Research in Transportation Economics 62 (2017) 25–36

Contents lists available at ScienceDirect

Research in Transportation Economics

journal homepage: www.elsevier.com/locate/retrec

The new public transport pricing in Madrid Metropolitan Area: A welfare analysis

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ARTICLE INFO

Article history:
Received 31 August 2016
Received in revised form
7 December 2016
Accepted 14 February 2017
Available online 24 February 2017

JEL classification:
H20
H71
R21
R28
R48

Keywords:
Public transport
Welfare
Pricing policy
Household
Urban transport
LA/AIDS models

ABSTRACT

In a context of economic crisis, the amount of the demand public transport subsidies in Madrid has been reduced to control the level of public deficit. This has implied a worsening of public service quality and an increase of public transport prices. Using the Spanish Household Survey, this paper analyses the impact on welfare generated by the increase of public transport prices in 2008–2012. For this price and income elasticities have been computed using an LA/AIDS model. Price public transport elasticities are low (around −0.1%) and only significant for the years of the highest price increase. Fuel is substitutive for public transport with a cross-price elasticity of 0.25% and the other goods consumption is almost independent of the consumption of public transport with a cross-price elasticity of 0.06%. The results of income elasticies prove that public transport is a normal good. Results show that this new policy has harmed with a similar impact, low and medium income households. Those households have supported an average loss of welfare of 3.66% of their income. The welfare loss supported by the richest households is 1.5% of their income, which represents only a 40% of the average costs supported by the rest of households.

1. Introduction

Regional and local authorities of Madrid have focused their resources toward the supply of an integrated, high-quality public transport system in Madrid Metropolitan Area.[1] Having reached that goal, Madrid City Municipality and Madrid Regional Government presented their public transport policy as one of the main achievements of their administration.

On the one hand, this transport policy has consisted in a strong public investment aimed at expanding public transport infrastructures, especially the underground network. In 1995, Madrid underground had 120 km of tracks and 164 stations. In 2009, 287 km of tracks and 291 stations were reached, which is the current network size. During these 14 years, the underground network grew 139%. The Madrid underground system is now the second largest in Europe following the London Underground.

On the other hand, the abovementioned policy was focused on subsidization of operational cost via fares. Thus, the price of public transport in Madrid has been traditionally low as a result of the high level of subsidization of fares (Vassallo, Pérez del Villar, Muñoz-Raskin, & Serebrisky, 2009). The only ticket type that covered the operational costs per trip was the single ticket (single ticket use represents approximately 9% of total trips).[2] Moreover, the fare increase which took place when the network was being expanded proved to be insufficient to cover the ever-increasing operational costs.[3]

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[1] Madrid Metropolitan Area corresponds to Madrid Region, where there are many medium and small towns economically and demographically connected to Madrid city's dynamism.

[2] Operational costs exclude infrastructure investments.

[3] Due to the indirect costs related to the massive investments carried out on the underground network and the increase of labour cost caused by the fast increase of real income.

http://dx.doi.org/10.1016/j.retrec.2017.02.005
0739-8859/

One of the direct consequences of such a public policy is that Madrid had in 2010 the highest public transport usage ratio compared to 21 other European cities, and the degree of satisfaction found among public transport users reached a level of 78% (Muñoz-Miguel, Simón de Blas, & Jiménez Barandalla, 2014, p. 114). From this perspective, Madrid's transport policy has been successful. But the long-term sustainability of such a high subsidization policy, both of infrastructures and fares, has been questioned by academic works such as those of Matas (2004), García-Ferrer et al. (2006), and Vassallo et al. (2009).[4] Nevertheless, Madrid authorities maintained their public transport policy, in view of user's high appraisal and claiming it would have a positive impact on social welfare and equity. As Serebrisky et al. (2009) pointed out this last argument is one of the two major premises all over the world to implement subsidy policies on public urban transport,[5] and the aim of this premise is to improve the welfare and the mobility of the poorest.

The economic crisis and its consequences on public budgets forced Madrid authorities to finally cut off public transport subsidies: (i) freezing capital investment, (ii) reducing operational costs. The reduction of operational cost has consisted of: reducing subsidization to fares -public transport prices have strongly increased since 2008 and offering an inferior level of service. For instance, 22 urban bus lines have been cancelled and the frequency of both the underground and urban buses has been reduced.[6] Then, since 2008, public transport has been the object of lower investments and reduced operational costs with a significant fare increase, thus the level of subsidization has been reduced.

This paper attempts to analyse the impact of public transport price increase (as one of the factors allowing a lower level of public subsidies to public transportation) on household and welfare in Madrid Metropolitan Area. In fact, our work is focused on the increase of prices of urban and interurban transportation means of public property, then our model is estimated using the expenditure in travel pass and multi-ride tickets. The users of these tickets are the frequent and very frequent users of the means of transport subject of this work.[7] Moreover, this study is focused on welfare costs generated by public transport price increases on households where the breadwinner is under 65 years old. The reason is that public transport fares for the population over 65 had usually been very highly subsidized, and the new public transport price policy implemented has maintained this high level of subsidization.[8]

To the best of our knowledge, there is no academic or institutional research that has analysed the impact of Madrid's public transport policy on welfare,[9] so this paper addresses this void of knowledge. Moreover, it will shed light on the trade-off between public financing and welfare, even more considering that it focuses on a period of deep economic crisis. From a methodological perspective, this work is carried out in two stages. In the first stage, we use an Almost Ideal Demand System (AIDS) model to compute household's behaviour on consumption of public transport, automotive fuel (as a measure of private car usage) and the rest of goods. From there we estimate own-price, income and cross elasticities of the demand of such goods. In the second stage, we use those elasticities to compute the impact that the increase of public transport prices has had on welfare year by year from 2008 to 2012.

This paper is structured as follows. The next section is dedicated to the Madrid Metropolitan Area Public Transport System and its new pricing policy. A review of the existing literature on public transport demand estimation is presented in section 3. The specification of the model and data are shown in the fourth section. The estimation and discussion of the results of the first-stage analysis, then transport demand estimation, are shown in section 5. The sixth section focuses on the results of the second-stage analysis, thus on the impact of public prices increase on welfare. Conclusions are presented in the last section.

2. Description of Madrid Region public transportation system and its new pricing policy

2.1. Characteristics of the public transport system in the Madrid Metropolitan Area

Following the example of other European cities, Madrid authorities decided in 1985 to implement an integrated public transportation system. The result of this decision widely reached its main objective: to boost the use of public transport. In fact, the number of passengers using public transport in Madrid has grown from 951 million in 1986 to 1.429 billion in 2012, this means an increase by 50.3% (Consorcio Regional de Transportes de Madrid, 2013a). At the same time, the total populations increased from 4.879 to 6.495 million of persons, so by 33.1%.

The new public transport system was based on fostering integration in three levels: public authorities, fare and modal (Vassallo et al., 2009, p. 264). The first level of integration resulted in the creation of a public entity called "Consorcio Regional de Transportes de Madrid" (CRTM) that is owned by the regional government. This new entity assumed many of the roles assigned to public transport that were dispersed in a set of public institutions. The second level of integration supposed the most significant change introduced by the new policy strategy. It consisted of an integrated fare system for the whole public transport network in the form of a travel pass (there is a normal travel pass, and specific ones for population under 26 and over 65). The third level was the physical integration of transport modes. Large infrastructure investments have been carried out to improve the physical connection between modes and extend the bus, underground and rail networks. In this respect, during the years prior to the economic crisis the improvement to the underground infrastructure was remarkable.

The public transport system of Madrid is based on four transportation modes: urban buses and underground that serve basically the city centre (ring A) and, in the case of the underground, also some suburban towns (located in ring B); commuter trains and interurban buses serving the entire region. Underground and urban buses are public companies controlled by local authorities. Urban buses are 100% managed by Madrid municipality, whereas the underground is managed by Madrid municipality (75%) and by Madrid regional government (25%). Commuter railways are property of the Spanish Railway Company (RENFE) owned by the central government. Interurban buses are mostly privately owned. The operation of each interurban bus line is conducted independently

[4] In fact, from 1995 to 2007 the public expenditure of Madrid Region Government in public transport policies was behind this Region public indebtment, which was growing year by year. For this reason the authors quoted, guessed in their works that this high expenditure policy could not be sustained for a long time.

[5] The other premise is to subsidize public transport as a way to internalize private transport externalities, and so to make transport sector more efficient.

[6] For example, in the case of the underground the average frequency has been reduced by 14% and as much as 50% night, and closing time from Monday to Friday has been shortened from 2.00AM to midnight.

[7] Moreover, the survey used to estimate public transport demand in Madrid region doesn't offer disaggregated data for the single ticket.

[8] A person aged over 65 could in 2008 travel all around the Madrid Metropolitan area for 10.5 Euros per month, since to do so people under 65 had to pay 76.6 Euros. In 2012 these fares were respectively 11.8 and 94.9 Euros. So in fact, the relative price of public transport for older of 65 has been reduced in the period analysed representing 13.85% of the normal price in 2008 and 12.4% of it in 2012. Others authors follow a similar methodological approach, for example, West and Williams (2004).

[9] The only work focused on measuring equity impacts of public transport subsidies for several Spanish cities is the paper by Asensio et al. (2003). Using data for the period 1990–1991, they found that subsidies were progressive.

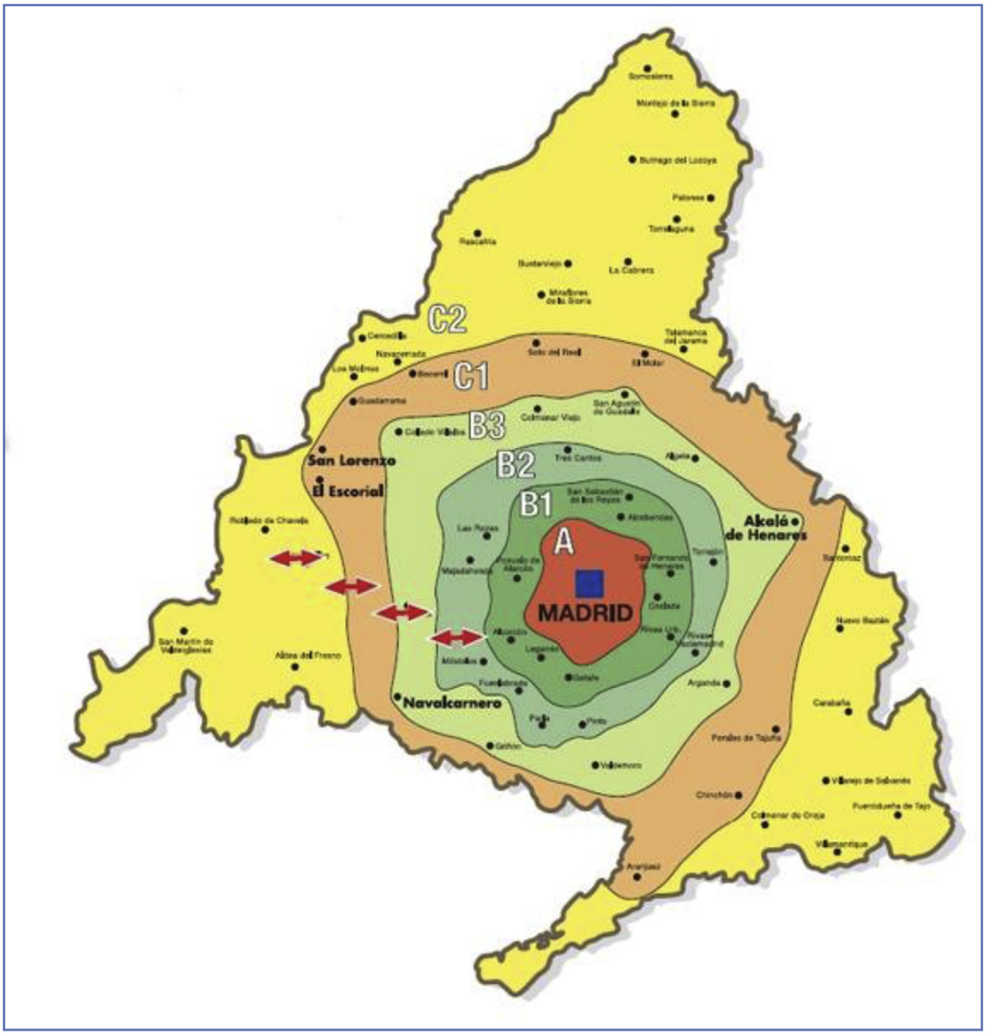

Fig 1. Madrid metropolitan area.

under an exclusive concession contract with the CRTM.

In order to establish different transport fares, the CRTM has divided the region in 6 areas shown in Fig. 1: ring A, ring B divided in 3 zones (B1, B2 and B3) and ring C divided in 2 zones (C1 and C2). Madrid city (ring A) is in the centre and represents 50% of the total population; ring B includes a set of small and medium cities that represent 43% of the total population; ring C includes several small towns which account for around 7% of the total population. Approximately 63% of jobs are located in Madrid city (Méndez-Gutiérrez del Valle, 2012). The highest employment densities are concentrated in ring A and in some of the northern municipalities located in ring B (García-Palomares, 2010). The distribution of residential areas and employment centres give rise to an urban structure that predominantly follows a monocentric model with radial trips from satellite settlements to the city centre. For example, in 2011, 43.4% of trips were made using the underground and 28.6% by urban buses (Consorcio Regional de Transportes de Madrid, 2013a) so most of the traffic was concentrated in ring A. Moreover, Madrid city was the origin and destination of 42% of the trips made by public transport (Ayuntamiento de Madrid, 2014).

The fare system consists of three types of fare: a single ticket, a ten-trip ticket (multi-ride ticket) and a travel pass. The travel pass is the most widely used ticket because public transport users can make unlimited trips within the fare area (the supply is perfectly elastic). It constitutes an important implicit subsidy for very frequent users (Vassallo et al., 2009). In fact, the more the users travel the smaller the average price they pay for trip; in other words, the more they travel the bigger the subsidy they received.

These authors calculated that the travel pass price covered only 37% of operational cost. However, this subsidy has decreased in the last years as a consequence of budgetary cuts. In 2012, 70.5% of public transport users travelled with a travel pass, 18.7% with the ten-trip ticket, and 9.2% with the single ticket (Consorcio Regional de Transportes de Madrid, 2013a).

2.2. A brief description of Madrid Metropolitan Area economy

The Metropolitan Area of Madrid is one of the most leading demographic and economic areas of Spain. In 2012, Madrid region had a population of 6.49 million. Between 1995 and 2008 its demographic growth[10], economic expansion and the level of concentration of big companies and advanced services made it the largest economic metropolitan area in Spain and the third largest in Europe (Méndez-Gutiérrez del Valle, 2012).[11] Households with the highest income levels are concentrated in Madrid city and in a few

[10] Mainly due to immigration.

[11] In 2012, its GDP per capita represented 128% of average GDP per capita in Spain, and 135% of average GDP per capita in Europe. (INE).

medium-size cities located within 40 km to the North and to the West of Madrid (in ring B). In 2011, the average income per capita in Madrid city was approximately 37,500 Euros, reaching 45,700 Euros in seven small and medium towns located in the North of Madrid city. These 7 towns have an aggregated population of 325,484 and represent 5% of the entire population of Madrid.[12] There are also 11 cities to the West of Madrid and representing 7.3% of the entire population with an income per capita close to 30,000 Euros.[13] In the rest of the region, with 38.5% of total regional population, the income per capita is around 20,000 Euros on average, which is lower than the Spanish income per capita, around 22,000 Euros (Instituto de Estadística de Madrid, 2013).

The recent economic crisis has had a devastating impact on growth, employment and public budget balance. Moreover, Spain has been one of the European countries most affected by the 2008 crisis.[14] In this context, public administrations (central, regional and local) have undertaken a rigorous program of public budgetary restructuring to control and reduce public deficit and public debt. Between 2007 and 2011, public deficit evolved from 2% to 11% and public debt grew from 35% to 84%. The crisis also had a very negative impact on the Madrid Region economy that resulted in a reduction of the level of per capita income from 30,550 Euros in 2007 to 28,914 Euros in 2012. Likewise, the unemployment rate increased from 6.30% in 2007 to 18.99% in 2012. The current economic situation is impacting on the use of public transportation. In 2007, the number of trips reached its maximum of 1.62 million while it went down to 1.42 million in 2012. There are three underlying factors: (i) the increase of public transport price as such; (ii) the effect of economic crisis in Madrid Region related to increased unemployment (so less need for transportation) and income reduction; and (iii) quality of service deterioration.

Our work is focused on analysing the effects of public transport price increase on households' welfare. The next sub-section presents a detailed description of the public transport pricing policy undertook by Madrid Region government during the analysed period.

2.3. New public transport pricing policy of madrid public transport

The new public transport pricing policy in Madrid basically consists of increasing prices. A new price per ticket type has thus been defined. Table 1a shows public transport utilization and Table 1b shows public transport prices in years 2008 and 2012 for the different types of tickets. In nominal terms, price of single ticket has increased by 50.0%, multi-ride by 79.1% and on average normal and young travel passes by 24.0%.[15] In real terms,[16] this variation has been by 39.7%, 66.9% and 15.5%. respectively. The different scheme of price changes applied to each kind of ticket has been a key factor to explain how the utilization of each one of them has changed. Thus, single ticket consumption has gone down by 7.1% and multi-ride by 28.0%, whereas travel pass consumption has increased by 17.4%. In absolute figures, single ticket sales decreased by 228.3 thousand, multi-ride ticket sales went down by 8.5 million and travel pass sales increased by 2.1 million.

Single ticket users are generally occasional public transport users. Multi-ride and travel pass tickets are used by frequent or very frequent travellers. But the difference was that multi-ride tickets[17] were a good-value option for many frequent users travelling within ring A and today this is not the case. For example, in 2008 a daily public transport user who went to work and back in ring A paid 28.81 Euros per month (supposing he or she works 5 days a week and a month has on average 4.3 weeks). In that same year, the normal travel pass price for ring A was 42.1 Euros per month, so for this type of user the multi-ride ticket was clearly the best option. In 2012, the same type of user had to pay 51.6 Euros per month for a multi-ride ticket and 51.3 for the travel pass. In this new situation, therefore, the travel pass is the best option. This explains why in 2012 there were approximately 2 million more travel passes purchased than in 2008. For many public transport users, the multi-ride ticket is currently on par with the travel pass, with the subsequent increase of the degree of substitutability of these two ticket types.

Such a strong degree of substitutability is in accordance with the results of other works analysing Madrid Metropolitan Area public transport characteristics. For the underground, García-Ferrer et al., (2006) found a cross-price elasticity of the demand of travel passes related to the prices of multiride-tickets of 2.36. Moreover, a low own-price elasticity of travel passes was founded in several studies (i.e White, 1981; Hensher, 1998; Tegner, Pol, & Holmberg, 1998; Matas, 2004; García Ferrer et al., 2006). "The main reason is that when the price of a travel card is raised, travel card holders do not reduce their trip frequency unless the price rises above a critical threshold at which the user switches to single tickets at a much lower trip rate" (Matas, 2004, p. 211). This combination of high cross-price elasticities between the demand of different types of tickets, low own-price elasticities of travel passes and the new fare scheme explains the increase by 17% of the number of travel pass users in Madrid during 2008–2012. In the present case, the critical threshold mentioned in the quote has not been reached, but it is also true that in relative terms, for some type of travellers, the price of travel pass is lower in the new fare scheme.

3. Related literature

Firstly, we offer a literature review focused on works related to the first stage of our research. Therefore, we pay attention to the relationship between public transport users' behaviour and changes in income and prices. Secondly, related to the second stage of our paper, we offer a review of studies focused on welfare impacts of public transport policies.

There are different methodological approaches to tackle with public transport demand. On the one hand, there are studies that estimate public transport demand using the number of trips as a dependent variable. These studies are based on models that estimate the number of trips demanded during a given period. Patronage depends on a set of explanatory variables like fares, income, car ownership (which can be a proxy of income) and fuel price. On the other hand, there are works that estimate the demand of public transport using expenditure -instead of the number of trips-as a dependent variable. This can be done with uni-equational models, like those developed by Arranz (2001), Asensio, Matas, and Raymond (2003) and Nolan (2003) or with a complete demand system model as the one we develop in this paper. The advantage of complete demand models is that they enable the estimation of complementarity and substitutability relationships between public

[12] Those towns are Alcobendas, Algete, Cobeña, Colmenar Viejo, Tres Cantos, San Agustín de Guadalix and San Sebastián de los Reyes, referred to as Metropolitan North Statistical Area by Madrid Regional Government.

[13] Those cities are Boadilla del Monte, Brunete, Collado-Villalba, Galapagar, Hoyo de Manzanares, Las Rozas, Mahadahonda, Pozuelo de Alarcón, Torrelodones, Villanueva de la Cañada y Villaviciosa de Odón, referred to as Metropolitan West Statistical Area by Madrid Regional Government.

[14] The unemployment rate grew from 8% in 2007 to 26% in 2013.

[15] The travel pass for population over 65 is excluded of this study.

[16] To deflate we have used the consumer Price index publicated by the Spanish National Institute (INE) and presented in Table 4b as the Price of "the rest of goods" analysed in this paper.

[17] Multi-ride tickets are 10-pass tickets that can be used in ring An underground and Madrid City urban buses.

Table 1
a Number of public transport tickets purchased by year.

	2008	2009	2010	2011	2012	Variation
Single ticket	3,190,144	3,223,896	3,412,689	3,648,535	2,961,819	−7.1%
Multi-ride ticket	30,305,695	29,502,711	22,674,711	21,849,311	21,814,890	−28.0%
Travel pass	12,160,695	12,348,579	13,003,345	13,638,640	14,279,764	17.4%

Table 1b. Public transport prices in nominal and real terms by year.

	2008	2009	2010	2011	2012	Variation
Single ticket	1.0	1.0	1.0	1.5	1.5	50.0%
	(1.04)	(1.05)	(1.03)	(1.50)	(1.46)	(39.77%)
Multi-ride ticket	6.7	7.4	9.0	9.3	12.0	79.1%
	(7.02)	(7.77)	(9.28)	(9.30)	(11.71)	(66.90%)
Travel pass[a]	45.11	49.28	49.28	50.98	55.96	24.0%
	(47.26)	(51.77)	(50.86)	(50.98)	(54.63)	(15.59%)

(2) Prices in real terms are in parenthesis.
[a] Weighted average fare in all areas excluding the travel pass for population over 65.

and private transport.

Most papers focused on public transport demand use the first methodological approach, then they measure passenger flows, so the number of trips or in other words the patronage. The literature on this topic is abundant; there are many surveys and meta-analysis papers summarising the available results. In that respect, Goodwin (1992) summarises the results of own-price elasticities of public and private transport demand which are to be found in works published until the eighties. In this article, a mean of short run own-price elasticity of public transport demand of −0.3 is mentioned as a rule of thumb. Also, Nijkamp and Pepping (1998), Balcombe et al. (2004), Holmgrem (2007) and Hensher (2008) reviewed the empirical evidence of public transport demand own price and income elasticities resulting from works published since the nineties. Nijkamp and Pepping (1998) found that own price elasticities ranged from −0.15 to −0.75 in their survey of 12 studies focused on 4 different European countries (Finland, The Netherlands, Norway and the UK). Balcombe et al. (2004) found a mean of short run own-price elasticity of −0.4 for the United Kingdom. Holmgrem (2007) obtained a mean of short own-price elasticity of −0.75 for Europe and −0.59 for United States and Australia, and a mean income elasticity of 0.17 and finally, Hensher found a mean of short run own-price elasticity of −0.40 from a meta-analysis of 319 studies. All these authors highlighted the high degree of heterogeneity of the results. According to them, this can be explained by factors like the functional form of the model, the analysed period, the type of data used, etc. Moreover, the dependent variable used in such studies is linked to patronage. Differences between results are due to reasons like the use of revealed preferences data, stated preferences data or a mix, the definition of the price (it can be an average fare or a specific fare), the time of day analysed, the mode of public transport analysed and the population under study (commuters, non-commuters, young, older, etc.).

To the best of our knowledge, there are two papers that estimate own-price and income elasticities of public transport demand in Madrid with models based on patronage measures. The paper of Matas (2004) analyses short run elasticities for underground and buses and an average price for the period 1979–2001. She found out that own-price elasticities ranged from −0.2 to −0.37 and an income elasticity of 0.15. The paper of García-Ferrer, Bujosa, De Juan, and Poncela (2006) estimates short-run own-price elasticities for underground and buses and different types of tickets for the period 1987–2000. They found results that ranged from −0.51 to −2.17, being the highest elasticities those of single tickets.

Table 2 summarises the works which follow the second methodological approach -using public transport expenditure as dependent variable and based on complete demand models similar to what is presented in this paper. Results are not as heterogeneous as those of works measuring patronage. We can observe an own-price elasticity around −1, and an income elasticity around 1. These studies concluded that in most cases private transport and public transport are substitute goods but the degree of substitution is weak. We could not find any work based on complete demand models analysing public transport demand for the case of Madrid. This paper addresses this void to allow a better understanding of Madrid transport users behaviour.

Concerning works related to the second stage of our research, which are focused on welfare impacts of public transport policies our first remark is that this literature is very scarce. As Serebrisky et al. (2009) and Bureau and Glachant (2011) pointed out there is an extensive literature in the transport field justifying public transport subsidization on economic efficiency arguments (internalization of private transport externalities) but, welfare and distributional issues of these policies have drawn significantly less attention in the literature.

A consequence of this scarcity of works is that almost each paper uses its own methodology; generally, well developed in the welfare economics and income distribution, but most times introduced for the first time to transportation research by each study. Moreover, as public transport policy is implemented through different types of subsidies: subsidies on operational costs (fares or quality of service), on infrastructures, on different social groups, for different transport modes etc. Each work is generally focused on one type of subsidy depending on the case analysed. In any case, studies as our relying on consumer expenditure surveys are only able to consider effects of fare adjustments (Bureau & Glachant, 2011) as we do, and as Asensio et al. (2003) do. To the best of our knowledge this is the only study that analyses distributional impacts of transport subsidies for the case of some Spanish cities.

Regarding the results, and considering that the main objective of these studies is to elucidate if subsidies to public transport reach the aim of making it more affordable to the poorest, we can state that they are controversial as it can be shown in Table 3 that summaries works analysing distributional and individual welfare impact of different types of public transport subsidies.

4. Model and data

4.1. Model

We use the well-known Almost Ideal Demand Model (AIDS) proposed by Deaton and Muellbauer (1980):

Table 2
Public Transport elatisticities survey.

Authors	Focus, period and type of data (1)	Own-price elasticity of public transport	Own-price elasticity of private transport (automotive fuel)	Income elasticities of public transport	Cross-price elasticities of fuel demand	Country
Choo, Lee, and Mokhtarian (2007)	Analysis of complementarity and substitutability relationships between transportation and telecommunications. 1984–2002. Disaggregated data.	−1.225	−0.442 -	−0.361 (Private transportation demand/PT price) Complementary goods PT demand/private transport price cross elasticity is non-significant	United States	
Mergos and Donatos (1989)	Analysis of an AIDS for seven groups of goods, one of which being transportation. 1960–1986. Aggregate data.	−1.17	−1.17	–	–	Greece
Pestana Barros and Prieto Rodríguez, 2008	Microsimulation of a neutral tax reform aiming to promote the use of PT and discourage the use of passenger cars. 1985–1995. Disaggregated data.	−1.03	−0.817	1.05	0.029 (fuel demand/PT price) and 0.122 (PT demand/fuel price) Substitute Goods	Spain
Romero- Jordán and Sanz (2008)	Analysis of the impact of a potential increase of energy prices. 1985–1995. Disaggregated data	−2.411	−0.958	1.03	0.030 (TP demand/fuel price) Substitute Goods	Spain
Selvanathan and Selvanathan (1994)	Analysis of complementarity and substitutability relationships between Public Transport, Private Transport and Communications. 1960–1986. Aggregate data.	−0.4 to −0.7	−0.5 to −0.6	0.98 to 0.8	0.19 and 0.49 (PT demand/price of private transport) Substitute goods	United Kingdom and Australia
Tsekeris (2008)	Analysis of complementarity and substitutability relationships between transport modes. 1994–2004. Aggregate data.	−1.8	–	1.202	0.113 (fuel demand/PT price) Substitute goods PT demand/fuel price cross elasticity is non-significant.	Greece

(1) Public Transport data include the expenditure in all transport modes (underground, bus, plane, etc.).

Table 3
Public transport subsidies: individual welfare and distributional impact survey.

Authors	Type of subsidy analysed	Country	Period analysed	Distributional impact
Frankena (1973)	Subsidies applied to different public transport modes	United States	Sixties	Regressive
Pucher (1981)	Subsidies applied to different transport modes	United-States	Seventies	Progressive
Guria and Gollin (1986)	Subsidies applied to different public transport modes	New-Zealand	−0.817	Progressive
Asensio et al. (2003)	Analysis of the impact of a potential increase of energy prices. 1985–1995. Disaggregated data	Spain	Nineties	Progressive
Serebrisky et al. (2009)	All types of urban transport subsidies	Survey of many countries	As it is a survey different periods	Regressive
Bureau and Glachant (2011)	Subsidies on public transport operational costs both on fares and quality of service (speed)	Paris (France)	2001–2002	Progressive

$$w_{it} = \propto_i + \sum_{J=1}^{n} \gamma_{ij} lnP_j + \beta_i lnX_{it} \quad (1)$$

where w_{it} is the expenditure share of good i corresponding to each household in the year t. In other words, w_{it} has been computed dividing the expenditure in the good i by the total expenditure. p is the price of each good and X is household's real income in the year t. The AIDS model used in this paper consists of three equations simultaneously estimated. The first estimates public transport expenditure, the second one estimates automotive fuel expenditure and the third one estimates the expenditure in the rest of goods. To fulfil the axioms of micro-economic theory, we impose restrictions of additivity, homogeneity and symmetry:

$$\sum_{i=1}^{n} \alpha_i = 1 \quad (2)$$

$$\sum_{i=1}^{n} \gamma_{ij} = \sum_{j=1}^{n} \gamma_{ij} = 0 \quad (3)$$

$$\sum_{i=1}^{n} \beta_i = 0 \quad (4)$$

AIDS Models have been widely used to analyse the demand of public transport (Pestana Barros and Prieto Rodríguez, 2008; Tsekeris, 2008; Romero-Jordán and Sanz, 2009). The advantages of these models are well known. First, they allow to incorporate or verify the axioms required in a complete demand model —homogeneity and symmetry. Second, they are useful to calculate price and income elasticities of goods analysed. Third, they allow to identify the existence of complementarity of substitutability relationships between those goods.

To capture unobservable heterogeneity, in equation [2] we insert a set of socio-economic variables (d_i) that characterise households: size, if the breadwinner is retired, if there are children in the household, location in urban areas and if the breadwinner is unemployed (θ_i is a set of parameters). In addition, a random error term has been included. The resulting equation is:

$$w_{it} = \propto_i + \sum_{J=1}^{n} \gamma_{ij} lnP_j + \beta_i \ln\left(\frac{X_{it}}{P_i^*}\right) + \sum_{i=1}^{5} \theta_i d_i + \varepsilon_{it} \quad (5)$$

As income declared in household budget surveys is often lower than the actual one, it is usual in literature, as we do in this paper, to use household expenditure as a proxy of income (Romero-Jordán, del Río, Jorge-García, & Burguillo, 2010 among others). An additional advantage of using expenditure is that it is a good proxy for permanent income. Following West and Williams (2004), among others, total expenditure of households has been adjusted using the OECD scale (2008, 2011). Deaton and Muellbauer (1980) suggested a linear approximation of the nonlinear AIDS model using the Stone index constructed as follows:

$$lnP^* = \sum_{i=1}^{n} w_i lnp_i \quad (6)$$

Using such index, we obtain a linear approximate AIDS (LA-AIDS) model.

Once the model is estimated, marshallian price (non-compensated) and income elasticities for public transport expenditure and fuel expenditure are computed using the following expressions (see for example, Baker, McKay, & Symons, 1990; Haden, 1990; Abdulai & Aubert, 2004; Romero-Jodán et al., 2010):

Table 4
a. Synthetic price of public transport fares in Madrid.

	2008	2009	2010	2011	20012	Period variation
Nominal	35.8	39.1	39.5	40.8	45.3	26.5%
Real (base 2011)	37.5	41.1	40.7	40.8	44.2	18.0%

Table 4b. Price indexes (base 2011)

	2008	2009	2010	2011	2012	Period variation
Fuel	90.0	71.9	84.8	100.0	107.6	19.5%
Public transport	87.5	95.7	96.6	100.0	110.8	26.5%
Rest of the goods	95.4	95.1	96.9	100.0	102.4	7.3%

$$\varepsilon_{ij} = \frac{\gamma_{ij}}{w_i} - \delta_{ij} \quad (7)$$

$$\eta_i = \frac{\beta_i}{w_i} + 1 \quad (8)$$

Where δ_{ij} is equal to one if $i = j$ and equal to zero if $i \neq j$. In other words, δ is 1 for own-price elasticities and 0 for cross-price elasticities. The symmetry condition implies equality of the parameters $\gamma_{ij} = \gamma_{ji}$. However, since expression [7] is weighted by the value w_i , cross-price elasticities between goods i and j should have a different value and sign. This means that complementarity or substitutability between goods should not be reciprocal. Using the Slutsky equation, Hicksian price elasticities (compensated) have been computed from the following expression:

$$h_{ij} = \varepsilon_{ij} + \eta_i \omega_i \quad [9]$$

4.2. Data

Data used in this paper have been taken from several waves of the Households Budget Survey (HBS) for the 2008–2012 period (see Appendix I). HBS is a repeated survey that includes detailed information about 256 expenditure groups and socio-economic characteristics of each household. The expenditure on the three groups of goods subject of this paper are available in the survey. Concretely, HBS presents an item that includes jointly the expenditure on travel-pass and multi-ride ticket. These two tickets allow for the use of the means of transportation of public property which are the subject of this work. Likewise, it presents jointly the expenditure on gasoline and diesel oil, then of automotive fuel. The expenditure on the third group of goods used in our model has been obtained aggregating the other 254 groups of goods available in the survey.

The total number of households from Madrid region used in the estimation is 7732 distributed as follows: 1461 in 2008, 1585 in 2009, 1550 in 2010, 1565 in 2011 and finally, 1571 in 2012.

As for prices, public transport ones have been elaborated from the information about fares and public transport demand offered by the Consorcio Regional de Transportes de Madrid (2013b). We have computed an index coming from a synthetic price of public transport fares considered in our paper (travel passes in all rings for normal and young users, and multiride). The synthetic price is then composed on the one hand by an average weighted[18] price of travel

[18] This average weighted price has been weighted by the share on demand of all this kind of fares.

Table 5
Variables of expenditure and income used in the model.

Quintile	Income by intervals (Euros)	2008			2012		
		Public Transport Expenditure Share (%)	Automotive Fuel Expenditure Share (%)	Income (Euros)	Public Transport Expenditure Share (%)	Automotive Fuel Expenditure Share (%)	Income (Euros)
1	Until 21,379 (Low income)	1.93 (0.03)	5.17 (0.03)	17,126.9 (3882.1)	3.28 (0.04)	6.22 (0.04)	15,174.0 (4172.7)
2	21,380 to 29,280 (Medium-Low income)	1.45 (0.03)	5.49 (0.03)	26,046.6 (2267.1)	1.10 (0.01)	7.49 (0.03)	25,537.9 (1805.8)
3	29,281 to 37,825 (Medium)	1.13 (0.02)	5.93 (0.03)	34,232.5 (2648.5)	2.20 (0.02)	6.69 (0.03)	34,092.8 (2799.3)
4	37,826 to 51,830 (Medium-high income)	0.93 (0.01)	5.33 (0.03)	45,739.4 (4324.0)	0.71 (0.01)	4.72 (0.02)	43,593.6 (3344.0)
5	More than 51,831 (High income)	0.55 (0.01)	4.65 (0.03)	72,997.2 (17,862,4)	1.81 (0.01)	3.60 (0.02)	83,026.7 (28,991.1)
Average		1.09 (0.01)	5.31 (0.03)	41,678.7 (21,266.6)	1.76 (0.02)	5.64 (0.03)	39,978.9 (26,491.1)

(1) Typical deviation is presented in parenthesis.

pass (this price is presented on Table 1b) considering for each year and each ring the prices of the normal travel pass and of the travel pass for young population. And, on the other hand composed by the price for each year of the multiride ticket. The synthetic price of public transport, is a weighted price (weighted by the average intensity of the demand of the multiride ticket and the travel pass in the period analysed)[19] of multiride prices and the weighted price of travel pass. Table 4a, shows, both in nominal and real terms, the synthetic price that we have constructed to estimate the model.

As, to compute the price of the other goods analysed in our paper we have used index prices, we have elaborated and index price for public transport from the synthetic price presented in Table 4a in nominal terms. The prices of fuel used come from the index published by the Instituto Nacional de Estadística (INE). For the price of the rest of goods we have used the consumer price index published by the INE. Table 4b shows the indexes of prices used in the estimation of the model.

Table 5 shows descriptive data about the expenditure in public transport, automotive fuel and income by quintiles for 2008–2012. As it can be shown, Madrid households spend a much bigger proportion of their income in automotive fuel than in public transport. In 2008, the expenditure share in automotive fuel was 4.87 times bigger that the expenditure in public transport. This proportion was 3.20 in 2012, then it diminishes in the period subject of this work; in fact, in this period the expenditure share in public transport increases by 61.76% (going from 1.09% to 6.21%). Moreover, these descriptive data show that in 2008–2012 income diminishes for all Madrid households except for those of the fifth quintile for which it increases on average by 13.7%. Therefore, in this period of crisis and public finance restructuration, Madrid households had increased the proportion of their budget dedicated to public transport, and all social groups have become poorer except the richest that became richer.

5. Results of the estimation: elasticities

To estimate the equation [5] we use the Iterative Seemingly Unrelated Regression (ISUR) proposed by Zellner (1962). Table 6 shows the results of the estimation. Most parameters have a high degree of significance; the only exception is the households with children parameter. In the estimation, we present the robust standard errors that have been computed using bootstrapping (Cameron & Trivedi, 2005). The Breusch-Pagan test strongly rejects the independence of the three equations ($\chi^2(1) = 21.37033$ with a p-value<0.001) showing that iSUR estimates are preferred to OLS ones.

Using the expressions [7] an [9], Table 7 shows hicksian own-price and cross-price elasticities by year and Table 8 shows income elasticities by year. We have found that the compensated own-price elasticities of public transport demand are only significant for the years 2011 and 2012 even if they are low (−0.10 and −0.13, respectively). Two questions can explain the change of response to prices in 2011 and 2012. First, in those years the increase of public transport fares was the highest in the period analysed, reaching an accumulated increase of 19,01% the travel pass fare, and a 39,01% the multi-ride ticket fare. Second, those years were the hardest of the economic crisis in Spain. Hicksian cross-price elasticities show that an increase of 1% in public transport price would increase gasoline consumption on average by 0.25%. Therefore, results show that automotive fuel is a substitutive for public transport in the whole period analysed[20]. The results show, also, that an increase of 1% in public transport price would increase the consumption of other goods on average by 0,06%. Then the other goods consumption is almost independent of public transport.[21]This is logical, due the high share of all this goods expenditure on household's total expenditure compared to public transport share. Also, the income elasticity of 0.8 of both public transport and gasoline demand show that they are normal goods. Finally, income elasticity for the other goods is close to 1.

6. Welfare effects

In this section, we compute the welfare effects generated by public transport price increase. To measure these effects, we use the well-known Hicksian Compensating Variation (CV). We start from the expenditure function $C(u, p)$ that identifies at a given level of prices p, the minimum cost required to maintain constant the

[19] In the period analysed on average a 75.6% of travellers used the travel pass, and a 24.4% used the multiride ticket (considering only the use of this two kinds of tickets).

[20] Public transport is also substitutive of automotive fuel during the whole period analysed. Cross-price elasticities in this case show that an increase of 1% in automotive fuel price would increase public transport consumption by 0.20% on average. As we are analysing what happens when public transport prices increase, in the main text we comment only the results concerning the response of automotive fuel consumption to public transport price increase.

[21] However, public transport is complementary of other goods consumption, with a cross-price elasticity of −0.3 on average. This is reasonable, first due to the high weight of other goods on households expenditure, and so on households Budget, and second, because public transport by itself cannot substitute the needs satisfied by all these goods.

Table 6
Model estimations.

Variables	Public transport demand Equation		Fuel passenger car demand Equation	
	Coefficient	Bootstrap Std.error[1]	Coefficient	Bootstrap Std.error[1]
Household expenditure	−0.0073394***	0.0007674	−0.0070111***	0.0009664
Public transport price	0.037653***	0.0057575	0.0067206***	0.0024454
Fuel price	0.0067206***	0.0024454	0.031098***	0.0038228
Price of the rest of goods	−0.0443736***	0.0062961	−0.0378186***	0.0044942
Household with children	−0.0003693	0.0009358	0.0068998***	0.0013349
Locations in urban area	0.0039644***	0.0006379	−0.0087031***	0.0010921
Household size	0.0016728**	0.0007122	0.0065919***	0.0011632
Breadwinner retired	−0.0029569***	0.0009809	−0.0034522**	0.0018627
Breadwinner unemployed	−0.005803***	0.0010646	−0.0134268***	0.0019471
Intercept	0.087834***	0.0083064	0.1271418***	0.010457
N	5.117			
Breusch-Pagan test	$\chi^2(1) = 21.37033$			
Ho: OLS − Ha: iSUR	p-value = 0.00000			
Wald test joint significance	$\chi^2(10) = 254.00$ p-value:0.000		$\chi^2(10) = 578.36$ p-value:0.000	

(*) Significant at 10% confidence level. (**) Significant at 5% confidence level. (***) Significant at 1% confidence level. The null hypothesis of Godfrey's tests is that the equation residuals are white noise.

Table 7
Hicksian own price and cross-price elasticities.

Year	2008	2009	2010	2011	2012
Public Transport (PT)					
Δ PT demand - Δ PT price	−0.0496477 (0.6174751)	−0.0478068 (0.7760501)	−0.0379936 (0.7514142)	−0.1011748 (0.6729692)**	−0.1305373 (0.6221688)***
Δ PT demand - Δ AF price	0.1951515 (0.1143876)***	0.2060416 (0.1449412)***	0.2058523 (0.1368995)***	0.198531 (0.1252098)***	0.1971207 (0.123216)***
Δ PT demand - Δ RG price	−0.3218762 (0.849638)***	−0.3797242 (1.106465)***	−0.3687083 (1.031828)***	−0.239157 (0.927211)***	−0.234881 (0.8745669) ***
Automotive Fuel (AF)					
Δ AF demand - Δ AF price	0.0059961 (0.6390756)	0.0619102 (0.0619102)	0.0621509 (0.8125489)	−0.1162806 (0.5615639)***	0.0339873 (0.7880194)
Δ AF demand- Δ PT price	0.2550924 (0.1357069)***	0.2717459 (0.1817288)***	0.2658307 (0.1690673)***	0.23201 (0.1263539)***	0.2687243 (0.1729159)***
Δ AF demand- Δ RG price	−0.2614309 (0.7642196)***	−0.3340905 (1.040551)***	−0.3353705 (0.9721594)***	−0.1242959 (0.6642108)**	−0.3043856 (0.9392412) ***
Rest of goods (RG)					
Δ RG demand- Δ RG price	−0.0740281 (0.0442039)***	−0.0855508 (0.0625471)***	−0.0784798 (0.0494575)***	−0.0910173 (0.0501204)***	−0.1062007 (0.0903015)***
Δ RG demand- Δ PT price	0.0576345 (0.0436803)***	0.0650283 (0.0559271)***	0.0568886 (0.045287)***	0.0663234 (0.052881)***	0.0870764 (0.0995769)***
Δ RG demand- Δ AF price	0.007188 (0.0201896)***	0.0114275 (0.0264645)***	0.0121706 (0.0283994)***	0.0120541 (0.0284152)***	0.0144063 (0.0336714)***

Notes: Standard deviation in parenthesis. (*) Significant at 90% level (**) Significant at 95% level (***) Significant at 99% level.

Table 8
Income elasticities.

Year	2008	2009	2010	2011	2012
Public Transport	0.8454031 (0.1130578)***	0.8467626 (0.1410616)***	0.8452574 (0.1371026)***	0.855999 (0.1230419)***	0.8647063 (0.1171447)***
Automotive Fuel	0.841121 (0.1073499)***	0.8328141 (0.1463277)***	0.8315116 (0.1368961)***	0.8621089 (0.0929978)***	0.8380828 (0.1318033)***
Rest	0.9962739 (0.0002001)***	0.9962091 (0.0003287)***	0.9962513 (0.0002315)***	0.9961948 (0.0002398)***	0.9960745 (0.0005771)***

Standard deviation in parenthesis. (*) Significant at 90% level (**) Significant at 95% level (***) Significant at 99% level.

utility level u. The partial derivative of the function of minimum expenditure respect to an increase of prices is:

$$\Delta C \approx q \Delta p \qquad [10]$$

where q is the quantity of goods consumed. From the expression [10], we can identify the welfare costs generated by an increase of public transport prices. The expression [10] includes the denominated first order effects that assume that households consume the same quantity of goods before and after the hike of prices. This assumption is, however not realistic, because households usually change the composition of their basket of consumption as a response to change in relative prices. Friedman and Levinsohn (2002) propose to use a second order Taylor expansion of C to incorporate the second-round effects yielding:

$$\Delta C \approx q\Delta p + \frac{1}{2}\Delta p S_{ij}\Delta p \qquad [11]$$

where S_{ij} is the matrix of cross-price hicksian elasticities. Thus, the first term of the equation (situated at the right side) expresses the first order effects, whereas the second term expresses those of second round effects. The expression [11] can be reformulated in terms of budget share:

$$\frac{\Delta lnC}{X} = \frac{\Delta lnC^T + \Delta lnC^F + \Delta lnC^R}{X} \approx \sum_{i=1}^{n} w_{ih}\Delta lnp_i + \frac{1}{2}\sum_{i=1}^{n} \times \sum_{j=1}^{n} w_i S_{ij} \Delta lnp_i \Delta lnp_j \qquad [12]$$

From [12], changes on welfare exclusively associated to changes on public transport price, ΔlnC^T, are:

$$\frac{\Delta lnC^T}{X} \approx w_T \Delta lnp_T + \frac{1}{2}\sum_{i=1}^{n} w_i S_{iT} \Delta lnp_i \Delta lnp_T \qquad \forall i = T, F, R \qquad [13]$$

The expression [13] shows that the first order effects ($w_T \Delta lnp_T$) are a direct function of the public transport expenditure share and the increase of prices of that good. Compensated price elasticities, presented in the precedent section, play a main role in the second order effects ($\frac{1}{2}\sum_{i=1}^{n} w_i S_{iT} \Delta lnp_i \Delta lnp_T$).

In [13] the welfare loss is expressed as a percentage of the total income of households. Given the different composition of households, the use of equivalence scales is usual in the literature to compare their income homogenously. In this work, we use the well-known equivalence scale of the OECD proposed by Hagenaars et al. (1994). This method converts the total income of households in equivalent income transforming the number of members of the household in equivalent consumption units (He).[22] Thus, the average effective cost on welfare is:

$$c^*_{we} \approx \frac{w_T \Delta lnp_T + \frac{1}{2}\sum_{i=1}^{n} w_i S_{iT} \Delta lnp_i \Delta lnp_T}{H_e} \qquad \forall i = T, F, R \qquad [14]$$

To illustrative purposes we can also calculate the welfare loss in absolute terms:

$$C_W \approx c^*_{we} * \frac{x}{H_e} \qquad [15]$$

Consequently, the distribution of c^*_{we} by income level permits to identify the households that have been more harmed by the prices hike. For the period analysed, Table 9 shows the distribution of the average values of c^*_{we} for income quintiles. These average values have been calculated from the values of yearly welfare costs presented in Table 10. For illustrative purposes, the second column of Table 9 presents the welfare costs expressed in absolute terms. As it is shown c^*_{we} does not grow monotonically with income. Conversely, the distribution of the relative welfare costs for the four first quintiles is ranged in a narrow range that goes from 3.51% of income for the third quintile to 3,76% of income for the second. For the firth quintile, the aggregated loss of welfare is, however, substantially inferior representing only 1.51% of income. As Table 10 shows, the most harmed quintile by year has been changing between the first and the fourth. In 2008–2009 the fourth quintile was the most harmed with a welfare loss of 1.59% of its income; in 2009–2010 it was the first quintile with a loss of 0.20%; in 2010–2011 it was the second quintile with a loss of 0.73% and finally, in 2011–2012 the most harmed was the third quintile that supported a welfare loss of 1.98% of its income. Thus, we can assert that the new public transport prices in Madrid Region has harmed all the income groups in a similar way excepting the richest group, which has been much less harmed.

[22] Assigning a value of 1 to the household head, 0.5 to each additional adult member and 0.3 to each child.

Table 9
Compensating Variation for the period 2008–2012.

Quintile	Income by intervals (Euros)	Compensating Variation	
		In percentage Of household income(1) c^*_{we}	In absolute terms Euros(2) c
1	Until 21,379 (Low income)	3.6744	355,65
2	21,380 to 29,280 (Medium-Low income	3.7682	463,01
3	29,281 to 37,825 (Medium)	3.5115	606,33
4	37,826 to 51830 (Medium-high income)	3.6928	682,40
5	More tan 51,831	1.5105	422,80

(1) Using OECD equivalence scale (2) Value in 2011 Euros.

Table 10
Compensating variation by years using the OECD equivalence scale.

Period/Quintile	1	2	3	4	5
2008–2009	1.2921 (1.11)***	1.3264 (1.38)***	0.9275 (0.86)***	1.5922 (1.96)***	0.4768 (0.51)***
2009–2010	0.2074 (0.21)***	0.1145 (0.10)***	0.1173 (0.12)***	0.0930 (0.08)***	0.0481 (0.04)***
2010–2011	0.4479 (0.32)***	0.7398 (0.67)***	0.4797 (0.38)***	0.3600 (0.29)***	0.3101 (0.28)***
2011–2012	1.7270 (1.26)***	1.5875 (1.30)***	1.9870 (1.80)***	1.6476 (2.01)***	0.6755 (0.55)***

Analytic weights used. Standard deviation in parenthesis. (*) Significant at 90% level (**) Significant at 95% level (***) Significant at 99% level.

Along the years analysed the magnitude of welfare loss has strongly fluctuated. This dispersion is explained by the different increase of prices implemented in each one of these years. Table 11 shows the weight of welfare costs generated in each year respect to the total welfare loss in the whole period. Thus, on average 81.3% of the welfare costs in the whole period were generated in 2008–2009 and 2011–2012, which were the years when the hike of prices was the highest. Likewise, the smallest loss of welfare corresponds to 2009–2010 when the absolute price of public transport in Madrid did not changed.

7. Conclusions

The imbalances in public finances have forced Public Administrations (central, regional and local) to reduce the level of public expenditure. In this context, the Madrid Regional Government has cut subsidies to public transport operational costs by both reducing the quality of service and increasing prices by 26.5% in the 2008–2012 period. This paper has analysed the impact that such price increase has had on welfare. The analysis has been carried out

Table 11
Weight of welfare loss by years.

Period/Quintile	Q1	Q2	Q3	Q4	Q5	Average Weight
2008–2009	35.2	35.2	26.4	43.1	31.6	34.3
2009–2010	5.6	3.0	3.3	2.5	3.2	3.5
2010–2011	12.2	19.6	13.7	9.7	20.5	15.1
2011–2012	47.0	42.1	56.6	44.6	44.7	47.0
Total	100	100	100	100	100	100

in two stages. Concerning the first stage, where public transport demand has been characterized, the main conclusions are:

- The demand of public transport has only been sensible to price hikes when those have been relatively high. Then only in the years 2009 and 2012, when prices increased by 9.2% and 10.8% respectively. In any case, even in those years the demand was inelastic to price increases.
- Automotive fuel is a substitutive good for public transport for Madrid Region households (with an average cross-price elasticity of 0.25 in the period analysed). So, in a scenario of growing public transport prices if automotive fuel prices remained constant, the use of cars would increase. This is negative from an environmental point of view and thinking in the need of sustainable urban mobility. Moreover, even if public transport is also substitutive for automotive fuel, the degree of substitutability is stronger in the first case.
- The consumption of other goods as a whole is almost independent of the consumption of public transport. Moreover, as the scheme of prices changes undertook by Madrid authorities was different between tickets, there has been a substitution of multi-ride tickets with travel passes, now relatively much cheaper. The very frequent users are highly subsidized and this is appropriate if the objective of transport policies is to grant those who behave in a more environmental friendly way when they move.

Concerning the second stage of our analysis, we can conclude that:

In relative terms and using the equivalence OECD scale, welfare loss in the whole period has been very similar for quintiles one to four. Welfare costs for these quintiles have oscillated from 3.5% to 3.7% of household's income. In contrast, the households that have been less damaged are those of the fifth quintile, with an accumulated loss of welfare representing a 1.5% of their income. However, if we observe the results year by year, in the years in which the price hike was higher (2009 and 2012) the households with a higher loss of welfare were those from the fourth and the third quintile respectively.

In sum, the reduction of subsidies to public transport fares in Madrid Region has damaged households of low and medium income in a similar proportion with an average loss of 3.6% for the period analysed. The welfare cost beard by the richest households is quite inferior, representing approximately a 40% of the cost of the rest of households. Precisely, in the period subject of this work, the average income has diminished in all quintiles except in the fifth where it has increased by 13.7%. But observing the results in more detail, the more damaged households where those of medium and high medium income levels.

These results teach us, then, that a public policy consisting in subsidizing public transport fares has been a good measure to improve welfare of, especially, medium income social groups.

Then, cutbacks subsidies to public transport operational costs via prices in Madrid Metropolitan Area have had the highest impact on this medium and high-medium households, and the richest households were by far the less damaged. In any, case, these cutbacks have not damaged the poorest.

From these conclusion, we can deduce some policy implications:

On the one hand, public urban transport subsidies on demand, concretely on fares, could encourage public transport use only if this policy is strong. Moreover, to cut public transport demand subsidies could encourage the substitution of the use of public transport with the use of private cars. This did not seem a good decision on efficiency grounds, concretely in a context where big cities need to promote a more sustainable urban mobility.

On the other hand, it does not seem that the subsidization of public transport fares has made particularly the poorest better off, which is, following Serebrisky et al., 2009, the main justification of such subsidies on welfare and distributional grounds. It seems, notwithstanding, that fares subsidies made the medium social groups better off. In that sense, the policy of cutbacks undertook by the Madrid public transport authorities, and the resulting increase on public transport fares, has damaged especially medium social classes, which have been in Spain and other occidental countries one of the main losers of the crisis (see Milanovic, 2016).

In sum, in a context where there is a clear necessity of promoting a sustainable urban mobility,[23] the justification of demand urban transport subsidies could have strong foundations on efficiency grounds. In view of our results, the justification of such a policy on welfare and distributional grounds is not so clear, because this policy did not have made the poorest better off.

Appendix I. Source of the data

Table 4. Data Source

Variable	Database	Unities
Household expenditure	Households Budget Survey 2008–2012	Euros
Automotive fuel expenditure	Households Budget Survey 2008–2012	Euros
Public transport expenditure	Households Budget Survey 2008–2012	Euros
Household size	Households Budget Survey 2008–2012	Members
Households with a car	Households Budget Survey 2008–2012	1 in households with a car and 0 otherwise
Breadwinner is retired	Households Budget Survey 2008–2012	1 if the breadwinner is retired and 0 otherwise
Household with children	Households Budget Survey 2008–2012	1 if there are children and 0 otherwise
Households located in a rural or in an urban area	Households Budget Survey 2008–2012	1 if urban and 0 otherwise
Public transport expenditure	Consorcio de Transportes de la Comunidad de Madrid (2013b) y elaboración propia	Price index base 2011
Automotive fuel price	Instituto Nacional de Estadística	Price index base 2011
Rest of goods price	Instituto Nacional de Estadística	Price index base 2011

[23] The European Union strongly recommended cities to implement and develop the so-called Sustainable Urban Mobility Plans (European Commission, 2005).

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