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G5 Social Impacts of Transportation

How unequal are sustainable transport policies?

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Summary:

Using data from the Household Survey, collected for the city of Lyon in 2006, we compare different income inequalities indicators to assess Lyon's current situation. We specifically use the Gini, Theil and Atkinson inequality indicators, calculated by unit of consumption and we compare their results.

Our main objective is to evaluate inequality trends and to identify the sensitivity of the indicators. Like Ramjerdi (2006), we want to illustrate that we need an examination of several inequalities measures to make a judgement about equity implication.

Compared to the situation of Lyon 10 years ago, our results show an increase in all the inequality indicators (Gini, Theil, Atkinson). That is to say, an increase in inequality between 1995 and 2005, but coherent with the national one. This trend is particularly significant for the Theil and Atkinson indicators. With a Theil indicator with decomposition calculus, our results show that the major part of the Theil level is due to inequalities between income classes.

Key-words : household survey, inequality evaluation, inequality, urban indicator

JEL classification : R40, R20, D31, D63

1. Introduction

Becoming a sustainable city is an uncertain and complex objective. One of the solutions is to aim at a city more respectful of the environment and offering a better quality of life.

From a transport point of view, targets are starting to be well known: decrease the space dedicated to car, increase the user cost of a car, encourage alternative modes, in particular public transport. Usually, solutions are implemented through a system of urban road pricing: congestion charging as in London or Stockholm (Leape, 2006 ; Santos and Rojey, 2006 ; Eliasson, 2009) or increase in car park cost. However, we tend to forget that these policies induce significant effects on inequalities.

Urban road pricing is a regressive fare measure as it tends to favour people with a high value of time, characteristic found in groups of people with the highest income (Richardson, 1974; Glazer, 1981; Niskanen, 1987; Evans, 1992). As demonstrated by Giuliano (1992), the so-called “loser” categories are strongly influenced by the price level of urban toll and the proposed alternatives. This new pricing system drives the cost of suburban localisation up (Emmerink and al., 1995) and, more globally, creates a territorial inequity (Raux and Souche, 2004). For the Stockholm urban road pricing, Armelius and Hultkrantz (2006), as well as Eliasson and Mattson (2006), show that the average revenue categories, who use the car and live in the suburbs, loose the most when this system is implemented.

Our objective is to identify who the “winner” and “loser” groups of people are, when these types of measures are implemented. However, this paper it’s only a preliminary approach. Our main objective is to evaluate inequality trends and to identify the sensitivity of the indicators. Like Ramjerdi (2006), we want to illustrate that we need an examination of several inequalities measures to make a judgement about equity implication. Based on this examination, an efficient fairness transport policy will be assessed, taking into account the trend of inequality measures.

We will use data from the Household Survey, collected for the city of Lyon in 2006. We will compare different income inequalities indicators to assess Lyon’s current situation. We will specifically use the Gini, Theil and Atkinson inequality indicators, calculated by unit of consumption and compare their results.

Even if Gini coefficients is rarely used in the transport literature, this indicator seems to be common in economics. To our knowledge, Theil and Atkinson indicators are absents from the transport inequality measure presented in the literature, except from Ramjerdi (2006) or Berri (2008). The Gini indicator calculates the income concentration: the closer to 1, the higher the inequality of revenue (this value is of 0.3 in average in France). The Theil indicator evaluates the difference between the weight of one individual in the population and the weight of his income in the total income. The Atkinson indicator integrates an ethical dimension in the calculus of the inequality indicator.

Compared to the situation of Lyon 10 years ago, our results show an increase in all the inequality indicators (Gini, Theil, Atkinson). That is to say, an increase in inequality between 1995 and 2005 which is coherent with the national one. This trend is particularly significant for the Theil and Atkinson indicators. With a Theil indicator decomposition calculus, our results show that the major part of the Theil level is due to inequalities between income classes.

Following a literature survey on the inequalities measures (Section 2), we will present the data and the methodology used in the study (Section 3). Then, the main findings will be presented and discussed (Section 4).

2. Brief survey on inequalities measures in the transport sector

In the transport literature, we can find papers that evaluate inequality effects with or without specific inequality indicators. To our knowledge, Theil and Atkinson indicators are absent from the literature, except from very recent papers.

Church and al. (2000) examine different indicators to assess the outcomes of mobility policies aiming at reducing exclusion. These indicators are not Gini's, Theil's or Atkinson's and are applied to the London case study. Firstly, they try to define and identify social exclusion in London. They underline the weakness of the exclusion indicator at national level at the end of 1999. They show that the approach currently tested is to use composite index (e.g. Index of Local Deprivation) or single measures. Transport is only assessed in terms of accessibility by the London Transport's tool for measuring travel time to a specific destination or from a specific origin (CAPITAL). CAPITAL evaluates the accessibility of specific locations to relevant facilities. However, the authors underline that the existence of a high level of accessibility does not necessarily imply that people are able to benefit from it. They conclude on the necessity to study public transport accessibility between areas with high levels of social exclusion and key opportunities.

Eliasson and Mattsson (2006) develop a specific method to evaluate the equity effects of the Stockholm pricing system. As they explain in this paper, whereas most current studies deal exclusively with how costs and benefits are distributed among income groups, they also want to consider other dimensions such as distribution of costs and benefits across gender, residential area or household type. The distributional effects of congestion-pricing scheme is evaluated by simply applying the sub-model of the sample enumeration model (SE)[1] to each individual in the sample in a before-and-after fashion. Their results underline two main factors actioning on equity: the initial motivation for a trip and the use of road pricing revenues. They show that if road-pricing revenues are used to finance public transport quality then the women and the poorest income group will be the winners.

Again for the Stockholm case study, Karlström and Franklin (2007) assess horizontal and vertical equity effects of the Stockholm trail morning commuters. They estimate welfare effects by combining observed commute mode choices, before and during the congestion pricing trail, with knowledge of the amount of toll paid and the estimated travel times for both the mode taken and not taken in each case. Their results show that welfare effects are not uniform. It suggests that it should not consider welfare effects independently from the income levels from which they are drawn. Based on that result, they want to compare the distributions of effects by income category. However, individual income is not available since only household income category is reported in the travel survey. Indeed, they have imputed individual income. In particular, they have used the characteristics of the household (age, household composition, and residential zone) to match each individual with similar individuals. They compute Gini coefficients, which level is 0.3146 when they introduce the toll system. The overall equity effect is to raise the Gini coefficient to 0.3164. The toll policy appears regressive according to the Gini coefficient. However, they assume that value of time and marginal utility of money are constant. So, as they explain in their conclusion, the estimates of travel time benefits may have been skewed, favouring effects on the well-off rather than effects on the worse-off.

Sumalee and al. (2005) also study pricing system. They develop genetic algorithms to identify the optimal location and toll level for a cordon-pricing scheme. They only integrate the impact

[1] It's an estimation of a system of logit models. They have been included in SAMPERS which is the most recent large-scale transport model developed for Stockholm.

of road pricing on the geographical distribution of benefits. They cannot take into account the pricing impact on different groups of the population. They adopt the Gini coefficient and test the change in social welfare for each origin-destination pair (compared to do-minimum case). The Gini coefficient varies between 0.2 (with an outer cordon) and 0.48 (optimal double-cordon scheme). So, the double-cordon scheme creates the higher equity impact. They conclude that constraints to achieve a given level of the Gini coefficient and optimisation against it, lead to cordons, that spread the benefit to less congested areas.

Ramjerdi (2006) presents an overview of some equity measures. She underlines that to address equity, a unit of analysis and the variable along which equity is to be analysed have to be defined. She demonstrates some of the challenges that arise in the analysis of equity implications of a transportation policy. The size of equity measures is quite sensitive to the level of spatial disaggregation and to the scale and translation in the measure of welfare. Their results show that it is difficult to make a judgement about the equity implication of a policy on the basis of a single measure. In fact, different measures of equity produce different rankings of the income distributions. Consequently, several equity measures must be used rather than a single measure. She uses more that 10 equity indicators on the Oslo case study. She concludes that relating the equity objective to a predefined value on any of these measures, is not a desirable approach.

Paulo (2006) uses the Oxford scale of equivalence to estimate income per consumption unit for each household: the first adult is evaluated as a 1 consumption unit, members older than 14 years are estimated as a 0.5 consumption unit; and members aged younger than 14 years are estimated as a 0.3 consumption unit. She explains what the advantage and disadvantage of the Lorenz curve are. In particular, mostly, inequality is calculated only on income. But for example, inequalities of heritage are more important. She calculates Gini indicator as well as a ratio between the extreme quintiles (Q5/Q1). Using Lyon household survey with 1995 data, she finds a 0.308 Gini indicator for all the household and a 1.81 ratio Q5/Q1 (Paulo, p.126). Moreover, even if the Gini coefficient stays constant (Gini=0.280), she shows, for example, a difference in value for the Q5/Q1 ratio: a household with a first member between 25-59 years (Q5/Q1 = 1.2) and a household of only one person between 60-74 years (Q5/Q1 = 5.5).

Claisse and *al.* (2 000) study the city of Lyon using the Household Survey collected in 1995. They use the household income *per* consumption unit. They test different indicators of inequality of the household income. Their objective is to assess inequality trend without the impact of the income classification. They want to neutralise the sensitivity of the indicator to the income category. Even if they create threshold effect they classify income in decile and they calculate several inequality indicator (Table 4). The Atkinson index, but also the Theil index with a minor impact, valorise the left asymmetry of the distribution.

More recently, and still on the French case study, Berri (2008) wants to evaluate inequalities in transport consumption among French household. He uses decomposition by expenditure component of the Gini inequality index. Each component appears through its proper Gini coefficient, its budget share and its degree of association with total expenditure. Gini allows negative values, which is not the case of other inequality indices such as Theil's. As Berri says, this characteristic is useful in the decomposition of Gini by income source, where taxes are considered as “negative incomes” (Lerman and Yitzhaki, 1994 in Berri). He uses quintiles of total expenditure by consumption unit. The contribution of a component to the overall inequality is determined by three factors: the proper inequality of the component, its degree of association with total expenditure, and its weight in the total budget. The results show the relative contribution to global inequality of car use, but with a decreasing effect over time. Inequality regarding transport is mainly due to automobile purchases, followed by vehicle use, items other than fuels, and fuels.

Finally, as literature shows, Gini coefficient seems to be use only in recent papers. However, for a better assessment, it is useful to take into account income per consumption unit. As we do not have detailed information on household spending, we cannot calculate a decomposed Gini. We will estimate and compare the two main inequality indicators: Gini's and Theil's. As a calculus has been done for the previous Lyons' household survey (1995), we can compare them to our results and add the Atkinson indicator. To our knowledge, Theil and Atkinson indicators are *quasi* absents from the transport inequality measure. Furthermore, we will also try to calculate a decomposed Theil indicator as it seems absent of the transport inequalities literature.

3. Data and methodology

Data

We use data from the Household Survey, collected for the city of Lyon in 2006. Conducted every 10 years, this survey provides data both on individuals and household. These data are principally on socio-economic characteristics, travel choice and zone location. Lyon is a conurbation of more than 1 million of inhabitants. In this study we have more than 10 000 household.

In 1995, the sample consisted of approximatively 6 000 household and the city was divided into 25 zones. The household income was annual and included national insurance benefits. In 2006, the sample size was higher but with the same method of random selection. The City is still divided into 25 zones and the income is still annual with the integration of the national insurance benefits.

We use only 7 902 household in the total amount of the database (11 229). We discarded the no-answer to income question as they cannot be included in a Lorenz curve calculation. It is also not possible to replace them with zero value as this would pull down the estimation.

Another difficulty appears because we do not have the precise income of the household but only its class of income. Classes of income have been established by the survey (Table 1).

Table 1: Household income class in 2006

Household income (Euro/year)	Household income (Euro/month)	Average income
Less than 10 000	[0, 417[	208,5
10 000 to 20 000	[417, 1 250[	833,5
20 000 to 30 000	[1 250, 2 083[	1 667,5
30 000 to 40 000	[2 083, 2 917[	2 500
40 000 to 60 000	[2 917, 4 167[	3 542
More than 60 000[2]	[4 167, 6 667[	5 417

In a first step, we make the hypothesis of a homogeneous distribution of income inside each income class. On this basis, we can use the average income of each income class.

To go further, it is necessary to use an income per consumption unit (CU). This unit takes into account the age of the household member. The idea is that household consumption spending are linked to the age of the member.

To do this, we use an equivalence scale given by the Statistical French Agency (INSEE): the first adult is evaluated as a 1 consumption unit, members older than 14 years are estimated as

[2] Superior limit: 100 000 euros.

a 0.5 consumption unit; and members younger than 14 years are estimated as a 0.3 consumption unit[3].

It is not possible to do this work immediately with the household data because we do not have information on the person's age. To obtain these data, we have to integrate data of another file.

When the integration have been made we can calculate the average income per consumption unit for each household. However, we are facing a threshold effect because of the income distribution in classes.

Methodology

We compare different income inequality indicators to assess Lyon's current situation. We use the Gini, Theil and Atkinson inequality indicators, calculated by unit of consumption and compare their results.

The Gini indicator calculates the income concentration: the closer it is to 1, the higher the inequality of revenue (this value is of 0.3 in average in France). It depends on the way the city zones are delimited.

In the case of an income distribution for a population of N individuals, $i=1,\dots,N$, y_i is the income for individual i and μ the average income, the Gini indicator, G, is the following:

$$G = \frac{1}{2N^2\mu}\sum_i \sum_j \left| y_i - y_j \right|$$

This zone definition modifies the composition of the income categories. Paulo (2006) shows that the underestimation linked to the way observations are grouped in classes is all the more important as the Gini indicator is high and the number of classes is low.

The Theil indicator evaluates difference between the weight of one individual in the population and the weight of his income in the total income. The Theil index is as follows:

$$T = \log(N) - \sum_{i=1}^{N} Y_i \log\left(\frac{1}{Y_i}\right)$$

With N the number of individual, Y_i the share of total income received by the individual i. Theil value can be 0, situation of perfect equality, and log N, where all income are null except one (perfect inequality).

The Theil index can be decomposed; i.e. we can distribute the population in groups, and re-distribute the latter in sub groups. It is therefore possible to look for inequalities between sub-groups of population.

The Theil index can be decomposed as follows: if we divide the total population in j group j = 1, 2, …,J by sample N_j and average income y_i with the Theil indicator T_j, then we have:

$$T = \sum_j \left(\frac{N_j}{N}\right)\left(\frac{y_j}{\overline{\overline{y_i}}}\right) T_j + \sum_j \left(\frac{N_j}{N}\right)\left(\frac{y_j}{\overline{\overline{y_i}}}\right) \log\left(\frac{y_j}{\overline{\overline{y_i}}}\right) = T_i + T_e$$

[3] The income categories *per* CU and *per* month in 1995 were: less than 381, 381 to 762, 762 to 1 143, 1 143 to 1 524, 1 524 to 1 906, 1 906 to 2 287, 2 287 to 3 049, 3 049 to 5 573, 5 573 to 7 622, more than 7 622 (Paulo, p. 101). In 1995, income was in french francs (FF). We use a conversion rate of 1 euro = 6.55957 FF (the official reference conversion rate).

With:
T_i is the Theil indicator sum calculated into each income class weighted by the class share in the total income. It evaluates *intra* class inequality.
T_e is the Theil indicator when all the individuals of income class *j* have the same income y_j. T_e evaluates inequalities between classes.

The Atkinson indicator (AT) is as follows:

$$AT = 1 - \left[\sum_p \left(\frac{n_p}{n} \right) \left(\frac{x_p}{x} \right)^{1-\varepsilon} \right]^{1/1-\varepsilon}$$

Where $\Sigma n_p = n$, p cumulated populations, n the number of observations. Epsilon is an ethic coefficient, that is to say a specific weight to each member of the society. For example, if ε=1, each population member has the same weight.

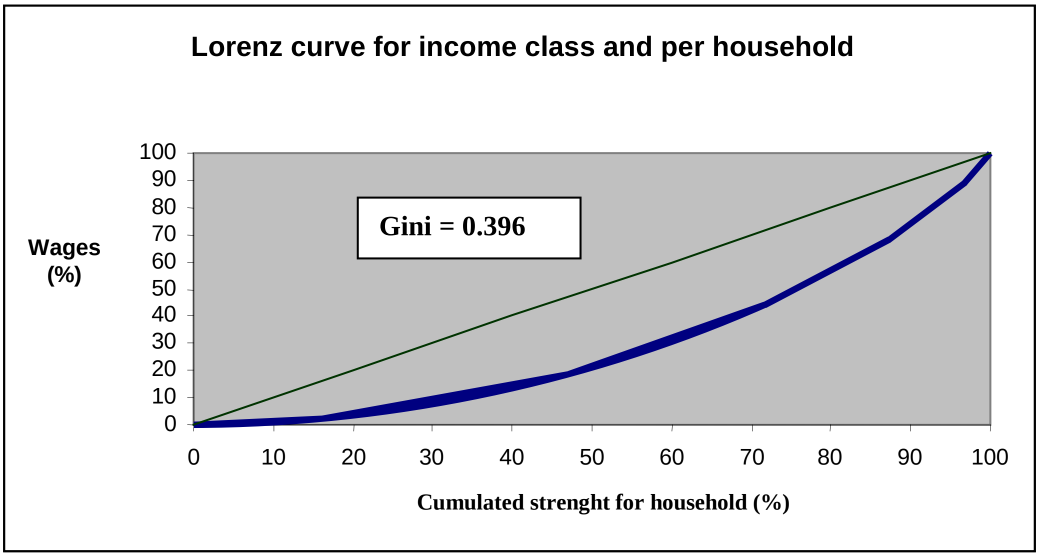
After data and method explanation, we can present our results.

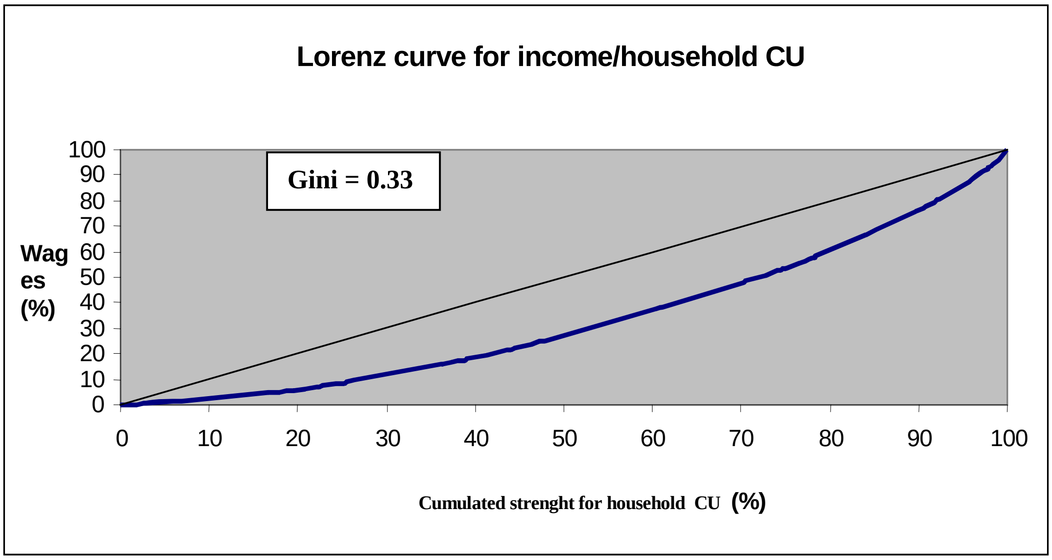
4. Results and discussion

Results

Firstly, we present results for the Lorenz curve for average income and for average income/CU.

Table 2 : Lorenz curves for income class and per household and for income per household per CU





As anticipated, taking into account the consumption unit modifies the Gini's results. The choice of the unit leads to different results. It is crucial to adopt, not only the appropriate unit to evaluate inequalities, but also the same unit to analyse inequality trend. Inequality becomes lower when size and age of the household members are integrated. The Gini coefficient is fairly similar to the French national situation (without CU, Gini = 0.3837 for individual wages in 2003, see Denis and Ruiz, 2009). Lyon is quite representative of the French situation.

Secondly, we present Gini, Theil and Atkinson indicators. Like Ramjerdi (2006), we can notice that the Atkinson measure is sensitive to the inequality aversion parameter: a multiplication *per* 4 between an aversion parameter of ½ and 2. Consequently, the equity implication of the policy depends on the normative positions on inequality.

Table 3: Inequality indicators for Lyon 2006

Inequality indicators	Income/CU
Gini	0.330
Theil	0.193
Atkinson (ε=1/2)	0.082
Atkinson (ε=1)	0.212
Atkinson (ε=2)	0.355

We can also compare these results to 1995 one's given by Claisse and *al.* (2 000).

Table 4: Inequality indicators evolution between 1995 and 2006

Inequality indicators	Income/CU 2006	Income/CU 1995	Variation (%)
Gini	0.330	0.308	+ 7%
Theil	0.193	0.157	+ 23%
Atkinson (ε=1/2)	0.082	0.072	+ 14%
Atkinson (ε=1)	0.212	0.178	+ 19%

Atkinson (ε=2)	0.355	0.295	+ 20%

Compared to the Lyon situation 10 years ago, we can notice a variation in all the inequality indicators. Inequality has increased between 1995 and 2005. This evolution is more significant for the Theil and Atkinson indicators than for the Gini indicator.

This evolution is also coherent with the national one (Table 5).

Table 5 : Income evolution in France in 10 years (Maurin, 2009)

Annual income in France	1 996	per month	2 005	per month	Evolution between 1996 and 2005
D1 (decile 1)	7 990	666	9 460	788	+ 18
D2	9 990	833	11 550	963	+ 16
D3	11 570	964	13 280	1 107	+ 15
D4	13 020	1 085	14 900	1 242	+ 14
D5	14 640	1 220	17 300	1 442	+ 18
D6	16 330	1 361	19 330	1 611	+ 18
D7	18 460	1 538	21 790	1 816	+ 18
D8	21 400	1 783	25 390	2 116	+ 19
D9	26 780	2 232	32 250	2 688	+ 20

Consequently, to better assess the equity implication of the policy, we need an examination of several inequalities measures, in order to make a judgement about equity implication. We also need to use several measures and to compare their evolution to assess inequality trend.

With her study, Ramjerdi (2006) shows that, relating the equity objective to a predefined value on any of the equity indicators, is not a desirable approach. We agree to this result except in the case of a trend inequality analysis. Then, the inequality indicator result for each period can be used as a predefined value. Thirdly, we present a decomposed Theil indicator.

Table 6: Cumulated sample for income deciles

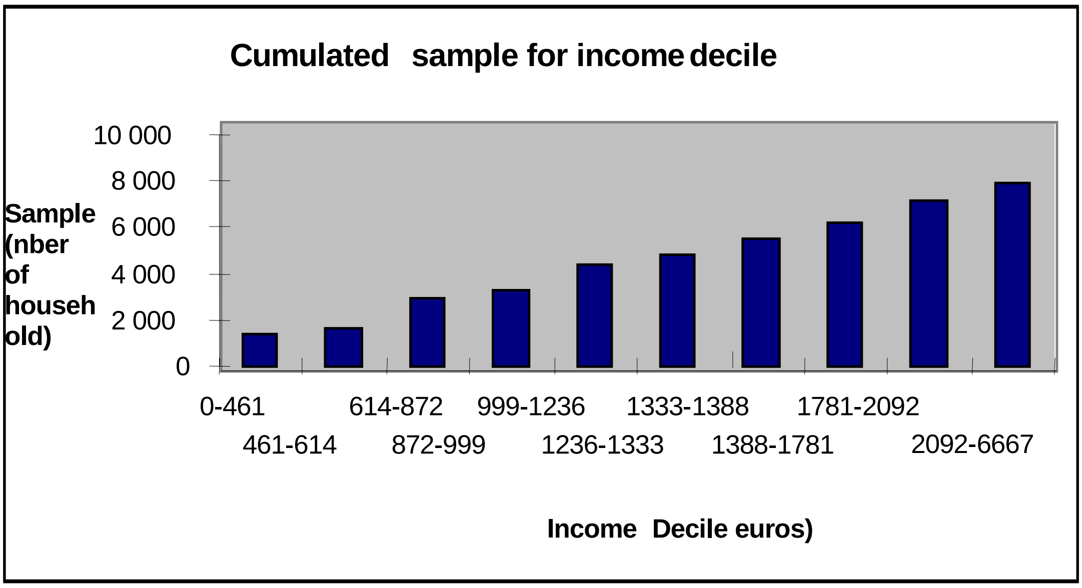


Table 7: Theil decomposed

	Theil decomposed	Share of total (%)
Theil e (*Te*)	0,23	76
Theil i (*Ti*)	0,07283	24
Theil decomposed	0,30034	100

When we made a Theil decomposition, we can see that the major part (76%) of the Theil level is due to Te, that is to say, to inequalities between classes.

We can remark that the Theil indicator results are different if we take 7 902 modes or if data are organised with income decile. Claisse and *al.* (2000) have already shown this difference. One of the explanation could be that the result is modified by the number of modes, the higher this number, the higher the Theil indicator level. Consequently, the data organisation in income decile seems to be less appropriate and precise to compare inequality indicators at different periods than the income mode.

5. Conclusion

Our objective is to evaluate inequality trend and to identify the indicators sensitivity.

Our results show an increase in all the inequality indicators (Gini, Theil, Atkinson) over the last 10 years in Lyon: inequality seems to be more important today than in 1995. This trend is more significant for the Theil and Atkinson indicators. We show that we need an examination of several inequalities measures to make a judgement about equity implication and to choose the appropriate unit. We also need to compare their evolution to assess inequality trend.

With a Theil indicator decomposition calculus, our results show that the major part of the Theil level is due to inequalities between classes. Consequently, an efficient fairness policy we need to implement actions to reduce inequalities between income classes.Next, we can simulate different sustainable transport policies (for example the introduction of a urban road toll) and calculate the impact of these policies on the here-above mentioned indicators and for each geographical zone. For this last point, we need to pay a special attention to the level of spatial disaggregation. Eventually, we should be able to evaluate the impacts of new transport policies on the variation of inequalities. The incidence of a transportation policy might be different for different segments of a population.

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