ECONOMICS AND PUBLIC POLICY

Masters Final Work

Dissertation

THE DISTRIBUTIONAL EFFECTS OF TRANSPORT COST AND ITS IMPACT ON INCOME INEQUALITY: EVIDENCE FOR LISBON AND PORTO METROPOLITAN AREAS

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“A certain percentage, they tell us, must every year go (…) to the devil, I suppose, so that the rest may remain chaste…”

Fyodor Dostoevsky

Glossary

AML – Lisbon Metropolitan Area

AMP – Porto Metropolitan Area

IMOB – Enquiry to Mobility in Lisbon and Porto Metropolitan Areas 2017

INE – Portugal National Statistic Office

PART – Program of Support to the Reduction of Public Transport Fees

ISP - Tax on oil products

AISP - Additional to the tax on oil products

ISV – Vehicle tax

IUC – Circulation tax

ERSE - Regulatory Agency for Energy Services

VAT - **V**alued added tax

EU - European union

Abstract

The impact of fuel consumption on climate change has prompted governments to increase the taxation of fossil fuels. This is often referred to as a Pigouvian tax, in other words, a tax that attempts to internalize a social cost (i.e., negative externality). However, indirect taxes like this risk being regressive – i.e., affecting disproportionally more the poorer members of society -, because their rates are invariant with consumers' income level. To ensure social justice in fuel taxation it is important to analyse the regressivity of fuel taxes. Furthermore, since richer people tend to pollute more, to effectively decrease pollution from fossil fuel consumption, it might be important to tax the richest people relatively more.

On the other hand, public transportation is more fuel and energy efficient compared to motorized private cars, which combined with the nature of its cost technology (i.e., large, fixed costs, average cost higher than marginal cost), justify subsidizing public transport use. In contrast to fuel prices and taxes, public transport pricing often includes social fares for more vulnerable groups of society – e.g., children, the elderly, and the unemployed -, which promotes social justice.

This paper analyses the degree of progressivity, or regressivity, of transport costs relating to driving (i.e., fuel, tolls, parking) and public transport use in the metropolitan areas of Lisbon and Porto. We use data on transport expenses and analyse the degree of progressivity, or regressivity, and the impact that these expenses have on income inequality by comparing the Gini index of income before and after transport expenses. The findings indicate that transport expenses increase inequality and that taxes can be slightly regressive. To evaluate the progressivity of fuel taxes we use the Suits index, which shows a slight regressivity of the fuel taxes. The policy implications from this analysis show the importance of investment in alternatives to reduce the use of private motorized vehicles, as well as in reducing the price of public transportation, at least in big cities where this kind of transportation is more viable.

Keywords: Inequality; fuel taxes; progressivity.

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From the bottom of my heart, thank you all.

1 Introduction

Transport costs account, on average, for 14.1% of total household expenses in Portugal, representing the third largest cost category, behind housing, water, electricity, gas, and other fuel costs (32%), and food and non-alcoholic beverages (14.3%) (INE, 2017). This provides direct evidence of the importance of analysing transport costs, particularly their distribution across different segments of the population in terms of income levels. Furthermore, the fact that the emission of greenhouse gases by petrol fuels has significant negative environmental effects provides another motivation for this study and is at the core of the justification for fuel taxes, which represent a large part of fuel costs. Fuel taxes are based on the Pigouvian principle of internalizing a negative externality through taxation in order to reduce the consumption (or production) of the good/service (Pereira, Afonso, Arcanjo, & Santos, 2016).

The objective of this thesis is to answer the question "what impact do transport costs have on income inequality?". Two main components of transport costs will be analysed: the costs associated with driving (i.e., fuel, tolls, and parking) and those associated with public transport use. Due to data unavailability, vehicle acquisition and maintenance costs were excluded.

In Portugal, there are two types of fuel taxes, the tax on oil products (ISP) and the additional to the tax on oil products (AISP, which effectively works as a carbon tax since its value depends on the amount of pollution a certain type of fuel emits). Besides fuel taxes, there are other taxes paid by car owners. The vehicle tax (i.e., Imposto Sobre Veículos, ISV) is paid once and is associated with the issuing of a license plate, and a circulation tax (i.e., Imposto Único de Circulação, IUC) paid annually by car owners. The value of these taxes increases with engine capacity and CO2 emissions, which partially creates an incentive in favour of less polluting and more fuel-efficient cars (Fragoso, 2021).

As of the 6th of December 2021, the taxes on petrol and diesel in Portugal accounted for 56% and 51% respectively of the total cost of fuel in Portugal. These taxes include all four taxes mentioned above, not only carbon and fuel taxes (ERSE, 2021).

We can access this information through the data made available by the Regulatory Agency for Energy Services (ERSE). Using the data from ERSE we can observe how much each tax affects the average fuel price. The ISP is the most expensive tax and affects primarily petrol. However, since diesel is more polluting (The International Council on Clean Transportation, 2019) this can create a contradictory incentive by penalizing less the most polluting fuel. Additionally, the AISP does not appear to be large enough to correct this difference, since petrol remains more expensive after all taxes are considered, even though excluding taxes petrol is cheaper than diesel. Moreover, the general tax on consumption of goods and services (i.e., valued added tax, VAT, or IVA in Portuguese) is applied to the price of fuel after the other taxes (e.g., ISP, AISP, IUC, or ISV), implying that there is double taxation.

The Oil Bulletin produced by the European Commission provides details on fuel prices for each EU country, and thus allows us to compare fuel taxes between Portugal and other European countries. According to the data for 2017 (which is the period we will analyse in this article), in Portugal, taxes on petrol and diesel corresponded to 63% and 56% respectively. While in the Eurozone the impact of taxes on the final price was, on average 60% on petrol and 54% on diesel (Oil Bulletins, 2021), to calculate these figures we used the prices of the first and last week of 2017

Portugal is one of the countries in Europe with less popular support for fuel taxes (Levi, 2021). Despite concerns over inequality seeming to be a secondary concern when the population opposes fuel taxes (Fairbrothera, Sevä, & Kulin, 2019; Levi, 2021), the progressivity, proportionality, or regressivity of fuel taxes is nonetheless important from the point of view of public policy. All four taxes (i.e., both fuel taxes, ISV, IUC) incorporate, at least partially, the principle of economic efficiency by internalizing the external cost of motorized private transport on the environment. Concerns about equity, particularly social justice, are not directly taken into consideration. Since households pay the same tax per litre of gasoline or diesel (and for the same car model), irrespective of their income level, the impact may be regressive, that is, poorer households may allocate a larger share of their income to transport-related expenses, compared to richer households.

However, even if fuel taxes are regressive, the revenue they create may be used in progressive investments and so, the overall net effect may be progressive (Eliasson, 2021). For example, part of the environmental fund (i.e., Fundo Ambiental) revenue comes from fuel taxes and was used, for example, to reduce public transport fares. Out of total revenue of around 647 million euros, 157 million come from earmarked revenue from the ISP and AISP, in total, around 24% of the environmental fund budget comes from earmarked taxes (DGO, 2021) (Gabinete de Gestão do Fundo Ambiental, 2021). A considerable share of the budget was allocated to public transportation, especially to the Program to Support the Reduction of Tariffs (PART), where the environmental fund spent 274,6 million euros in 2020, from which 138,6 million euros were directly earmarked from revenue originating from environmental taxes (Gabinete de Gestão do Fundo Ambiental, 2021).

Regardless of our view on the link between fuel taxes and inequality, if the main purpose of a fuel tax is to reduce the negative environmental externalities of driving, it is important to look at who pollutes the most. Referring to this matter, a recent report published by the Stockholm Environmental Institute (2020) analysed the source of carbon emissions in different countries, considering both the country of origin and the relative income of the polluters. This analysis allows us to see, for example, how much of the total carbon emissions in Portugal are created by the top income earners. In 2015, the top 5% richest individuals in Portugal were responsible for 20% of the total pollution, i.e., four times more than what would be expected if everyone polluted the same. On the other hand, the bottom 5% of the population were responsible for only 1% of pollution, five times less than what would be expected. It is important to note that this pollution does not mean only pollution derived from transport. However, even if the richest individuals spent the same percentage of income on fuel as the poor, they would still consume more fuel and pollute more. Other authors (Pye, et al., 2008) also find similar results, showing that the richest households are the most polluting. These figures suggest that to effectively reduce pollution we might need to actively target those who pollute the most. If we accept this view, then, creating a progressive tax is not just important to ensure social justice but also to efficiently reduce pollution.

We start this study with a review of the literature in Section 2. This includes some basic concepts, such as a definition of regressive, progressive, and proportional taxes; the theoretical implications of the elasticity of demand with relation to prices and income; and a review of existing articles focusing on the distributional effects of fuel taxes. Section 3 presents the data and explains the methodology used in the study. Section 4 presents and discusses the results, while Section 5 summarises our main conclusions.

2 Literature Review

2.1 The economic rationale for fuel taxes

Unlike most taxes that exist to raise public funds, fuel and carbon taxes are often justified by environmental concerns. This is because driving creates negative environmental externalities through the emission of pollutants, notably CO_2 (The International Council on Clean Transportation, 2019) and NO_2 (Khomenko, et al., 2021). The concept of externalities was developed by Alfred Marshall and Arthur Pigou (Boudreaux & Meiners, 2019), and economists usually talk about negative externalities when the market price of a good or service does not fully reflect the social cost associated with the consumption or production of that respective good or service (Cooter & Ullen, 2016). The economic theory on externalities shows that the presence of negative externalities leads to inefficient market outcomes whereby the level of consumption or production is greater than the optimal level. To correct the level of consumption or production, governments can set taxes to incorporate the external marginal cost in the social marginal cost.

There is abundant evidence that greenhouse emissions resulting from the burning of fossil fuels are linked to global warming, rising sea levels, and unpredictable weather events (Pachauri & Meyer, 2015). Furthermore, air pollution has a direct impact on human health with some estimates calculating 40 thousand deaths per year in Europe caused by air pollution (Khomenko, et al., 2021). Not all air pollution is due to car use, however, on average, between 14% and 39% of all air pollution is due to traffic (Khomenko, et al., 2021).

Another economic justification for environmental taxes is that they can serve to incentivize efficiency-oriented innovations and the usage of renewable energies or

alternatives using cleaner technologies such as, for example, electric and/or hybrid vehicle (Tietenberg and Lewis, (2018).

Since fuel taxes aim to internalize a negative externality, we can classify them as a Pigouvian tax. This sort of tax tries to express the private and social marginal cost of a good or service into its market price, as a way to ensure an optimal level of consumption or production of that good or service. In practice, it is difficult for the government to calculate the right level of tax since the government would have to find the right level of tax that provides for the most efficient solution. To overcome this difficulty, some taxes use market instruments, for example, the Portuguese carbon tax called AISP is calculated based on the European emissions trading system (Fragoso, 2021).

The European Commission distinguishes between four types of environmental taxes: energy; transport; pollution and resources (European Commission, 2001). Fuel taxes are included in the energy category, whereas taxes related to the registration and the acquisition of vehicles are classified as transport taxes. In Portugal there is a fuel tax directly applied to oil-based products the "Imposto sobre Produtos Petrolíferos" which directly translates to "Tax on Oil Products" (ISP); a carbon tax, that is measured by the amount of pollution a fuel produces, the "Adicional ao Imposto sobre Produtos Pretolífereos", that directly translates to "Additional to the Tax on Oil Products" (AISP); a circulation tax, the "Imposto Único de Circulação" or the "Single Transit Tax" (IUC), set based on the weight, type and year of the car (Fragoso, 2021); and a tax on vehicles that charges according to fuel type, the power of the vehicle and the type of vehicle, the "Imposto sobre veículos" or Vehicle Tax (ISV) (Fragoso, 2021).

2.2 The distributional effect of fuel taxes

Besides the more efficiency-oriented economic rationale for fuel taxes, there are also distributional, or equity-oriented, reasons to consider. Fuel taxes may affect different groups of the population unevenly, and can therefore increase, decrease, or have no effect on socioeconomic inequality.

Fuel taxes are said to be progressive if the average tax rate increases in relation to income, i.e., when the income rises so does the average tax rate. Conversely, a

regressive tax is present when the average tax rate decreases as household income rises. In a proportional or neutral tax, the average tax rate is constant across household income groups (Pereira, Afonso, Arcanjo, & Santos, 2016). Taxes affect the prices of goods directly and are not sensitive to the income of consumers. In some cases, as in the case of luxury goods, the effect might still be progressive since individuals with low incomes have limited purchasing power to obtain these types of goods regardless of tax levels. In other cases, notably, the case of basic goods such as staple food, taxes on goods may be regressive. This is one of the main rationales for the rates of VAT to vary according to the type of good or service. Luxury goods are taxed at a higher rate than basic goods, thus exhibiting a redistribution role.

Earlier studies on the progressivity, regressivity or proportionality of fuel taxes in the United States (US) have found some evidence of regressivity in fuel taxes (Poterba, 1991). However, Poterba found that when using expenses instead of income, fuel taxes seemed to be neutral, rather than regressive. More recently, Sterner (2012) found similar results. Furthermore, this author studied the impact of fuel taxes in different countries and concluded that in less developed countries fuel taxes can be progressive, while in more developed countries they tended to be proportional. These results have been replicated in other studies focusing on developing (or less developed) countries (Datta, 2010; Agostini & Jiménez, 2015).

To understand the impact of transport costs on inequality it is important to look at how inequality can increase. The *principle of transfers* tells us that any transfer from an individual with more income to an individual with less income that does not change their relative position decreases inequality (Cowell, 1998). If we consider this to be true, and that income has diminishing marginal returns on utility, i.e., its more valuable the less income an individual possesses, the logical conclusion should be that a proportional tax also increases inequality, since the same proportion of income has more marginal utility to someone who has less income than to someone who has more income. However, if we assume the principle of *scale invariance*, i.e., that a proportional change in income does not change inequality (Cowell, 1998), then a proportional tax should not increase inequality.

Another important aspect to bear in mind when discussing the progressivity of fuel taxes is how the revenue raised is reinvested, called revenue recycling. If the taxes are used for investments that benefit mostly the poorest members of society, then, the net-result might be progressive. Additionally, the progressivity of a tax is measured in relative terms (i.e., percentage of income), while the progressivity of investments is measured in absolute values (i.e., the absolute benefits of the investment). This means that for an investment to be regressive it must benefit the richest more in absolute terms, while for a tax to be regressive it must only benefit the richest more in relative terms (even if it taxes the rich more in absolute terms) (Eliasson, 2021). A possible example of revenue recycling in Portugal is how the revenues from fuel taxes (i.e., ISP and AISP) are used for public transport (Fragoso, 2021): for example, the taxes are used to support lower tariffs on public transport, and increase the level of public transport services in areas scarcely covered by public transport (Gabinete de Gestão do Fundo Ambiental, 2021).

2.3 Elasticity of fuel demand with respect to prices and income

Another aspect of taxation that cannot be overlooked is the role of elasticity. In the case of the price demand elasticity, we refer to "the percent change in demand divided by the percent change in price"[1] (Cabral, 2021), which allows us to measure how sensitive consumers are to price changes. Additionally, income demand elasticity, measures "the sensitivity of the quantity demanded with respect to a change in consumer income"[2] (Cabral, 2021). Ramsey's law (Ramsey, 1927) states that the more inelastic the demand for a certain good, the higher the tax must be to decrease its consumption. For example, if we equate elasticity with the capacity to substitute a certain good (Cooter & Ullen, 2016), we can see how, when there is an easily accessible substitute, a relatively small increase in the price is enough for a relatively large decrease in consumption. Similarly, the incidence of the tax is also linked with elasticity. In this case, when the elasticity is higher the producer is forced to take on more of the tax since consumers will

[1] If the elasticity is 0, then the demand for the good is inelastic and does not respond to price changes, the higher the elasticity is the more sensible the consumers are to prices. (Pereira E. , 2011).

[2] A negative elasticity would mean that the consumption of the good decreases as income rises, a neutral elasticity would mean that the consumption is unaffected by the income, a positive elasticity means that as income rises so does the consumption of the good (Pereira E. , 2011).

significantly reduce their consumption if the price increases (Graves, Sexton, & Lee, 1996).

The literature on price elasticity for fuel demand points to an elasticity of around -0.8 in the long term and around -0.3 in the short term (Sterner, 2012; Graham & Glaister, 2002). In the Lisbon Metropolitan Area, the short-term price elasticity was calculated at between -0.48 and -0.72, and the long-term price elasticity at between -1.19 and -1.82, while income elasticity varied between 0.51 and 0.54 in the short term and 1.26 and 1.37 in the long term (Melo & Ramli, 2014). The larger longer-term elasticity might reflect how it may take some time for people to adjust their behaviour, notably the ability to substitute fuel, or rather, driving, by alternative travel modes; it might also reflect an increase in alternatives, such as electric cars or public transport.

Public transport or active travel can be an effective substitute for individual motorized vehicles, especially in urban areas. By using public transport, we can reduce the number of private motorized vehicles in circulation and the associated negative externalities, notably congestion and air pollution. The size of the elasticity of fuel (or driving) in relation to fuel prices is thus likely to be higher when transport services can compete with solo driving. A competitive public transport system requires a wide reaching and well interconnected network, offering frequent, fast and comfortable services to its users. Following Ramsey's law, if public transport is a viable alternative, *ceteris paribus*, we would expect that a smaller tax on fuel would be enough to reduce its demand.

To better understand the main motivations for using car or public transport in Lisbon Metropolitan Area, we refer to the travel survey IMob carried out by Portugal's National Statistics Office (INE) in 2017 (Instituto Nacional de Estatística, 2018). The results show us that the main reason why people use public transportation is the lack of alternatives (i.e., not having a car or not knowing how to drive). The main reasons for car use are mostly due to comfort and speed. Monetary cost plays a bigger part in using public transportation than in using a car (in both Lisbon and Porto): the monetary cost is the 3rd biggest reason for public transport use, but only a secondary concern for car users. This might suggest that to make public transport more attractive it is necessary to

increase its accessibility, comfort, and speed in addition to reducing its price. The full results are provided in the Appendix.

3 Data and Methods

3.1 Measuring income inequality and tax proportionality using the Lorenz Curve, Gini Index and Suits Index

There are various approaches to the measurement of income inequality. The Lorenz Curve, the Gini Index and the Suits Index are some of the most popular measures. The Lorenz Curve is a graphic representation of the cumulative relative distribution of income and the cumulative relative distribution of the population ordered from the individuals with less income to the individuals with more income (Gastwirth, 1971). The resulting curve can then be compared with the "line of equality", i.e., the line that would exist should all individuals earn the same income, which graphically corresponds to the 45º line. To illustrate the concept, we have used hypothetical data to create a Lorenz Curve, in graph 1: the X axis (i.e., horizontal axis) shows the cumulative relative distribution of individuals, while the Y axis (i.e., vertical axis) shows the cumulative relative distribution of total income. The line of equality (in blue) shows how the distribution would be if every individual group had the same income. The ratio of the area between the two lines (denoted by B in graph 1 and formula 1) and the area underneath the equality line (denoted by A in graph 1 and formula 1) corresponds to the Gini index and measures the extent of inequality (Dorfman, 1979). That is:

$$Gi = \frac{B}{A}$$

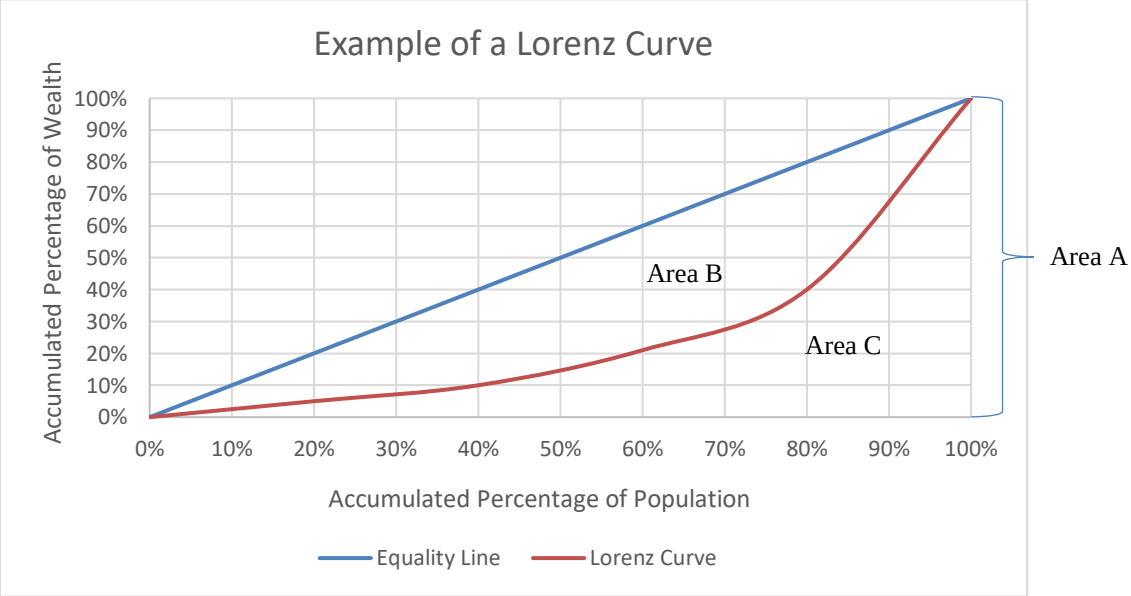
Formula 1: Gini Index (Dorfman, 1979). Where A is the area under the equality line and B the area between the equality line and the Lorenz Curve.

The Gini index is widely used by international organizations such as the OECD. In a situation of perfect equality, the Gini Index would be 0, while in a situation of perfect inequality the Gini index would be 1 (OECD, s.d.). The area bellow the equality line (that we define as A) is always 0.5, since the equality line divides the graph in two, however, to calculate the Gini index we need to find Area B. To find area B we must first find the area bellow the Lorenz Curve (that can be described as Area C), using the formula:

$$C = \frac{\sum_{i=1}^{n}(q_i + q_{i-1})(p_i - p_{i-1})}{2}$$

Formula 2: Area under the Lorenz Curve. Where q_i is the cumulative proportion of income and p_i is the cumulative proportion of population. (Bellù & Liberati, 2006).

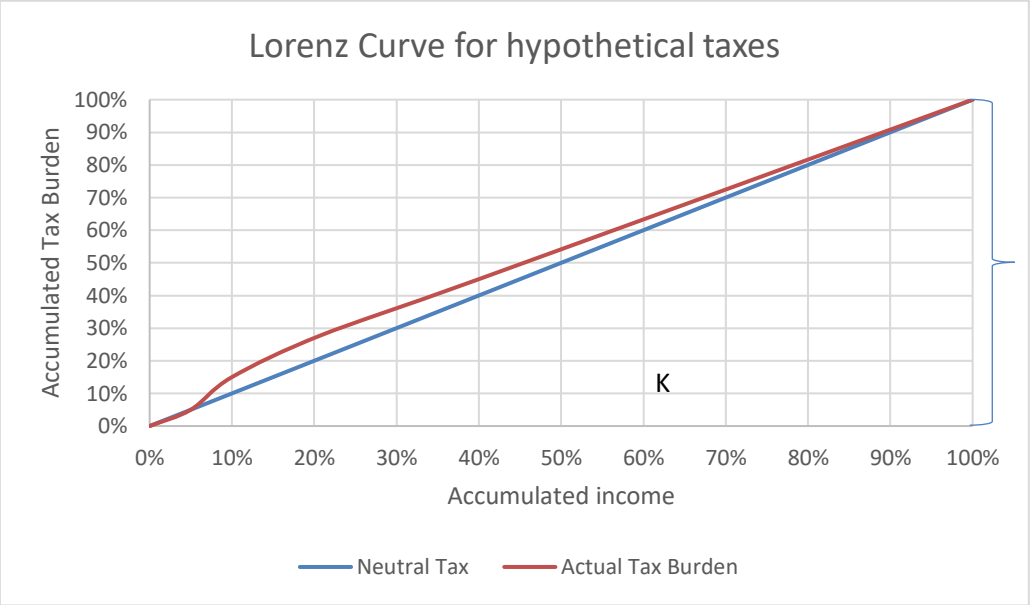
Once the area C is found, we can subtract area C to area A (0.5) and get area B. Once we have area B and A we need only to apply the aforementioned Formula 1 to obtain the Gini index. The Gini index is widely used by international organizations such as the OECD. In a situation of perfect equality, the Gini Index would be 0, while in a situation of perfect inequality the Gini index would be 1 (OECD, s.d.).



Graph 1. Example of a Lorenz Curve. Made by author.

The Suits index is a measure of the progressivity of a tax. This index uses a similar methodology to the Gini index representation based on the Lorenz Curve, but instead of using the cumulative percentage of total income as the Y axis and the cumulative percentage of the population as the X axis in its graphical representation, it uses the cumulative tax burden as the Y axis and the cumulative percentage of total income as the X axis. In order to have a comparative framework, a 45º line represents a proportional tax. Unlike the Gini index, the Suits index varies between -1 and 1, where negative values represent tax regressivity and vice-versa (Suits, 1977).

For the Suits index we will also use a hypothetical scenario to demonstrate; in this example, the tax is regressive. The X axis represents the cumulative percentage of income, while the Y axis represents the cumulative percentage of total tax burden. The red line denotes the 45º line and shows a perfectly neutral tax, while the blue line represents the actual tax burden distribution curve. If the curve of the actual tax burden is below the 45º line the tax is proportional since individuals pay a proportion of tax larger than the share of the total income they hold. However, if, as is the case in Graph 2, the line of the distribution of the actual tax burden is above the 45º line, this means that the tax is regressive, and we should expect a negative Suits index; in this case the Suits Index is equal to -0.1.



Graph 2: Lorenz Curve for hypothetical taxes. Made by author.

The Suits index is similar to the Gini index, in the sense that it also attempts to measure the area between the curve of the actual tax burden (which is the equivalent to the Lorenz Curve) and the 45º degree line (the equivalent to the Equality Line). However, instead of using the cumulative percentage of population and cumulative percentage of income, we use the cumulative tax burden percentage and the cumulative income percentage. To calculate the index, we use the formula suggested by Suits (1977):

$$Si = 1 - (\frac{L}{K})$$

Formula 3: Suits Index. Where L is the area under the curve of the tax burden and L the area under the 45º line.

To calculate L we use the formula:

$$\sum_{i=i}^{n} \frac{\left([T_x(y_i) + T_x(Y_{i-1})](Y_i - Y_{i-1})\right)}{2}$$

Formula 4: Area under the tax burden curve. Y_i represents the horizontal axis, that is, accumulated income. T_x (Y_i) represents the vertical axis, that is the accumulated tax burden. Source: Suits, 1977.

3.2 Selecting the main variable: income or consumption expenditure

One of the first things to consider in the design of the methodology to study the progressivity of a given tax is whether to use income or total expenditure to measure households' economic situation. Authors such as Poterba (1991) and Sterner (2012) advocate that the study of the progressivity of fuel taxes should be based on expenditure rather than income. Using expenses has the advantage of bypassing temporary circumstances that may decrease current disposable income due to unemployment. For example, a high-income individual or household might take a year off work, to travel, but although this may lower current disposable income it may have little impact on consumption levels if there in an expectation of returning to work, and stable earnings in the future. Additionally, labour income does not account for the effects of wealth, such as savings and other forms of capital earnings.

However, there are also some drawbacks to using expenditure to measure the proportionally of a given tax. Firstly, expenses rely mostly on individual self-reporting, which might be liable to distortion. Some individuals might over or underestimate their expenses; this distortion, however, may also happen with respondents' self-reporting of income, although possibly to less extent since individuals have a better knowledge about their income level. Using expenses may also be distorting because access to easy credit may fuel households' consumption above the level allowed by their income. Furthermore, for the usage of expenses to be fully reliable, even if self-reporting is correct, saving rates should be the same for every individual. Since individuals with higher incomes tend to save more (Alves & Cardoso, 2010), using expenses might underestimate the regressivity of the tax.

Our approach, based on data from the travel survey IMob 2017, compares the relative distribution of the expenditures relating to transport (fuel, parking, tolls, public transport) and the relative distribution of total income. Due to data unavailability, we do not have information on households' total expenses and must use their income, which might overestimate the regressivity of the tax. We can distinguish between expenditures relating to driving costs (fuel, parking, and tolls) and public transport costs to better understand how much each type of cost affects different groups. We explain the data use in the study in the next section.

3.3 Data

In this study we use data from the survey on mobility in the metropolitan areas of Lisbon and Porto, called IMob 2017, published in 2018. The survey was carried out by the National Institute of Statistics (INE) in collaboration with the Metropolitan Areas of Lisbon and Porto (AML and AMP respectively). The survey has an occasional nature, i.e., it was a one-off event, and there is no intention of it being continued, thus limiting the ability to use the survey results to monitor travel mobility patterns in Portugal's largest metropolitan areas. The survey was implemented in two phases. The first phase, from October to November of 2017, represents most of the sample (around 92.2% of the sample) and was conducted online, while the second phase, performed in December 2017 and representing around 7.8% of the sample, was carried out in person (INE, 2018). One possible drawback can be derived from this methodology, if poorer households are less likely to have access to computers it is possible that poorer households might appear under-represented. The second phase might help to compensate for this, however, since it represents a much smaller percentage of the sample it is still possible that poorer households are under-represented.

The IMob 2017 survey is divided into three parts: 1) characterization of the population; 2) mobility in the metropolitan area; and 3) opinions of residents on mobility. Our analysis will use mostly data from the third chapter (expenses on mobility) of the first part of the survey (characterization of the population). Additional information, such as the reasons for choosing different transportation methods is derived from question 8 (reasons to use car) and question 9 (reasons to use public transportation) of the third part (opinions of residents on mobility) of the survey.

The main variables of interest for our study are obtained from the survey's questions relating to the aggregated household's income and expenses. Throughout our analysis we will use self-reported household's net monthly aggregate income and their respective aggregate average monthly expenses on public transport, fuel, tolls and parking all measure in euros (INE, 2018). The responses were given by one individual of the household but refer to the whole household, not the individual. One limitation of the IMob 2017 survey is that the data available in the sections regarding expenses on transport and total income (taken from the first section of the enquire) is only recorded in groups, e.g., income brackets between 0-400€ a month or expenditures between 0-30€ a month. Consequently, since we are using the income brackets available in the enquiry, we need to rely on the midpoints for our calculations, which inevitably involves some measurement error. Besides the income brackets, we will also use expenses on fuel, tolls, parking and public transportation, also grouped in intervals defined in the survey. Likewise, we use the midpoints of each expense bracket as the basis for our analysis. Similar to income, the expenses are also the aggregate expense of the household.

Tables 1 and 2 show the income and expense brackets and midpoints that the IMob enquiry specifies. We separated the tables to simplify the reading. Table 1 demonstrates the income and public transportation expenses brackets and midpoints, Table 2 demonstrates the brackets and midpoints for expenses on car travel. Expense brackets (and by extension midpoints) differ across category of travel expenditure. Since we have no upper limit on income or expense, we are forced to use the highest value we have in each bracket. This means that we cannot account for abnormally large incomes or expenses which might undervalue theses values, however, this also means that there are no outliners.

Income Brackets	Income Midpoints	Expense Brackets for Public Transport	Expense MidPoint for Public Transport
0€ - 430€	215 €	0 €	0 €
430€-600€	515 €	<10€	5 €
600€-1000€	800 €	10€ a 30 €	20 €
1000€-1500€	1 250 €	30€ a 60€	45 €
1500€-2600€	2 050 €	60€ a 100€	80 €
2600€-3600€	3 100 €	100€ a 200€	150 €
3600€-5700€	4 650 €	200€ a 400€	300 €

5700€-7000€	6 350 €	>400€	400 €
7000€ +	7 000 €		

Table 1. Income and Public transportation expenses brackets and midpoints. Made by author based on data from IMOB 2017. Source: (Instituto Nacional de Estatística, 2018).

Expense Brackets for Fuel	**Expense MidPoint for Fuel**	**Expense Brackets for Parking**	**Expense Midpoints for Parking**	**Expense Brackets for Tolls**	**Expense Midpoints for Tolls**
0 €	0 €	0 €	0 €	0 €	0 €
<10€	5 €	<5€	2.5€	<5€	2.5€
10€ a 30 €	20 €	5 a 10€	8 €	5€ a 10€	8 €
30€ a 60€	45 €	10 a 30€	20 €	10€ a 30€	12.5€
60€ a 100€	80 €	30 a 50€	40 €	15€ a 30€	22.5€
100€ a 150€	125 €	50 a 100€	75 €	30€ a 60€	45 €
150€ a 250€	200 €	100 a 200€	150 €	60€ a 150€	105 €
250€ a 400€	325 €	>200€	200 €	>150€	150 €
>400€	400 €				

Table 2. Expenses on car brackets and midpoints. Made by author based on data from IMOB 2017. Source: (Instituto Nacional de Estatística, 2018).

In total we use data for 39,374 households in the enquiry: 24,666 refer to Lisbon metropolitan area (AML) and 14,708 refer to Porto metropolitan area (AMP), meaning that around 62.6% of the sample refers to the Lisbon Region. When we account for individuals in each household, there are 62,712 individuals in AML and 42,870 in AMP, meaning that around 59% of the 105,582 individuals enquired are from AML. The population of the Lisbon metropolitan area at the time was of 2.8 million individuals, while in Porto metropolitan area it was of 1.7 million, which means the sample represents around 2.2% of total population of the Lisbon Region and 2.5% of the population of the Porto Region (INE, 2018). In our calculations we consider the individuals who answered all the relevant answers. This means that our sample drops from an initial value of 46,080 households to 39,374 households.

Since the survey covers only the metropolitan areas of Lisbon and Porto, the results might not be representative for the whole Portugal. In particular, since these two regions enjoy some of the best public transport systems in Portugal, it is likely that the importance of public transport is overestimated, especially when compared to less urban or rural areas. Moreover, rural areas are usually more opposing to fuel taxes, due to their perceived lack of alternatives (Levi, 2021). Nevertheless, some authors suggest that, at

least in Canada, revenue recycling eliminates the disproportional burden on rural populations (Beck, Rivers, & Yonezawa, 2016).

Another problem that might arise is the fact that petrol and diesel have different taxes and prices. For example, in 2017, petrol had a higher tax rate and a higher overall price than diesel. Since we cannot distinguish between the two from the data, we might not be able to correctly calculate the prices and are forced to make approximations or use the average price on fuel as a reference.

Finally, the data available refers to the year 2017 and may not reflect present preferences, expenses, and income. For example, fuel price has grown significantly from an average price for petrol of 1.50€ per litre in 2017 (PORDATA, 2022) to an average price for petrol of 1.825€ per litre on the first trimester of 2022 (ERSE, 2022). Regarding public transportation, the introduction of the 40€ per month cap on public transportation travel cards in the metropolitan areas of Lisbon and Porto is likely to have affected the expenses with public transport, as seen by an increase of 20% of public transportation users in Lisbon metropolitan area, and 17% in Porto metropolitan area before the COVID-19 pandemic emerged in March of 2020 (Fragoso, 2021). This increase is not accounted for in the data available and might have changed the demand for fuel and public transportation.

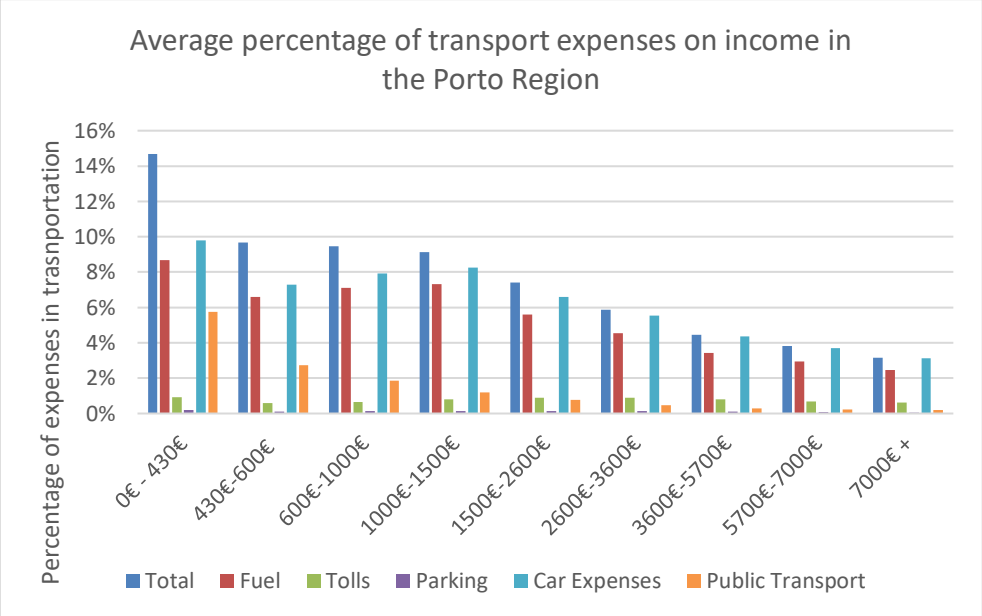
4 Results and Discussion

In section 3 we explained the Lorenz Curve, Gini Index and Suit index. We will now apply these concepts to the data from the IMob 2017. All data on expenses and income concerns self-reported aggregates for households. Firstly, we apply frequency methods to compare the average expenses on transportation for each income bracket, following the work of Poterba (1991). We will follow this analysis by drawing the Lorenz Curve for the income distribution before and after transport costs for both Lisbon and Porto metropolitan areas, calculating their respective Gini Index. This should give us an overall idea of how much income inequality rises after expenses on mobility are accounted for. Lastly, we will focus on fuel taxation and analyse the progressivity of fuel taxation based on the Suits Index and associated diagram, similar to the analysis of Sterner (2012) and Agostini and Jiménez (2015).

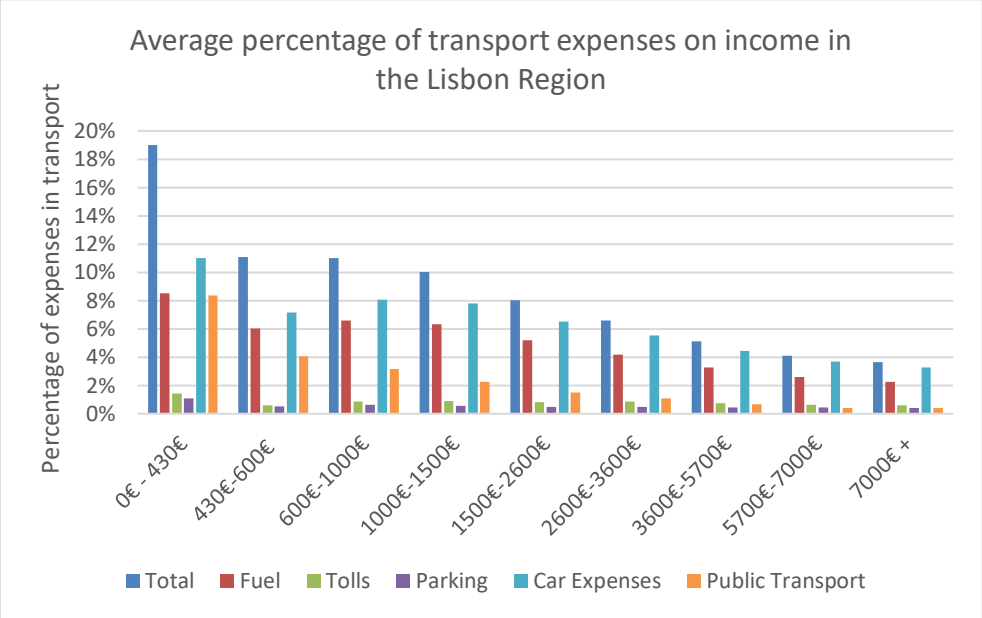
4.1. Analysis of the distribution of transport expenses by income groups

The graphs 3 and 4 below show how much households in each income bracket spend on the different categories of transport as a percentage of their income (in the vertical axis). The horizontal axis shows the income brackets. We measured the average transport expense for each category of transport cost. To calculate the average expense, we measured the mean impact the expenses have on each transport category, for each income bracket: e.g., if a household belongs to the first income group, with midpoint 215€, and pays 21.5€ for fuel, the household spends 10% of its income on fuel. For "car expenses" we add every expense relating to driving (that is, fuel, tolls and parking), whereas "total expenses" include fuel, tolls, parking and public transport.

The trajectories depicted in the figures are similar in both metropolitan areas: car-related expenses are the main category of transport costs in households' income budget, especially due to the impact of fuel costs. As one would expect, the proportion of expenses is particularly larger for low-income groups and reduces as income rises, especially for higher income groups. This is reasonable because the amount of travel does not increase proportionally to income group for all income groups: while more income allows people to travel more, the number of trips to shops, school, work, leisure may not increase much beyond a certain level of income.



Graph 3. Average expenses in transportation on income in Porto Metropolitan Area. Made by author based on data from IMOB 2017.



Graph 4. Average expenses in transportation on income in Porto Metropolitan Area. Made by author based on data from IMOB 2017.

Tables 3 and 4 show in detail the effort rates for each income bracket, plotted in graphs 3 and 4. The biggest source of expenses in every income bracket is fuel, while public transport is the second highest expense. Interestingly, relative to income, public transportation has a bigger impact on lower income households than on higher income households. This has also been observed for other countries and can be explained by the fact that poorest households tend to have lower car ownership levels and are more dependent on public transportation, compared to richer households. Note that this data refers to a period before the implementation of the PART program, which reduced substantially the prices of public transport.

Income	Fuel	Parking	Tolls	Public Transport	Total
0€-430€	8.61%	0.21%	0.91%	5.94%	14.68%
430€-600€	6.46%	0.12%	0.55%	2.81%	9.68%
600€-1000€	7.09%	0.14%	0.68%	1.95%	9.45%
1000€-1500€	7.19%	0.13%	0.82%	1.22%	9.12%
1500€-2600€	5.83%	0.13%	091%	0.77%	7.41%
2600€-3600€	4.48%	0.13%	0.89%	0.49%	5.87%
3600€-5700€	3.36%	0.10%	0.82%	0.29%	4.46%
5700€-7000€	2.95%	0.09%	0.76%	0.22%	3.83%
7000€ +	2.39%	0.06%	0.64%	0.21%	3.17%

Table 3. Average percentage of income spend on traveling expenses in Porto metropolitan area. Made by author based on data from IMOB 2017. Source: (Instituto Nacional de Estatística, 2018).

Income	Fuel	Parking	Tolls	Public Transport	Total
0€-430€	8.48%	1.12%	1.41%	8.18%	19.00%
430€-600€	6.95%	0.51%	0.58%	4.02%	11.08%
600€-1000€	6.54%	0.61%	0.83%	3.14%	11.00%
1000€-1500€	6.25%	0.57%	0.88%	2.28%	10.03%
1500€-2600€	5.16%	0.49%	0.82%	1.51%	8.02%
2600€-3600€	4.16%	0.51%	0.84%	1.08%	6.61%
3600€-5700€	3.24%	0.45%	0.74%	0.67%	5.11%
5700€-7000€	2.56%	0.46%	0.63%	0.43%	4.11%
7000€ +	2.22%	0.41%	0.59%	0.38%	3.66%

Table 4. Average percentage of income spend on traveling expenses in Lisbon metropolitan area. Made by author based on data from IMOB 2017. Source: (Instituto Nacional de Estatística, 2018).

In tables 5 and 6 we compare the relative frequency of the population in each income bracket, and the share of each income bracket on total income across all income brackets. In order to calculate this, we assume every household inside a given income bracket earns the same income (i.e., the midpoint of each income bracket or, in the case of the last income bracket, 7000€) and multiply this value by the number of households inside each income bracket; we then divide the total of each bracket by the total of all brackets combined. The results allow us to visualise how much each income bracket is responsible for in the total income. As expected, the poorest households have disproportionally less income (for example the 7.15% poorest households are responsible for just 1.01% of the total income in the Porto metropolitan area, around seven times less then what was expected if every individual earned the same income); the richest households, accounting for 1.23% of households have 4.72% of the total income in Lisbon metropolitan area, about four times more than what would be expected if every individual earned the same income.

A similar process is executed for each transport expense class. We calculate the percentage of expenses that each income bracket is responsible for by transport expense category. To illustrate with data for the AML and the lower income bracket, we see that the households in this group account for about 7% of the population, but only 1% of total income, and about 2% of total expenses with transportation (however, they represent about 6% of total expenses in public transport compared to only 1.5% of total car

expenses). In contrast, higher income households account for larger shares of total expenditure with car use than total expenses with public transport.

Income	Rel. Freq. of Pop.	Rel. Freq. of income	Rel. Freq. of fuel exp.	Rel. Freq. of Public transport exp.	Rel. Freq. of car exp.	Rel. Freq. of total exp.
0€-430€	7.15%	1.01%	1.48%	6.08%	1.47%	2.07%
430€-600€	11.38%	3.84%	4.43%	10.87%	5.53%	6.22%
600€-1000€	21.80%	11.42%	14.35%	21.95%	13.63%	14.71%
1000€-1500€	23.58%	19.29%	25.02%	23.57%	24.05%	23.99%
1500€-2600€	23.58%	31.64%	32.90%	25.36%	32.89%	31.91%
2600€-3600€	7.23%	14.68%	11.81%	7.20%	11.58%	11.01%
3600€-5700€	3.75%	11.40%	6.87%	3.39%	7.46%	6.93%
5700€-7000€	0.65%	2.71%	1.42%	0.60%	1.54%	1.42%
7000€ +	0.88%	4.02%	1.73%	0.97%	1.85%	1.74%
Total	100%	100%	100,00%	100%	100%	100%

Table 5. Relative frequency of expenditure transport in Porto metropolitan area. Made by author based on data from IMOB 2017. Source: (Instituto Nacional de Estatística, 2018).

Income	Rel. Freq. of Pop.	Rel. Freq. of income	Rel. Freq. of fuel exp.	Rel. Freq. of Public transport exp.	Rel. Freq. of car exp.	Rel. Freq. of total exp.
0€-430€	5.01%	0.59%	1.06%	3.10%	1.07%	1.48%
430€-600€	7.34%	2.07%	2.61%	5.40%	2.42%	3.02%
600€-1000€	17.43%	7.63%	10.54%	15.51%	10.08%	11.16%
1000€-1500€	22.74%	15.07%	19.94%	22.44%	19.24%	19.88%
1500€-2600€	27.75%	31.15%	33.98%	30.86%	33.40%	32.89%
2600€-3600€	11.08%	18.81%	16.54%	13.26%	17.16%	16.38%
3600€-5700€	6.28%	15.99%	10.93%	7.04%	11.70%	10.76%
5700€-7000€	1.14%	3.97%	2.17%	1.11%	2.41%	2.15%
7000€ +	1.23%	4.72%	2.22%	1.28%	2.52%	2.27%
Total	100%	100%	100%	100%	100%	100%

Table 6. Relative frequency of expenditure on transport in Lisbon metropolitan area. Made by author based on data from IMOB 2017. Source: (Instituto Nacional de Estatística, 2018).

In table 7 we show the percentage of households that used car or public transport in each income bracket. In order to do this, we counted as using car or public transportation every household that had any expense on fuel (for car use) or public transportation. The results show that car use increases with income both in Porto and Lisbon. However, the rate of utilization of public transport seems to be stable in Lisbon (always between 50% and 60% regardless of income) while in Porto there is a decrease

after the 800€ income category. It is important to note that this data relates to households, not individuals. Furthermore, although there is a positive relation between the frequency of travel using a given transport mode and the expenditure allocated to that mode, it not possible to know how often people actually use each transport mode from expenditure data. Despite of these limitations, the data still gives us important information in understating the general trend of the usage of car or public transportation in relation to income.

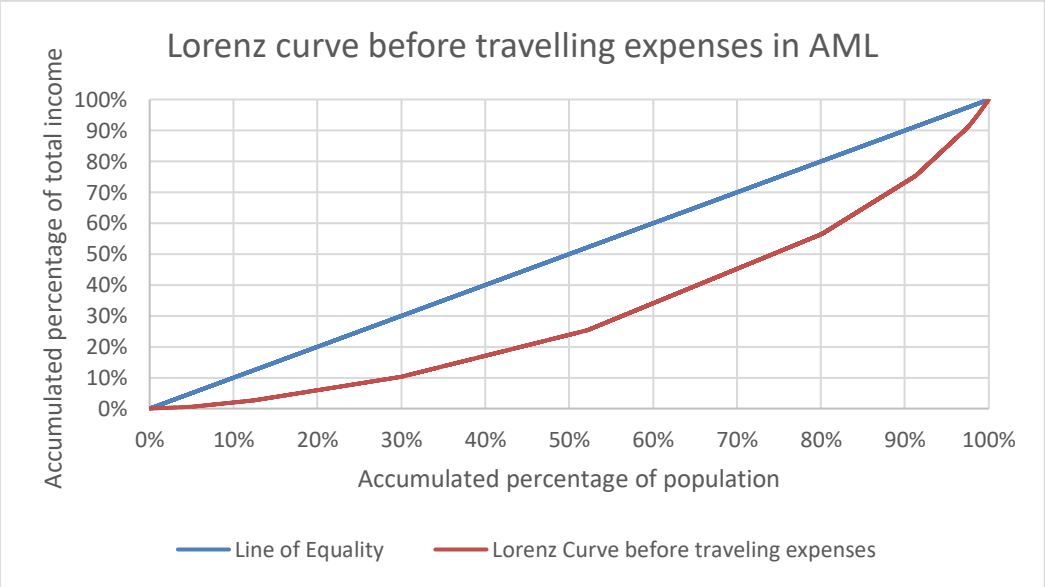
Income	Percentage of car use AML	Percentage of public transportation use AML	Percentage of car use AMP	Percentage of public transportation use AMP
0€-430€	33%	50%	34%	71%
430€-600€	48%	50%	53%	83%
600€-1000€	70%	52%	74%	92%
1000€-1500€	85%	54%	89%	46%
1500€-2600€	92%	56%	94%	47%
2600€-3600€	96%	58%	96%	49%
3600€-5700€	96%	57%	96%	49%
5700€-7000€	96%	54%	96%	41%
7000€ +	91%	52%	94%	41%

Table 7.: Percentage of car and public transportation use in Lisbon and Porto Metropolitan Areas by each income category. Made by author based on data from IMOB 2017. Source: (Instituto Nacional de Estatística, 2018).

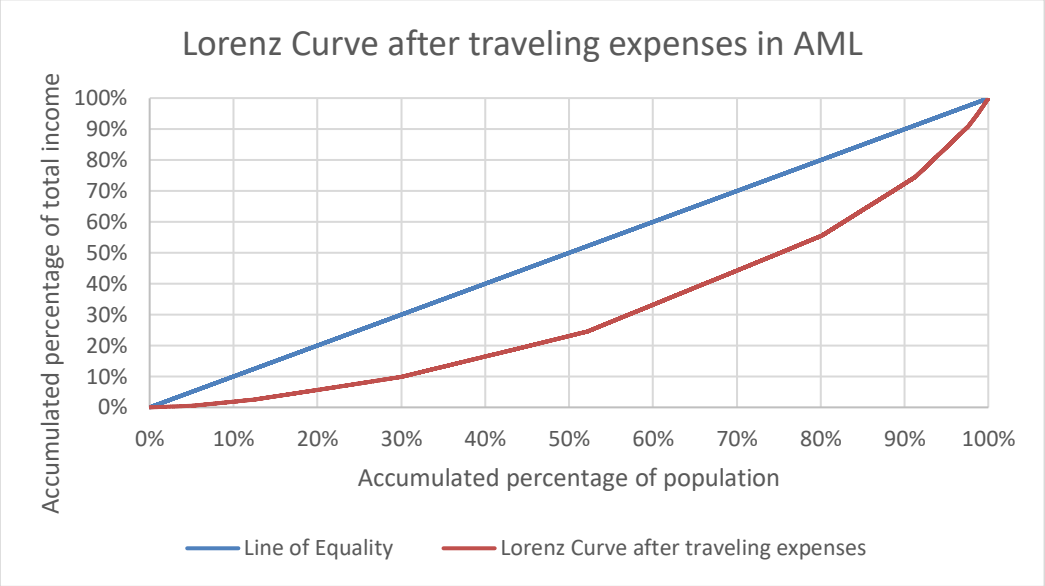
4.2. Analysis of income inequality before and after transport costs

To better understand the effect of transport costs on income inequality, we calculated the Gini Index before and after traveling expenses in Lisbon and Porto metropolitan areas. Two theoretical problems might arise in this calculation: Firstly, the Gini Index can be considered to have a "bias" to the middle of the distribution, i.e., the middle of the income distribution might have more importance in the result then the extremes. An example of this effect can be seen in the evolution of the Gini Index in Portugal between 2011 and 2015 which showed that inequality had decreased during the financial crisis and austerity period. However, other measures such as the percentile ratios 10/90 or 20/80 showed an increase in inequality (Rodrigues, Figueiras, & Junqueira, 2016). The second problem results from the data available, since we do not have continuous income data, but rather grouped income data, we are forced to use approximations, meaning that the true values might be different from the ones we have calculated.

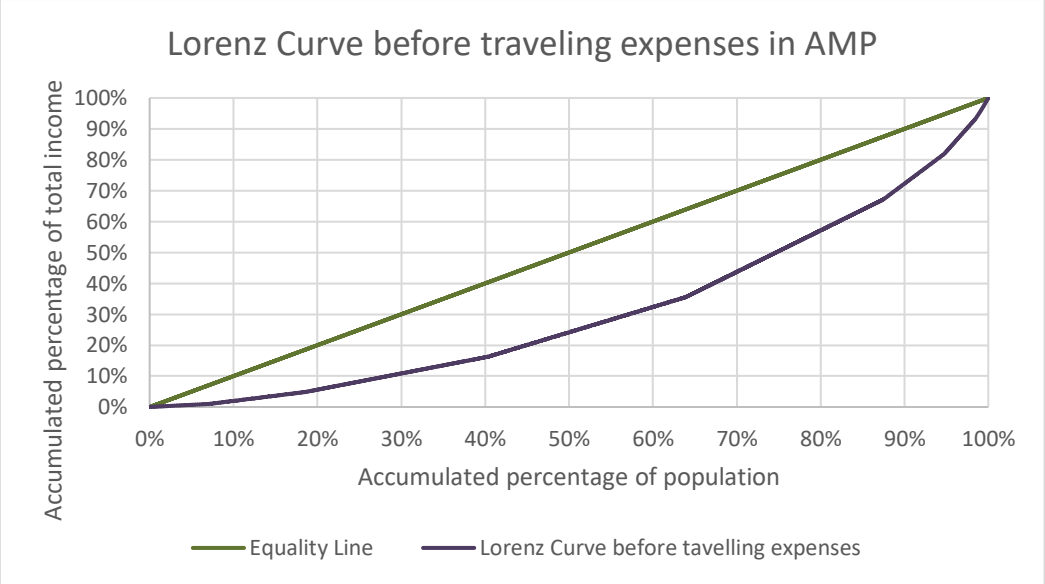
On graphs 5, 6, 7 and 8 we see the Lorenz Curve before and after travelling expenses for both metropolitan areas. The closer the Lorenz Curve is to the line of equality, the more equally distributed income is. The X axis shows the relative cumulative distribution of the population while the Y axis shows the relative cumulative distribution of income. On graph 5, which shows us the Lorenz Curve before expenses on travelling for the AML, we can see, for example, that the first 30% of households are only responsible for around 10% of total income. On graph 6, which shows the Lorenz Curve after travel expenses for the AML, we see similar results. In fact, the differences are difficult to grasp using the graphs. The patterns are also very similar when comparing the Lorenz curves before and after travelling expenses for the AMP in graphs 7 and 8.



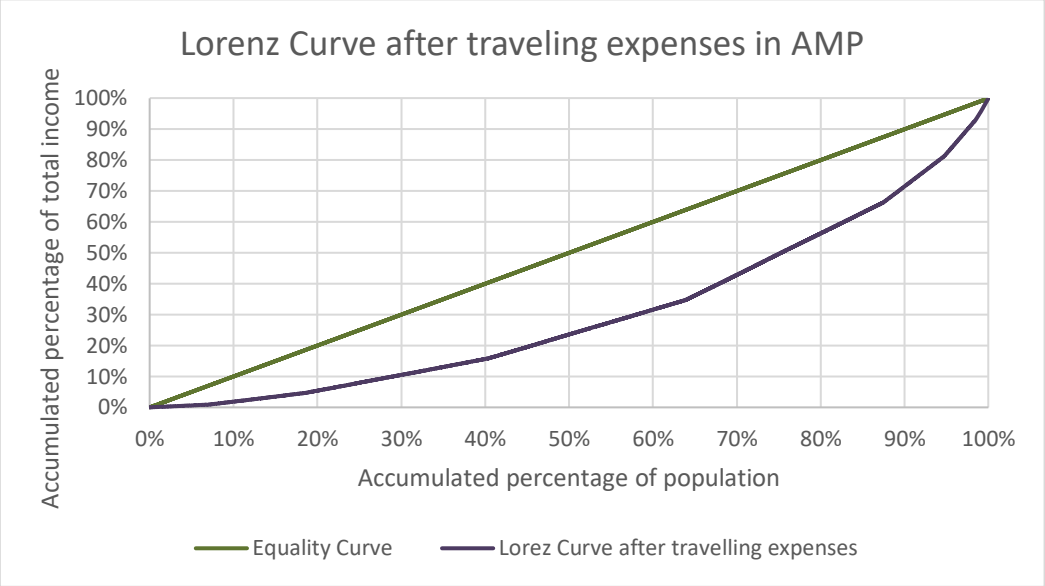
Graph 5. Lorenz Curve before traveling expenses Lisbon. Made by author based on data from IMob 2017.



Graph 6. Lorenz Curve after traveling expenses in Lisbon. Made by author based on data from IMob 2017.



Graph 7. Lorenz Curve before traveling expenses Porto Table. Made by author based on data from IMob 2017.



Graph 8. Lorenz Curve after traveling expenses Porto Table. Made by author based on data from IMob 2017.

Since by looking at the Lorenz curves it is difficult to grasp any changes, we computed the Gini Index to measure the impact of transport costs on income inequality. Table 9 below shows that traveling expenses slightly increase the value of the Gini index of the income distribution, meaning that income inequalities increase after considering travelling expenses, but the effect seems moderate. Another aspect to note is that the effect on inequality from public transport is weaker than the effect of car use. According to INE, the Gini Index for Portugal in 2015 was 0.339 (PORDATA, 2022). The differences observed in relation to our values might be explained by the sample we use, that is, only Lisbon and Porto regions, which tend to have greater income inequalities.

Gini Index of income distribution	Before Traveling Expenses	After Traveling Expenses	After Car Expenses	After Public Transport Expenses
Lisbon	0.370	0.381	0.376	0.374
Porto	0.379	0.389	0.386	0.382

Table 8. Gini Index in Lisbon and Porto Metropolitan areas before and after travelling, car and public transportation expenses. Made by author based on data from IMOB 2017.

4.3. Analysis of the degree of progressivity of fuel taxes

Using data from the Oil Bulletin we can estimate the average tax rate for 2017. To do this, we used the average percentage of tax on the price of fuel for the first week of every month in 2017 and the result was that, on average, 57% of the price of fuel was

due to taxes. We should note that this is the average of petrol and diesel combined. Using this estimate we can calculate how much average tax is paid by each income group. We used the average percentage of income spend on fuel (see tables 2 and 3) and calculated how much of this expense was on tax. Therefore, the result (showed in Table 10) is the average percentage of income each income bracket spends on fuel taxes monthly. In Table 10, we can see that taxes seem to affect more disproportionally the poorer and middle-income households, when compared to richer households, suggesting that taxes are regressive. Another interesting aspect is that the distribution is relatively similar in both the Lisbon region and the Porto region.

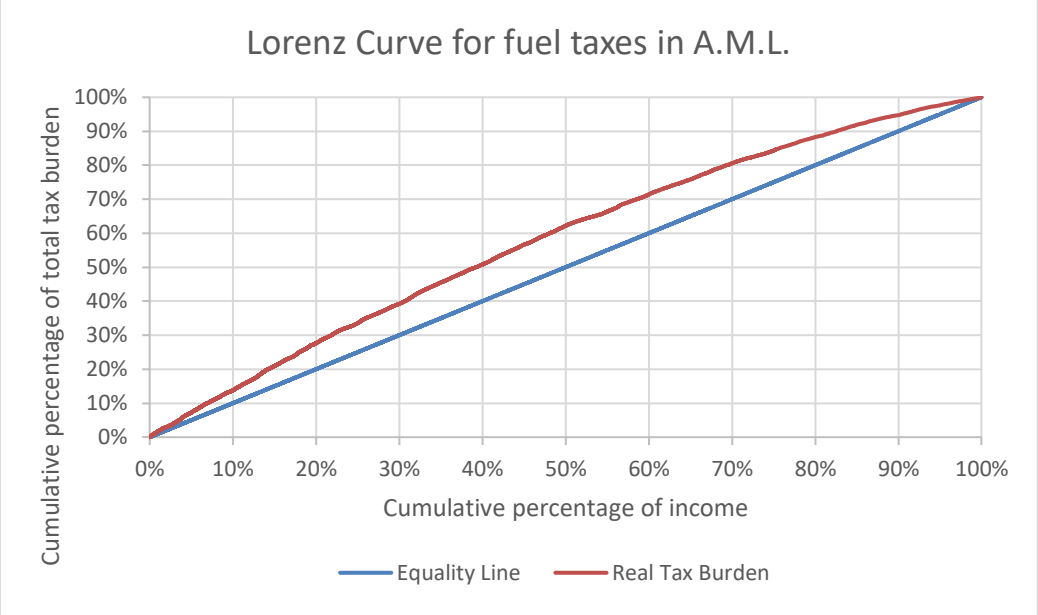
Income	Relative frequency (%)	Taxes on fuel in Porto region	Taxes on fuel in Lisbon region
0€-430€	5.8%	4,94%	4,85%
430€-600€	8.9%	3,75%	3,44%
600€-1000€	19.1%	4,06%	3,76%
1000€-1500€	22.7%	4,17%	3,60%
1500€-2600€	26.3%	3,19%	2,96%
2600€-3600€	9.7%	2,58%	2,39%
3600€-5700€	5.4%	1,96%	1,86%
5700€-7000€	1%	1,67%	1,47%
7000€ +	1.1%	1,40%	1,29%

Table 9. Average percentage of tax expense on income in Lisbon and Porto Metropolitan Areas. Made by author based on data from IMOB 2017.

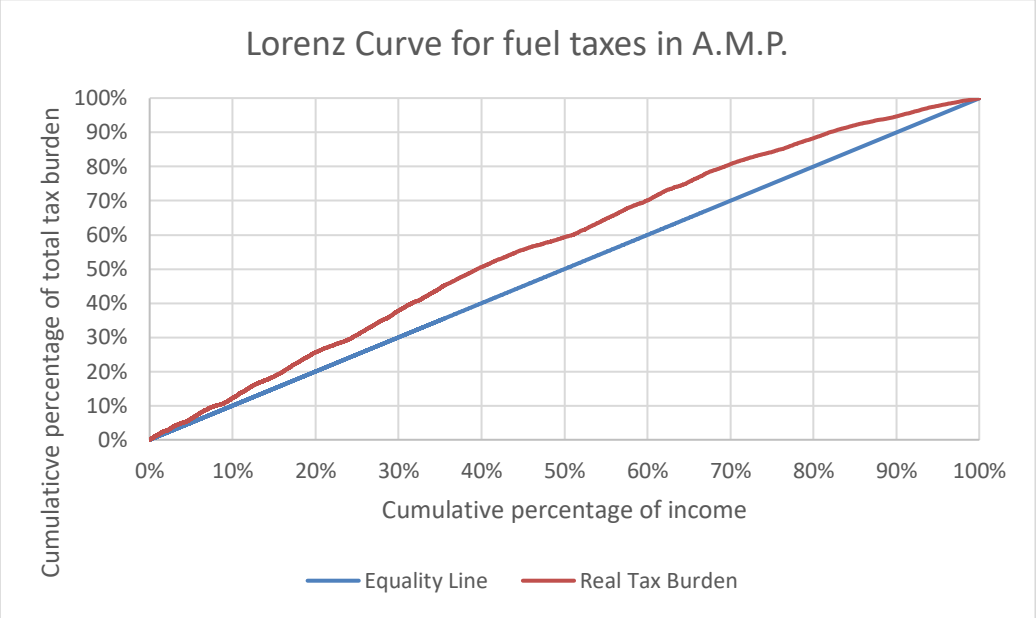
Graphs 9 and 10 below, show the cumulative relative distribution of the tax burden (vertical axis) in relation to the cumulative relative distribution of income (horizontal axis). Since the curve that represents the actual tax burden (in red) is above the 45º line of tax proportionality (in blue), we can conclude that there is some regressivity in fuel taxes. For example, in graph 9, which represents tax proportionality in the Lisbon Metropolitan Area, we can see that the cumulative tax burden was around 60% for the first 50% of households in terms of income. Should the tax be proportional, the cumulative tax burden at that point should be 50%, if the tax was progressive, the cumulative tax burden should be below 50%.

To quantify the magnitude of fuel tax regressivity we applied the Suits index and obtained a value of -0.14 for Porto region and of -0.16 for Lisbon region. This suggests

that taxes are slightly regressive. These values are in line to what Sterner found for other western European countries, e.g., -0.16 for France or the -0.18 for Sweden (Sterner, 2012). Sterner posited that a slightly regressive tax would be expected in higher income countries, where cars are not seen as a luxury good. In poorer countries, for instance, in Serbia, fuel taxes showed a degree of progressivity (Sterner, 2012). Nevertheless, we should note that, as mentioned by Poterba, using income and not total expenses might overestimate the degree of regressivity of fuel taxes. This means that if we had used total expenditure data, rather than income, we would likely have obtained a higher Suits index (indicating more progressivity). As noted earlier, this was not possible because the IMob 2017 travel survey does not inquire individuals about their total expenses.



Graph. 9. Suits Index visualized for the fuel tax impact in Lisbon Metropolitan Area. Made by author based on data from IMob 2017. Source: (Instituto Nacional de Estatística, 2018).



Graph. 10. Suits Index visualized for the fuel tax impact in Porto Metropolitan Area. Made by author based on data from IMob 2017. Source: (Instituto Nacional de Estatística, 2018).

5 Conclusion

Previous studies on the proportionality of fuel tax have shown that fuel taxes tend to be mostly proportional. In developing countries, fuel taxes often tend to be slightly progressive, while in developed countries they tend to be slightly regressive. Our calculations for Portugal using microdata from the IMob 2017 travel survey show a slight fuel tax regressivity, similar to what has been estimated for other Western European countries. According to Poterba and Sterner, using income data instead of total expenditure data tends to overvalue the regressivity of fuel taxes. This means that our results, which are based on income data, may overvalue the degree of regressivity.

When we look at travelling costs as a whole, we see that the lowest income households have relatively higher expenses in transportation, while high-income households have relatively lower expenses. This pattern is also present on the middle-income brackets although it is less noticeable on certain brackets. The measures obtained for the Gini Index suggest that travelling expenses increase the degree of inequality of disposable income, but only moderately. Furthermore, the fact that many of these expenses (such as public transport, tolls, and taxes) are directly under the responsibility of the national and/or local government, suggests that the government can have an

important role in decreasing inequality. However, we should note that the data available refers to 2017 and hence does not consider the general reduction in public transport fares that took place in April 2019 as part of the PART programme (Gabinete de Gestão do Fundo Ambiental, 2021), which reduced the price of monthly travel cards substantially in both metropolitan areas (in some municipalities, prices fell from 120 euros to 40 euros), and which seems to have increased the number of public transport users before the onset of the covid-19 pandemic on March 2020 (Fragoso, 2021).

Since the evidence seems to suggest that the fuel tax is regressive, we might want to find mechanism to guarantee its progressiveness. However, because the fuel tax is an indirect tax, it is difficult to select the richest individuals. A feasible alternative could be a tax return adjusted to income, that is, lower income individuals would receive a higher tax return on the taxes they paid on fuel. We should note that, unlike a progressive income tax, the idea of a progressive fuel tax would be to increase the effectiveness of the environmental aspect of the tax without compromising the social equity of the tax system. Naturally, the application of this measure would have its own drawbacks, notably the difficulty in accurately measuring income, the fact that wealth might not always be directly linked to income, and the possibility that the Pigouvian effect of the tax might be reduced, that is, if the price of fuel with tax represents the total cost of fuel (including the social cost), by giving a tax return to the lowest income individuals we are moving away from the optimal cost of fuel. Lastly, since income tax is already progressive, we might consider a tax return for the lowest income individuals as a *de facto* double tax on some individuals.

In March of 2022, the Portuguese government announced the AUTOvoucher programme to try and mitigate the negative impact of the rise in fuel prices on drivers' fuel cost. The AUTOvoucher is a government subsidy for fuel consumption where the government gives 10 cents per litre of fuel consumed at a maximum of 5€ a month if the individual buys 50 litres of fuel in a month. Due to the war in Ukraine, the 5€ maximum was increased to 20€ if the individual buy 200 litres of fuel in a month (Portuguese Government, 2022). At this point we do not have any data to evaluate the effect of this programme, however, we might assume that, since the subsidy is proportional to the consumption of fuel, it is possible that lower income individuals (who consume less fuel)

will be those least benefited by the AUTOvoucher. Additionally, the AUTOvoucher does not consider the income of the recipients. Therefore, it is possible that the richest households will gain the larger benefits from the AUTOvoucher.

Our study does not consider the recycling of revenue from fuel taxes. Considering the investments financed by the fuel tax revenue it is possible that a regressive tax might have a progressive net benefit. One possibility is to allocate the fuel tax revenue to public transport. Investment in public transport can offer a good solution for three reasons. First, it offers a greener alternative to fuel consumption. Intuitively, this would increase the price elasticity of the demand for fossil fuels, a higher elasticity would mean that a smaller tax would be able to reduce relative more the consumption of fuel. Second, a higher elasticity would also mean that producers would have to internalize more of the tax, since a rise in price would lead to a steeper drop in demand. Third, if public transport were a viable alternative, then it would be easier for individuals to substitute driving, which could, potentially, help the poorest members of society since they would have a more affordable alternative to driving.

In Portugal, in 2020, 24% of the budget of the environmental fund came from earmarked fuel taxes, corresponding to 157 million euros. Out of these 157 million euros, 138 million (around 88%) is funnelled directly to public transport through the PART initiative. In 2020, according to the state budget, the total ISP revenue was of 3 720 million euros, meaning that around 4% of the revenue from fuel tax was used for the environmental fund. We suggest an increase in the revenue earmarked for the environmental fund in order to increase the ecological efficiency of the fuel tax.

Lastly, we must conclude that more complete studies are difficult to perform on travel expenses due to the lack of data offered by the government and the fact that the data available is not up to date and lacks regularity. Therefore, it is difficult to properly evaluate the policies implemented, which limits the ability of the government of understanding whether policies deliver their expected outcomes.

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Appendix

The first two tables show that most people who use cars use it because they are faster and more comfortable. Prices only account for 14,01% of the stated reasons to use cars, in comparison to 35,6% of the reasons to use public transportation.

Reasons to use a car in LMA	%
Speed	62,86
Comfort	50,24
Public transport doesn't have a direct commute	30,50
Public transport doesn't have enough frequency or reliability	25,08
No alternative	22,95
Professional reasons	17,08
Price / Cost	14,01
Privacy	12,95
Easy parking	12,83
Safety	9,82
Difficulty in mobility on Public Transport	9,49
Car-sharing	8,52
Good roads	8,12
Other reasons	7,01
Company Car	6,71
Lack of knowledge of public transport.	1,82

Table A.1 – Reasons for using a car in Lisbon Metropolitan Area. Source.: (Instituto Nacional de Estatística, 2018)

Reasons to use a car in PMA	%
Speed	58,8
Comfort	49,3
Public transport doesn't have a direct commute	35,7
No alternative	34,8
Public transport doesn't have enough frequency or reliability	27,5
Professional reasons	18,4
Car-sharing	10,5
Privacy	10,4
Good roads	9,4
Price / Cost	8,2
Difficulty in mobility on Public Transport	7,9
Easy parking	7,9
Safety	7,2
Other reasons	6,6
Company Car	5,2

Lack of knowledge of public transport	2,3

Table A.2- Reasons for using a car in Porto Metropolitan Area. Source.: (Instituto Nacional de Estatística, 2018)

The following two tables suggest that people who use public transport mainly do it because they have no other options. Price plays a much more important part in the reasoning for using public transport in comparison with driving a car.

Reasons to use public transport in LMA	%
Doesn't drive/has an individual vehicle	43,98
No alternative	42,49
Price / cost	35,60
Easy to access	30,92
Direct connection to the destine	30,62
Speer	25,21
Hard to park individual vehicle	21,72
Transit	21,42
Other	14,30
Comfort	13,18
Environmental concerns	8,89
Quality of the service (frequency, trustworthy….)	6,47
Easy to park next to public transport	5,19

A.3 – Reason for using public transport in Lisbon Metropolitan Area. Source.: (Instituto Nacional de Estatística, 2018)

Reasons to use public transport in PMA	%
Doesn't drive/has an individual vehicle	52,6
No alternative	49,1
Price / cost	38,2
Easy to access	32,5
Direct connection to the destine	30,2
Speed	18,9
Comfort	16,4
Difficulty in parking individual vehicle	16,3
Transit	13,7
Other reasons	12,3
Quality of the service (frequency, trustworthy...)	11,1
Environmental concerns	5,5
Easy to park next to public transport	3,1

A.4 – Reason for using public transport in Porto Metropolitan Area. Source.: (Instituto Nacional de Estatística, 2018)