central zones to avoid the charge. Given that both cities were assumed to be identical then there was no net migration from one city to the other.

The models were also then used to investigate the same toll cases but with differing and asymmetric base conditions. Here the cities are assumed to vary in size and amenity, i.e. they now have different populations and workplace to population ratios. This was approximated with the network model by varying the level of demand between the two centres in the no toll case whereas with the MARS model, the different populations and workplace distributions between the cities were modelled directly.

In moving to the asymmetric case, we found that both cities are still motivated to charge if they were the only city to charge and that once again allowing competition increased both sets of tolls and reduced the welfare gains for the residents. The “stronger” or “more attractive” city was able to charge more than the other city in both models and imposing a regulator again reduced the toll levels while increasing welfare overall. This time there is however a problem in terms of incentives to co-operate or accept the regulated solution. Both models showed that the stronger city may have less of an incentive to accept the regulated solution (or no incentive) than the weaker city.

Further investigations with the MARS model showed that the effects are more pronounced with higher initial levels of interaction between cities i.e. if there are more trips between cities in the no toll case, then the impacts of competition are greater. It was also shown that if there is no initial interaction between cities, then the tolls are close to the regulated tolls and the cities may act independently. This implies there is a greater need for regulation or co-operative behaviour to reduce the negative impacts of competition when there is a higher level of interaction. However with this higher level of interaction, there is more to lose from the perspective of the stronger city.

Finally, in terms of location response, residents again moved towards the central charged areas, and due to asymmetry, there was a net movement of residents towards the “stronger/more attractive” city in all toll scenarios. Whilst this movement was only in the order of one or two percent of all residents, it still could be a cause for concern where cities are perceived to be in decline and given the known importance of fiscal revenue to local decision-makers.

5. Discussion and Conclusions

This paper presents a significant advance in the debate around the potential wider impacts of fiscal demand management. Whilst there are not many major congestion charging schemes in existence from which to observe the behaviour of city decision-makers we have attempted to being together the mental models that are held regarding fiscal demand management choice with new modelling tools that allow such concerns to be, at least partially, recognised.

It is important to state that competition between adjacent towns and cities does matter and is a feature in the type of strategies that the city decision-makers will adopt. In the interviews, the participants were looking for strategies that maximised employment and in particular high gross value added jobs. However, the basis for the decision-makers' preference for employment growth, whilst politically clear, were not well grounded in empirical evidence. The stronger cities were seen to lead, with smaller towns and cities gaining from spin off employment. Welfare gains for residents were mentioned as part of the decision-making process but less significantly. This is a little different therefore to the information that is used in the modelling tools we employed which focussed on welfare maximisation as a proxy for economic benefits.

The rationale for congestion charging largely revolved around the ability of the system to bring up-front investment and to secure a stream of on-going revenue for future transport system investment. In England, the upfront investment would be funded by the national government and this is therefore a major potential tool to steer system adoption. The realities of local politics and the costs of the introduction of such a system meant that major cities were seen to be critical in a decision to adopt whilst smaller towns and cities would take a cautions follower view as to the impacts of any scheme.

The modelling exercises highlight potential negative impacts overall and on any weaker cities if cities operate in isolation. Regulation or co-operation is preferred from the whole system point of view. Where one city is stronger than the other then this may not be the preferred solution for that city. Further research is necessary however to explore the extent to which this holds true when the travel to work area significantly extends into adjacent administrative areas. Typically, the investment packages that were discussed in interviews operated at a regional scale across the different cities. The reality is therefore that some form of co-ordinated solution may not just be desirable but also practically necessary (unless the funds to repay the schemes resulting from the charge were to be divorced from the spending plan for the region).

It also seems clear, although we have devoted little space to it here, that parking management is different to congestion charging. Parking supply choices and pricing choices are not always within the control of the public sector and parking supports commute, retail and residential uses whilst congestion charging is focussed on the commute. There are many more factors at play in parking competition decisions but there is evidence that weaker towns and cities do indeed focus on low cost competition. What is important for the broader implications of this work is that parking and congestion charging policies should relate to each other and be developed as a suite of policies. This will require further consideration of how to incorporate multiple motivations and usage classes into the decision-support modelling tools we have.

Our overall summary of the key theoretical expectations, how these map to decision-makers' motivations and how in turn these were represented in our modelling exercises is shown in Table 2. We conclude that it is possible and useful to establish a bi-level model that incorporates decision-makers' motivations as well as system level outcomes. Welfare benefits proxy for some important impacts. However, as the table shows, there are further factors which are important to decision-makers that are not captured in current models (e.g. public realm quality) or which go beyond the distribution of a series of exogenous inputs (e.g. competition for mobile investment) which may prove to be important if we are to really move to a position where the modelling tools provide information that closely matches the factors that decision-makers drawn down on. This study marks an important step towards identifying those factors and their relative priority for further investigation.

Table 2: Mapping empirical and modelling findings onto assumptions about congestion charging and competitiveness

Factor	Anticipated Impacts	Decision-makers perceptions	Modelling study
Creating an attractive built environment (Florida, 2005)	Demand management policies aim to reduce the extent to which urban environments are over trafficked and may therefore be beneficial.	Charges can help reduce detrimental impact of congestion. Investment of charges in public realm and public transport can improve quality of place and is more important than current appraisal processes allow for	This is not captured in the modelling tools applied and more generally difficult to quantify and model **Modelling gap identified**
Promoting Economic Growth (Lever, 1999)	Reducing congestion externalities increases user benefits and widens labour markets	Congestion charge can be used for public transport investment - supply side conditions to promote employment growth. Labour market logics were strong, congestion less so although these are clearly related.	Tolls can bring welfare gains whether set in competition with neighbours or collaboratively. Gains vary with relative differences between city size and level of interaction between the cities. **Welfare used as a proxy**
Growing public funds (Lever, 1999)	Major demand management policies important for acceptability. They also generate a revenue stream for future investment.	Collaboration within regions understood to improve prospects of securing public funds. Local arguments about fair, possibly non-maximising, distribution of those funds	Tolls contribute to public funds. Collaboration maximises overall welfare, but may not be to absolute benefit of each city. **Tools can be used for clearer political distributional analysis**
Competing for population (Lever, 1999)	Demand management policies may impact on the relative attractiveness of some areas relative to others due to charges (or exemptions)	Discussions focussed more on business movement than population movement.	Tolls can have some impact on population movement **Looks at redistribution rather than total population impacts**
Competing for mobile investment (Lever, 1999)	Reduced congestion may be attractive to industry, demand management policies may also encourage job relocation and deter investment.	Investment of income from charge in public transport and infrastructure might be attractive to inward investors. Weaker cities concerned about losses to other competitors.	Models take exogenous inputs of jobs and look at redistribution. **Volumes of inward investment not covered.**

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