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Evaluating the equity effects of road-pricing in the European urban context - the Madrid Metropolitan Area

Research highlights

1. Identifies an evaluation framework to assess the social impacts of road-pricing
2. Applies the framework to a proposed scheme for the Madrid Metropolitan Area
3. The increased economic burden particularly affects lower income individuals
4. Lower income drivers will reduce their use of the proposed tolled roads
5. This will decrease accessibility where there is no viable public transport alternative

Abstract

The paper identifies the potential spatial and social impacts of a proposed road-pricing scheme for different social groups in the Madrid Metropolitan Area (MMA). We appraise the accessibility of different districts within the MMA in terms of the actual and perceived cost of using the road infrastructure 'before' and 'after' implementation of the scheme. The appraisal framework was developed using quantitative survey data and qualitative focus group discussions with residents. We then simulated user behaviours (mode and route choice) based on the empirical evidence from a travel demand model for the MMA. The results from our simulation model demonstrated that implementation of the toll on the orbital metropolitan motorways (M40, M30, for example) decreases accessibility mostly in the districts where there are no viable public transport alternatives.

Our specific study finding is that the economic burden of the road-pricing scheme particularly affects unskilled and lower income individuals living in the south of the MMA. The focus groups confirmed that low income drivers in the south part of the MMA would reduce their use of tolled roads and have to find new arrangements for these trips: i.e. switch to public transport, spend double the time travelling or stay at home. More generally, our research finds that European transport planners are still a long way from recognising the social equity implications of their policy decisions and that more thorough social appraisals are needed to avoid the social exclusion of low income populations when road tolling is proposed.

Keywords: Road pricing, urban context, social equity, spatial equity, Madrid.

1. INTRODUCTION

The analytical focus for this paper is on how transport systems and access to them determine the participation of different social groups in everyday activities and/or lead to their social exclusion. Social exclusion perspectives emphasise the importance of ensuring that individuals are able to fully participate in the key economic, social and political activities of the societies in which they live (Levitas 2007). This conceptual framing has specific consequences for transport planning because it enriches the accessibility paradigm to include considerations of spatial and social equity.

Understanding the accessibility outcomes of transport policies and investments is becoming increasingly important issue for the field of applied geography, as well as for transport and urban planning practice within the local and regional context. The state-of-the-art for transport accessibility methodology within the academic literatures is towards the definition of measures of the (in)equality of access not only to the transport system itself but also to the access to key life activities and opportunities that these transport systems provide (Coutard, 2002; Carrasco and Miller, 2009; Páez et al., 2010; Lucas, 2010).

Until now, social equity considerations have not generally been well embedded within transport decision-making outside of the North America context. Even in the United States, the primary focus for such research has tended towards assessment of the environmental justice of major infrastructure projects and has been less focused on accessibility evaluation (see Geurs et al., 2010 and Levinson, 2010 for a more comprehensive overview of the relevant literature). There have been some notable exceptions to this in recent years, where wider accessibility criteria have been included within assessments (e.g. Casas et al. 2009; Paéz et al. 2010). Our own research focuses on the European urban context, where much less attention has been paid to social equity within mainstream transport policy evaluation.

The underpinning European transport policy goal is for all European citizens to be connected to public or private transport infrastructure and not be disconnected from key activity destinations against their will (Coutard, 2002). Our paper contributes to this line of enquiry by seeking to clarify the relationship between access to transport infrastructures and the social exclusion of individuals. In particular, a goal of the paper is to improve transport and urban planners' and policymakers' understandings of the transport inequalities that can arise from the introduction of metropolitan road-pricing schemes. We make the distinction between different degrees of (in) accessibility to the transport system by different social groups, living in different geographical locations and include consideration of latent or suppressed demand.

Our research is developed in response to a recognised need for new socio-political conceptualisations of mobility and accessibility in the context of the dynamic human geographies of cities (Graham and Marwin, 2001; Coutard, 2002). Transport and urban planners and other key stakeholders with a role in shaping the urban form of cities need new and improved methods and tools to assess the differential accessibility outcomes of transport policies and investments for planning preparation and policy development. These assessments can also help to encourage more sustainable patterns of travel in our cities by moving away from the current mobility-oriented to more accessibility-based goals for urban transport systems (Straatemeier, 2007).

Our research is based on a case study of the Madrid Metropolitan Area (MMA). Specifically, we have analysed different quantitative and qualitative datasets relevant to

an assessment of the consequences of implementing a proposed road-pricing scheme for the metropolitan area. We first compare the results from a quantitative travel demand model for the MMA before and after the hypothetical implementation of a road-tolling scheme on the M-40 ring road (see methodology section of the paper for more details of the model). We then use qualitative data from focus group discussions with local residents in two low-income districts in the south of the MMA (Getafe and Leganés) to understand how they perceive their travel might be affected by such a scheme (details of the focus groups design is also included in the methodology section of the paper).

A road-pricing example was chosen for the analysis because we can predict with some degree of certainty that this project has a strong potential to worsen the accessibility of poorer residents (Ramjerdi, 2006; Di Ciommo et al., 2011). As the Dresden (Germany) commuter pricing scheme has demonstrated, if toll revenues are not hypothecated to specifically improve public transport services (as well as the improvements explicitly directed towards low-income travellers) transport supply in the city will be more unequally distributed after the introduction of a road pricing toll (Teubel, 2000). Adopting the hypothesis of unaffordability, we can surmise that in the lower income urban areas the implementation of road pricing produces increased disparities in access to the road network infrastructure, with a higher economic burden on low income users.

The paper is organised in five sections. The second section—after this introduction—provides a background literature review of the theories and concepts describing the interface between transport, accessibility and transport-related social exclusion. Section three, describes the methodology we devised to estimate the risk of social exclusion for individuals arising from accessibility problems. In section four, we discuss the results of the simulation model concerning transport-related exclusion in terms of their (in) accessibility to key activities, differentiated by income and social status. The fifth section offers conclusions about the social exclusion implications of transport policies in terms of road-pricing policy.

2. A LITERATURE REVIEW ON ACCESSIBILITY AND TRANSPORT-RELATED SOCIAL EXCLUSION

In the transportation field, the notion of accessibility of public and private transport systems can be related to two key dimensions: i) 'spatial' i.e. relating to the location of housing, work, leisure and consumption locations and ii) 'financial', i.e. linked to the generalised costs, money and time budgets spent on travel (Flamma and Kaufmann, 2006). The literature identifies a number of potential indicators of spatial accessibility, including the proportion of individuals in the population who are within X minutes walking distance of a bus service, or the proportion of people who are within X minutes from a determined service, by public transport. Church et al. (2006) adopt a cut-off value of 400 meters as their buffers to measure the accessibility to a transport system. Kwan (1998) defines a number of cumulative opportunity indicators based on 20-, 30- and 40-minute trips.

In terms of financial accessibility, the literature focuses on how much an individual needs to spend in order to use the transport system, which can be also proportionately represented in terms of their monthly or annual income. In the development context, Salon and Gulyani (2010) have statistically demonstrated poverty to be strongly negatively correlated with the use of motorised transport. The authors identify that affordability is key to the transport poverty of people living in the townships of Nairobi.

Although certainly less dramatic, the situation in developed European cities presents an interesting parallel with developing countries. Almost every National Travel Survey (NTS) across the Western world identifies significant inequalities in the travel patterns, and access to transport of lower income populations in comparison to their higher income counterparts, and consequently to key economic and social activities (e.g. work, personal business, education, shopping, leisure, etc.). In part this is due to issues with transport affordability.

In particular, this phenomenon is worsened by a spatial mismatch between home and workplace locations (Lucas 2010; Wenglenski and Orfeuil, 2004; Coutard et al. 2002). For example, car dependency has rapidly increased amongst low-skilled and lower income people in European cities like London, Paris and Madrid. This is due to the simultaneous dispersal of home locations (in search of more affordable housing) and employment locations (due to the flight of jobs from many city centre locations and the physical fragmentation of local employment activities) (Monzón and De la Hoz 2009, Korsu and Wenglenski, 2010).

Banister (2002: 5) has argued that in this way, *'while the impact of road pricing on all travellers is progressive, the impact on low income car owners is regressive'*; i.e. it affects lower income people more. Davezies (2008) shows how currently lower income urban inhabitants tend to cross-subsidise rural infrastructures and services and thus, indirectly, pay for the privileges of higher income inhabitants. This also occurs in Spain where a long-term pattern of regional income inequality is apparent (Martinez Galarraga et al., 2013). This kind of unintentional policy consequence increases the problem of social exclusion, which is usually seen as a predominantly urban phenomenon.

Recently, the transport literature has considered not only the income affordability and the consequent re-distributional effects of road pricing schemes, but also time budget constraints and the issue of time poverty. Various authors have measured accessibility using space-time measures to recognise the constraints imposed by the demographic, social, economic and cultural contexts of individuals (e.g. Miller, 2003); Tribby and Zandbergen, (2012) have defined a multimodal, network-based model oriented to measure the accessibility, in the form of travel time, by way of public transport. Neutens et al. (2010) have used personalised measures of accessibility to identify spatiotemporal gaps in public service delivery for time- constrained individuals. In another article, Neutens et al. (2010) have evaluated accessibility measures using a regression model and have identified equal distribution of accessibility to out-of-home activities using Lorenz curve and Gini coefficient.These studies suggest that lower income women, are more time-constrained than men since they often combine work with caring responsibilities (Palma et al., 2009).

There is also an identified risk that road-pricing schemes may give less benefit to lower income people relative to higher income people, due to a general tendency for lower income people to have a higher marginal utility of money and lower values of time (Layard, 1977). This suggests that both the income affordability and time-poverty constraints resulting from road-pricing schemes could lead to greater transport inequity and related social exclusion.

One of the proposed ways to reduce these income disparities could be to use (at least some of) the revenues obtained to improve the public transport system. This is commonly referred to as 'hypothecation' within the transport literatures. The logic is that since people on higher incomes disproportionately use roads, this should help to

transfer costs to lower income individuals (Foster, 1974; Santos and Rojey, 2004). Small (1983 and 1992) has been suggested that hypothecated revenues from road-pricing schemes can be used to improve public transport alternatives, which can then (theoretically) serve to remedy any decrease in accessibility to the road network for lower income groups. He suggests this can be achieved provided that: a) the costs of toll collection are not too high and so no one pays; b) car dependency is reduced through modal shift; and c) a switch to other modes is not too expensive in monetary or increased travel time terms for current road users. Most of the discussions of the effects of revenue hypothecation have taken place in an American context, where car dependency is higher, even for low-income people (e.g. Schweitzer, 2009; Levinson 2010).

Some authors have taken the position that there can be less concern about the equity effects of road pricing in the context of major European cities like London and Stockholm. This is because the majority of lower and middle income residents already travel within the city mostly by public transport and so will be largely unaffected by the toll (Glazer & Niskanen, 2000; Santos & Rojey, 2004; Eliasson & Mattsson, 2006; Karlström and Franklin, 2009). However, empirical, post-implementation analysis of the equity effects of the London Congestion Charge suggested that its equity effects were more complex. In practice, there has been a mixture of potential 'winners' and 'losers' (both road and public transport users), characterised by a reduction of generalised costs for road users and decreased travel times for public transport passengers (Santos and Bhakar, 2006).

Two ex-post studies of the equity effects of the Stockholm Congestion Pricing Scheme have also re-calculated the expected welfare effects on different commuters across income, gender and mode using observed data on commute mode choice from a panel survey of households before and after the trial (Transek, 2006, Karlström and Franklin, 2009). The results showed the greatest burden of congestion pricing falling on the lowest and highest income groups. Work-hour flexibility was significantly associated with shifts to an earlier departure time, and this, in turn, was correlated with income. Higher income people demonstrated a more flexible work schedule that allowed them to more easily avoid the payment of the congestion toll (Karlström and Franklin, 2009).

3. THE MADRID CASE STUDY: DEVISING A MIXED-METHODS APPROACH TO SOCIAL EQUITY ASSESSMENT

With these background literatures in mind, our paper aims to address the two over-arching research questions regarding the accessibility and social exclusion effects of the proposed MMA road-pricing scheme:

1. How do the market effects, policies, funding and maintenance structures (i.e. road pricing) of the MMA transport system combined with its urban and land use organization affect the accessibility capacities and constraints of individuals who are already experiencing social exclusion?

2. Which social groups are most affected by social exclusion from transport and do they all experience similar or different accessibility problems with the transport system?

The literature has identified that there are three key causal factors in people's use of public transport: generalised cost, accessibility to the infrastructure network and the quality of private transport alternatives (Ortúzar, 2001). As Levinson has shown (2010), equity can be considered from various angles. One of the most common is "vertical or social equity", which can be understood as the equal or unequal impacts that result from the scheme on different population groups, distinguished according to income, gender, age, ethnicity and available transport options (Ramjerdi, 2006). The income level of users is one of the main variables considered in equity analysis, which can be translated into lower or higher levels of accessibility to the transport system. From a social exclusion perspective, the most usual disaggregations are also according to income, gender, age, ethnicity, as well as car availability (Preston and Raje, 2007).

In this analysis, we used a mixed-methods quantitative and qualitative analytical approach. Several previous studies of transport equity guide the 'mixed-methods' approach that we have adopted for our analysis (Mejía-Dorantes et al., 2011, Lucas, 2011, Martens et al. 2012). Here we bring together the combined results of two different quantitative and qualitative research studies:

i) A quantitative study to estimate a cost burden of a road pricing on road users, especially on lower income users (Di Ciommo et al., 2011, Martín et al. 2010). The quantitative analysis involved exploitation of the Madrid Mobility Regional Survey data using a micro simulation model (MARS) (Pfaffenbichler et al. 2008, Guzman et al., 2013). In the absence of individualised travel survey data, the model uses a generalised cost measure of accessibility (which captures both travel times and transport costs) disaggregated by low and high income areas to estimate the economic burden of a road pricing scheme on different road users.
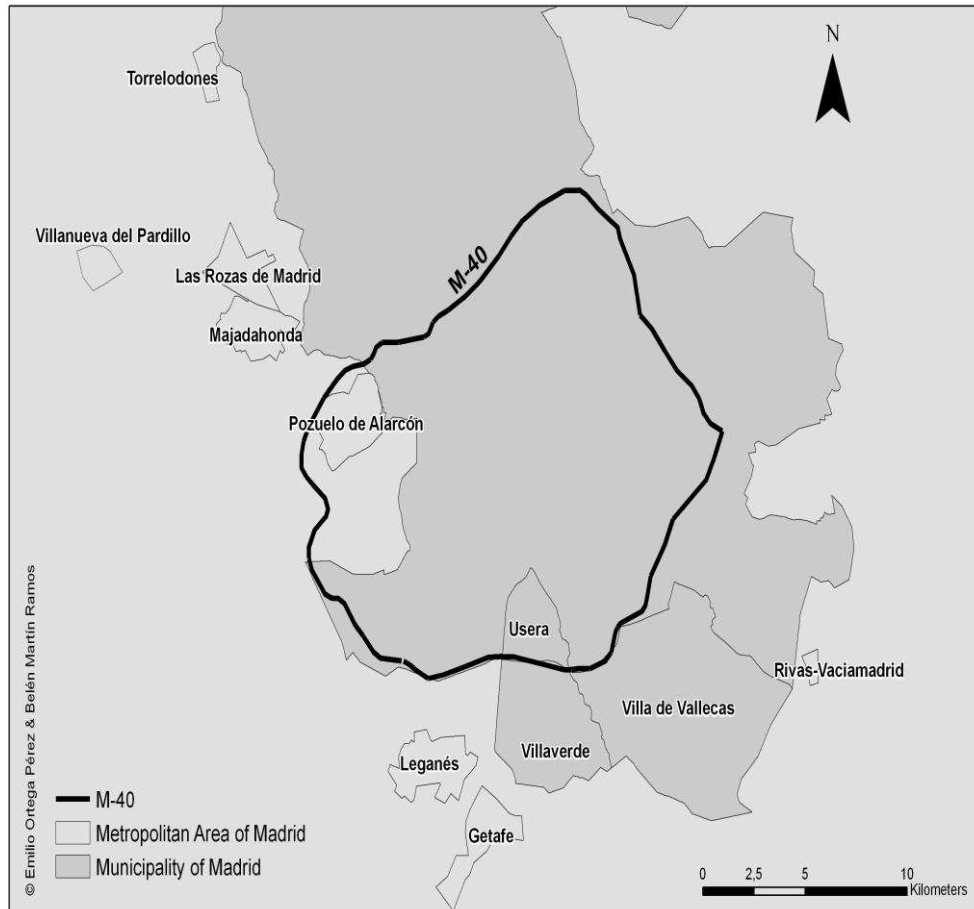
And

ii) Three, one-hour, focus groups with ten people in each group. The participants were recruited from two southern districts in the MMA, Getafe and Leganés. These areas were selected because they are characterised as having the highest travel time ratios between public transport and car (1.62), and the lowest average personal monthly incomes (943€ and 880€). The focus group discussions were used to identify people's access and use of private and public transport, and to qualitatively assess the potential impact of the proposed MMA road-pricing schemes on their travel patterns, levels of accessibility and social exclusion.

3.1 Quantitative modelling of the accessibility and the affordability effects

Scenario design

The simulated road-pricing scenario for the model is based on a hypothetical orbital road cordon on the M-40 metropolitan orbital highway (see figure 1). The scenario copies one of the most popular congestion pricing policies as used in cities in Norway (such as at Trondheim and Bergen) and in London and Stockholm. The vehicles are charged when entering or exiting the city centre, with higher charges during peak periods. It is generally assumed that a cordon toll scheme such as this discourages orbital diversions, achieves higher traffic flow efficiency and provides environmental benefits from deduced air pollution.

Fig 1: Map of Madrid Metropolitan Area and M40 ring

The M-40 is the main metropolitan ring surrounding Madrid. Its total length of 63.3km loops around the city at a mean distance of 10.1 km to the city centre. It is the only one of the several ring roads serving Madrid that functions as a fully-fledged motorway for all of its length. The highway is characterised by an increasing number of car-based trips, several congested sections, inadequate public transport alternatives and a general difficulty for people to time-shift their trips. An access toll scheme is simulated during the peak hour, capturing mainly the workplace and school trips. The toll is set at all the key entry points to the inner ring delimited by M40 and at the links of the M40. The access charge in the scenario is set at 3 €/vehicle.

Income disaggregation

To analyse the monetary impacts of the MMA road-pricing scheme, we first identified the users who would be most sensitive to the pricing policy scheme, characterised by the lowest per capita incomes by districts within the MMA in which they live. Specifically, we selected five districts in the south with the lowest average monthly incomes per capita and five districts in the north with the highest average monthly incomes per capita, as shown in table 1.

Table 1: Income of the M40 users of southern and northern congested sections

Southern Districts	Average monthly income per capita (€)	Northern Districts	Average monthly incomes per capita (€)
Rivas Vaciamadrid	1187	Pozuelo de Alarcón	1903
Getafe	943	Las Rozas de Madrid	1719
Villa de Vallecas	944	Majadahonda	1696
Leganes	880	Torrelodones	1646
Villaverde	830	Villanueva del Pardillo	1251

Road user characteristics

The users of two most congested sections of M40 are characterised by three main factors:

1. Dependency on the car because of the radial form of the public transport networks and the urban sprawl of workplaces and residences that jointly increases the travel time ratios between public transport and car (1.62 in average).

2. Travel motives identified basically by work, school or accompanying other people - mainly children - to school (i.e. obligatory travel purposes, around 90% make it difficult to shift the time, and lessen the congestion during the peak hour).

3. Perceived cost by users of public and private transport modes. Three focus groups were held in the southern east area of MMA to detect the perceived cost.

The travel time ratios between northern and southern districts of MMA are currently very similar. However, a future implementation of a road pricing scheme could change the starting situation and produce a worse situation for southern low income areas.

Model description

We employed a travel demand model for all mode travellers for the main transport networks of the MMA, using the roads during the peak hour (7-10 a.m.) of weekdays. Demand modelling deals with traffic conditions, as determined by people's daily travel behaviours (De Palma et al., 2006). The adopted simulation program (MARS) is implemented in 'Vensim', which is a system dynamics programming environment, based on analysis of speed versus origin and destination (O&D) demand relationships. This includes speed-flow functions that simulate the current transport network.

These functions are calibrated for the Madrid transport network with the VISUM® specialised transport model, which comprises of the main transport networks of the Madrid region. MARS-Madrid was specifically developed to simulate the future development of the transportation and land-use over time. The model is able to support policy evaluation and scenario testing over short, medium and long-term horizons. It uses the concepts of causal loop diagrams (CLD) from the system dynamics, which

provide the basis to study the cause and effect among the variables of the transportation system and the land-use (table 2) (Guzman et al. 2013).

Table 2: Main Features of LUTI Model

Model Feature	MARS-Madrid Model
Number of zones	90
Travel modes	Car, transport public (bus and rail), soft
Congestion effects	OD-specific speed-flow curves for trips V/C ratios)
Generalised costs	In-vehicle time, access/egress time, parking search time, waiting times, transfer times, car costs, PT fares
Journey purposes	Commute, others
Household features	Employed population, car ownership, household income
Mode and destination choice	Simultaneous choice
Demand response	Commute trips inelastic. Constant time budget
Land-use response	Yes

Source Guzman et al. 2013

Model Calibration

An origin–destination matrix (O-D matrix) for the rush hour was obtained from the 2004 Madrid Region Mobility Survey (CTRM, 2006), which was conducted with about 35,000 families in the Madrid region who were interviewed about their daily trips. The O-D matrix was calibrated by using 394 data points of traffic flow from the Ministry of Transport and Infrastructures (Ministerio de Fomento, 2004.), the Regional Government of Madrid and the Council of Madrid (Ayuntamiento de Madrid, 2006). Table 3 identifies the current modal split of trips within the MMA.

Table 3: Modal split calibration data

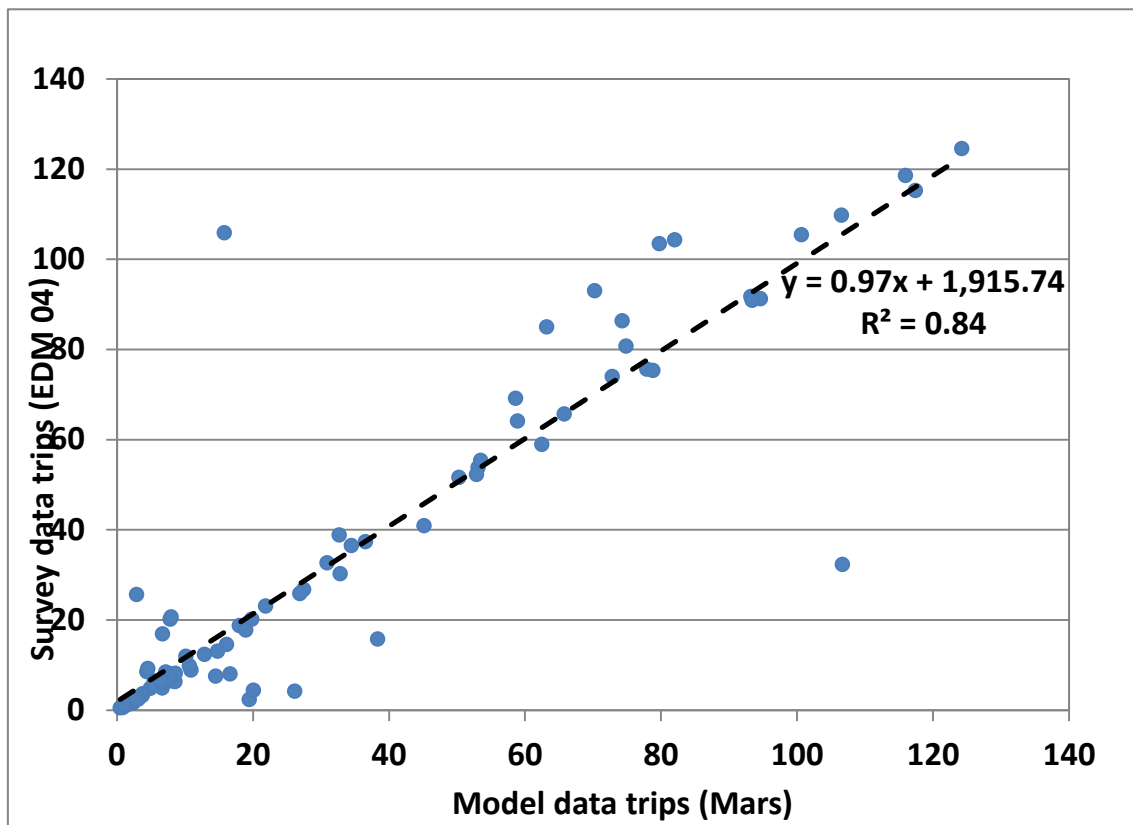| Mode	Commuting trips %	Other trips %	Total %
Walk/cycle	12.3	24.2	20.5
Bus	15.7	18.2	17.4
Rail	26.3	19.3	21.5
Car	45.7	38.3	40.6

Source Guzman et al. 2013

An extensive model-testing program was performed. In a back-casting exercise the MARS simulation results were compared with empirical data. An equilibrium algorithm

was used for assignment, which means each user selects the route and the mode of least generalised costs; in our case, the generalised cost function includes travel time, operation costs, and the cordon toll. Different statistical methods and indicators were used to measure the ability of MARS to reproduce the historical Viennese developments.

Figure 2 shows the dispersion of the model data and survey data. For comparing the real observed data from the mobility survey in year 2004 and the model generated data, we obtained a quite accepted result, which the gradient of 0.97 is a satisfied figure and the correlation coefficient R^2 is also quite good (0.84).

Figure 2: Trip Generation Calibration between MARS model and Survey data

Source Guzman (2011)

We then calculated the estimated economic burden of the road-pricing cordon on the lowest revenue area of MMA (i.e. southern area) and on the highest revenue zone (i.e. northern area). In this way, we analysed the accessibility effects of a metropolitan road toll on users with different levels of income in areas with the same levels of road congestion. The discussion of results is presented in section 4 of this paper.

3.2 Qualitative study of inhabitants' perceptions about the Madrid transport system

The focus groups were conducted in two southern districts characterised by the two lowest travel time ratios between public transport and car (1.62), and by the lowest individual monthly incomes (943€ and 880€), Getafe and Leganes (see Fig.1). The aim was to test people's perceptions of transport affordability in respect to its generalised costs, including the ratio of time between public transport and car. The focus group

discussions took place between May and June 2011. The participants of the focus groups were recruited by distributing invitations to people using any of the public and private transport modes or walking around the stations of public and private transport infrastructures. We also left leaflets at coffee shops, restaurants, shops, apartments and at the University.

We conducted three different one-hour focus group sessions comprising around 10 participants in each in order to capture inhabitants perceptions of various aspects: the condition of the public transport in the area, the effects of a new road pricing implementation and the suitable design of a transport fare. We had a diverse profile of people attending the sessions: professors/students at universities, professors/students at high school, unemployed people, policy makers, transport authorities, researchers, among others. All participants also completed individual questionnaires with socio-economic data and trip information for their current patterns of travel within the MMA.

4. ANALYSIS OF RESULTS: ACCESSIBILITY AND THE RISK OF SOCIAL EXCLUSION

In this section of the paper we discuss the main findings from our evaluations of the effect of the proposed MMA road-pricing scheme based on this mixed-method approach. We first discuss findings from the modelled analysis and then complement this with analysis of the qualitative data from the focus groups. We bring together the findings of both in the final section of the paper to draw conclusions and make recommendations for the assessment of future road-pricing policies.

4.1 Findings from the quantitative study

Spatial analysis

The geographic and institutional unit considered is the district because it is the most stabilised territorial unit. Ideally the analysis would be carried out first at low income and rich areas and then consider the circumstances of different individuals living within these areas in order to identify winners and losers. However, in the absence of this individual level data we use deprived areas as a proxy for social inequality, although we recognise this is a somewhat sub-optimal approach.

Modal shift analysis

Analysing the modal shift effects of introducing the MMA road-pricing scheme, it is possible to identify that the outcomes are similar to the spatial analysis. People living in the low income southern area who shift to public transport after the introduction of the scheme (i.e. 25% of the previous M40 users) will experience an increased generalised cost and an additional burden on their average per capita incomesof between 11% and 17% (table 4). While, the people living in the northern upper income area and shifting to public transport after the introduction of the congestion pricing (i.e.15% of the previous M40 users) will support a lower increased generalised cost and an additional per capita income between 8% and 13% (table 4).

Of additional note is that the road users who must pay most for the road toll (i.e. 12% of their income) are also the same people who are most likely to give up its use. Furthermore, even if the public transport system is less costly in monetary terms it is less efficient in journey time costs, as demonstrated by the travel time ratio between public transport mode and car mode (table 2). As such, these people living in these low

income areas also experience increased generalised costs because of their additional journey times. This is because the people who 'give up' the tolled highway have to change their mobility strategies; i.e. reduce their use of the tolled roads and find new arrangements for their trips. The choice is either to spend double time for their commuter trips by switching to the public transport or to not make the trip and simply stay at home – a double disbenefit with serious connotations for encouraging their social exclusion.

Table 4: Travel choice change after toll in southern and northern selected districts

Southern districts	Car share before %	Car share after %	Northern districts	Car share before %	Car share after %
Villa de Vallecas	39.17	18.97	Pozuelo de Alcarón	37.74	21.40
Getafe	44.26	21.48	Las Rozas de Madrid	47.68	32.44
Villaverde	35.57	15.12	Majadahonda	35.60	23.72
Rivas Vaciamadrid	57.33	32.98	Villanueva del Pardillo	85.10	75.60
Laganes	44.26	20.79	Torreldones	82.79	74.68

Affordability analysis

The income disaggregated area-based modelled outputs from the MARS-Madrid clearly demonstrate increased levels of generalised costs to access and use the MMA highway network. Categorising road users by their alternative travel route choices (--, A) leaving the M40 and using an alternative less costly path, B) continuing as users of the M40, or C) becoming new users of the M40. An analysis of the burden of the road pricing shows that the new charge to use the metropolitan highway affects the average annual incomes of the lowest income groups most. Table 5 shows that people with higher average monthly per capita incomes 1,000€ per month are affected by a range of 9% (for new users and still using the highway) and 12% for giving up its use, whereas people with higher income levels suffer an additional burden of between 6.2 – 6.6%.

Table 5 - Toll-ring burden on the income of the M40 residents

Southern Districts	Monthly income per capita (€)	Income Burden variation (%)	Northern Districts	Monthly income per capita (€)	Income Burden variation (%)
Villa de Vallecas	944	11	Pozuelo de Alarcón	1903	8
Getafe	943	17	Las Rozas de Madrid	1719	9
Villaverde	830	13	Majadahonda	1696	9
Rivas Vaciamadrid	1187	17	Villanueva del Pardillo	1251	13
Leganes	880	17	Torrelodones	1646	9

4.2 Findings from the qualitative study

Three key findings emerged from our subsequent analysis of the group discussions.

Firstly, participants confirmed that they perceive price as a key factor in their choice of whether to use private or public transport. People living in the southern districts pay a higher price for a monthly public transport ticket and perceive it as an exclusionary factor because of their poor connectivity with the centre of Madrid. Secondly, they suggested a problem of connectivity inside of the southern districts. Some new public transport infrastructure projects like Metrosur, for example, have only solved the problem of the connectivity between districts, and even then not always very effectively (Mejía Dorantes, 2011). Thirdly, the private car transport was described as a big competitor of public transport in terms of its travel time ratios, specifically for the people living outside of the southern districts and working in these districts. A lower fare price could incentivise these people to choose public transport instead of the car.

It was interesting to find there were similarities in points of view across the different focus group sessions, although they involved different social groups. Students and unemployed people were more aware of transportation monetary costs and fare limitations:

> Fifteen years ago, when I was working in Switzerland, I was gaining the same revenue I could get now in Spain. It is true that the current price for a public transport ticket in Madrid could be between 30% and 100% lower than other European countries, but the minimum salary is also between 50% or 100% lower than other countries. [Unemployed female, 35-45 years, Getafe]

There was a difference in people's perceptions depending on their age: older people perceived a public transportation improvement in this zone while younger people did not observe this. For example, regarding timetables, older people still remembered the time when if you missed your train (Cercanias) you would have to wait a long time for the next one. Now the frequency has notably increased, almost on a par with the Madrid Metrosur service. These journey time reductions have increased the use of public transport, although there are still issues with the price of fares:

Years ago, when Metrosur was not into operation, if I had to go from Alcorcon to Leganes, I had to go to Madrid first using the commuter rail line, therefore, Metrosur has reduced the travel time although there are issues with the price that I do not agree with". [Student male, 19 years, Leganés].

It was interesting to note that most of the participants wanted a public transport network that fully connected the five main towns to Madrid City Centre with radial routes rather than the single circular route that is currently available via the Metrosur. When we told them that the commuter rail line is already offering this service, and after re-thinking the problem, they said that the problem is that rail is not part of the metro system and so not properly integrated because they have to pay for separate ticket. This lack of fare integration was what the majority of participants pointed out as most important to them in terms of their use of the public transport. Actually, in Madrid fare integration is possible with a monthly or annual ticket. The use of different network transport systems (i.e. metro and regional railways) is much more expensive than the use of a single mode. The basic fare system is based on Pay as you Live. To live far away from the centre means to pay a higher price especially in the case of a single ticket.

Students and unemployed people have a combined ticket to make use of different transport services (commuter rail, bus and metro) at certain times. However, the Transport Authority of Metropolitan region of Madrid, does not offer a decreased fare in the south-east area because it is not seen as cost effective. Recently, the authority introduced a combined ticket at certain times for interchanging between urban buses within 60 minutes inside of the city of Madrid. The periphery of the MMA was excluded from the new fare measure. This has an effect of excluding people in the south-east of the MMA from activities in the city centre. In the words of one participant:

The public transport in the south is fine but it does not take you everywhere. For example, I am unemployed, and if I have to go to a job interview in the industrial part of Getafe, I have to take the Metro from Alcorcon (where I live) to go to Getafe and then wait to the bus, which does not have a high frequency, therefore it takes me years to get to my final destination plus I paid for four rides". [Unemployed male, 45-60 years, Getafe]

This shows how the high price of the ticket compromises accessibility to a new job. Another unemployed person who attended the meeting agreed and added:

"Actually I even used the car to come to my employment search meeting because it was faster and cheaper than taking other transportation modes". [Unemployed female, 35-45 years, Getafe]

Therefore people on very low-incomes living in areas that are served by the MMA road network are highly car dependent and so likely to be highly negatively affected by the introduction of the road-pricing scheme.

5. CONCLUSIONS

The combined evidence from our quantitative and qualitative assessment of the MMA transport system before and after the hypothetical introduction of a proposed road-pricing toll on the M-40 ring road allows us to draw some important conclusions about its spatial and social equity. We would note that what we have achieved with our study

is not rocket-science in terms of its methodological advancements. In many ways that is the whole point of our study. We made use of the MARS-Madrid standard travel demand model,which could beutilised by transport planners in their decision processes. Simply by running the model for different areas of the MMA disaggregated by the average per capita income of each area, we have been able to demonstrate that significant inequalities of outcome could potentially occur from implementation of the proposed toll scheme. We then used further qualitative evidence from focus groups with residence in the areas most likely to be negatively affected to confirm the perceived consequences for low-income residents of implementing the toll scheme. This not only demonstrated the potential inequity of the scheme itself but also the inadequacy of any proposed transport alternatives for meeting the accessibility needs of local people.

A particularly novel contribution of our research is that it has empirically demonstrated the regressive nature of road pricing schemes even in a European context where, theoretically, car dependency amongst low-income population is much lower and their access to public transport is much higher than in the North American context. It is not our intention to advocate that road-pricing schemes should not be introduced to relieve traffic congestion in cities, but rather that policy makers need to be more alert to the potentially negative social equity effects of such schemes and more actively seek to ameliorate these effects through appropriate "compensatory measures".

Firstly, we have demonstrated that changes in the level of access to transport systems caused by the proposed scheme combined with an expensive and inefficient public transport fare system would produce a very real risk of reduced accessibility and could serve to exclude some lower income individuals from the transport system entirely. Road pricing inevitably increases the cost of travel for all drivers but this will disproportionately affect low-income drivers. The model simulation results from the road pricing- scenario on the M-40 demonstrated a clear inequity of outcome for people living in low-income areas in the southeast of the MMA (the generalised costs increased by 11% for higher income users and 17% for low income users).

Secondly, we have identified that the proposed MMA toll scheme would significantly increases the travel time budgets of low-income drivers. Drivers who 'give up' the M-40 would have to find new arrangements for their commuting trips. This could be achieved by reducing their use of the toll roads and either spending more time for their journeys by public transport or by making less trips. In this case, an important relationship between accessibility and social exclusion is found (people have less opportunity to travel, reduced physical access to new job opportunities and thus less time to participate in life enhancing social activities).

Thirdly, we found that lower income people would not only be adversely affected by the decrease in accessibility brought about by the proposed scheme but also from the longer journey times of the public transport alternatives. In this particular case, unemployed people living in the poorer south east of the MMA would be especially negatively affected. However, social equity issue is universal for every congestion-pricing project planned and implemented and our study only serves to demonstrate that how and where to set up the toll, how the toll is collected, and what is the potential benefit (in travel time and monetary value) is highly context specific.

One of the key lessons to draw from the research from the perspective of applied human geography is that spatial and social equity assessment is still far from common practice

in the transport planning practices of many European cities. Urban transport planners and transport policymakers appear to be particularly prone to ignoring the negative and potentially punitive social consequences of their policy actions. Aggregate models of travel demand such as MARS-Madrid are regularly used to predict the likely travel impacts of major transport policy decisions within cities such as Madrid. Yet despite the relative ease of interrogating the differential social consequences of these impacts for different population sectors and different areas of the city region (as we have demonstrated) this rarely occurs in practice. There is, thus, an urgent need to find better ways to communicate state-of-the-art research findings on the social equity of transport policies to the world of applied urban policy and planning practice.

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