

Bachelor's Programme in Economics

Emission Distribution of Finnish Drivers by Gender and Income in 2022

How Emissions of Finnish Drivers are Distributed Across Gender and Income
and the Choice of Less Emitting Vehicles of the Model in the Distribution

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Abstract

This thesis studies the emission distribution from vehicle usage by Finnish drivers in 2022. By using the Finnish registry data, I calculate the total emissions from natural persons driving and the share of emission reduction potential by changing to less emitting version of the same model. I study these emissions based on the driver's income and gender and compare them on their shares of emissions to better understand the vehicle emission distribution in Finland.

Unexpectedly, female drivers cause a larger share of total emissions than expected by their share of total drivers. Otherwise, the results reflect the expectation set by the literature on the subject that higher income groups drive less emitting vehicles but drive more overall, and females tend to drive less emitting vehicles than males. An interesting group are median and high-median incomes as they have large emissions and large emission reduction potential giving them more choices in reducing their total emissions and therefore reducing the total vehicle emissions in Finland.

Keywords vehicle use, emissions, income, gender, emission distribution

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Tiivistelmä

Tämä työ tutkii suomalaisten kuljettajien ajamisen päästöjen jakaumaa vuonna 2022. Hyödyntäen suomalaista rekisteridataa, laskin totaalipäästöt luonnollisten henkilöiden ajamisesta ja säästettävissä olevien päästöjen osuuden, jos kuljettaja vaihtaisi vähäpäästöisempään saman malliseen autoon. Tutkin näitä päästöjä kuljettajan tuloluokan ja sukupuolen mukaan ja vertailen näiden ryhmien päästöosuuksia luodakseni paremman käsityksen ajoneuvopäästöjen jakautumisesta Suomessa.

Odottamattomasti naiskuljettajat aiheuttavat suuremman osan kaikista ajoneuvopäästöistä kuin naisten osuus kuljettajista antaisi odottaa. Muuten löydökset ovat hyvin linjassa aiempien tutkimusten kanssa. Korkeatuloiset ryhmät ajavat enemmän mutta vähemmän päästöjä aiheuttavia autoja ja naiset ajavat vähäpäästöisempiä autoja kuin miehet. Mielenkiintoinen tutkimuksessa esille noussut ryhmä ovat mediaani- ja sen yläpuoli tuloiset kuljettajat. He aiheuttavat paljon päästöjä, mutta heillä on myös korkea päästöjen vähennys potentiaali, joten heillä on enemmän vaihtoehtoja omien kokonaispäästöjensä vähentämiseen ja siten koko Suomen ajoneuvopäästöjen vähentämiseen.

Avainsanat ajoneuvon käyttö, päästöt, tulot, sukupuoli, päästöjakauma

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Preface and acknowledgements

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Espoo, 21 July 2024
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1 Introduction

As the climate change continues to bring change to our environment, both the people and governments need to take action to reduce emissions. As one source of these CO₂ emissions is usage of motor vehicles, it is important to take action to reduce these emissions. In EU the new expansion of the emission trading scheme (ETS₂) aims to take action on these emissions from the transportation sector. Even though there are also policies in place as a part of ETS₂ to protect more vulnerable groups from the fuel price increases likely to follow the policy (Haywood & Jakob, 2023), it is important to understand how emissions from vehicle usage in Finland are distributed across gender and income as those emitting more likely pay more under the ETS₂.

To also better understand the differences between groups of drivers and their emissions it is also vital to understand the differences in the vehicle usage and vehicle choice of these different groups. As there is a large number of studies with focus on interest in environmentally friendly vehicles (such as (Kurani & Buch, 2021; Waygood & Avineri, 2016)), it creates a strong foundation to understanding the vehicle emissions and their distribution when combined with existing understanding of driving habits and vehicle usage (such as (Ng & Acker, 2018)). By using Finnish registry data this study aims to both understand the how emissions from transportation are distributed across income and gender, and what shares of their emissions they could reduce by changing their vehicle to less emitting version of their model of choice. This study also aims to connect this information to existing studies creating better understanding how increase in the cost of emissions from transportation could affect these groups differently based on their possibility reduce their own emissions.

This study's second section is the literature review followed by the research methodology. The fourth section is the results of the study followed by the concluding remarks.

2 Literature review

There is a large interest in the carbon emissions, and as a large contributor to total emissions, the transportation sector and choices are a topical field of study. The literature on the interest in the environmentally friendly vehicles is also available and there are some studies with special focus on the Nordics (Nayum et al., 2013; Sovacool et al., 2018). In their study of Norwegian purchases of new cars (Nayum et al., 2013) found that females chose low emission vehicles more often than men and (Waygood & Avineri, 2016) found that females were more “willing to pay to reduce their personal impacts”, which means they are also more willing to pay to reduce their vehicular emissions. However based on their study (Sovacool et al., 2018) found that males, especially those with higher education were most likely to purchase electric vehicles. They did also identify higher income females as a possible segment where electric vehicles may become common. One way to understand these contradicting findings is through the study by (Kurani & Buch, 2021). They found that both genders show similar interest in electric vehicles, even though males drive more electric vehicles. They identified that males are interested in “new technology” which increase their interest in electric vehicles and females are more interested in the environmental aspects of electric vehicles.

On top of understanding the vehicle choice, it is also important to understand the differing driving behaviours. In their study (Ng & Acker, 2018) found that females tend to drive shorter distances than males and have more non-work related trips and use more public transportation. This was also collaborated in (Vajjarapu & Verma, 2022) where they found that the average trip length and total emissions per capita were higher for males. In the same study (Vajjarapu & Verma, 2022) also found that those with higher income tend to drive more. This is also supported by findings in a study by (Büchs & Schnepf, 2013) where they concluded that transportation emissions increase as the income increases and that having a female headed household decreases emissions from transportation.

Based on the literature, one would expect to see higher emissions from male drivers and higher reduction potential from males, as females tend to prefer less emitting vehicles. As the male groups interest is more likely in the new technology side instead of the environmentally friendly side of the vehicle choice the females should be more likely to have lower reduction potential. Those with higher income should show both more emissions and more interest in less emitting vehicles.

3 Research material and methods

In this thesis I used part of Finnish registry data with 1 442 136 individuals (1084055 males and 358081 females) who control or own total 3 933 145 vehicles from which 587 155 had available data to calculate the vehicles total emissions from driving in 2022. The data in question was anonymized individual level person and vehicle data from which I aggregated the total CO₂ emissions from driving by individuals in 2022. From the vehicle inspection data, I calculated the total emissions and emission reduction potential of replacing current vehicle with similar less emitting vehicle (similar vehicle was defined as same model of vehicle or commercial name to reduce the error caused by other preferences in vehicle)

$$ERP = a * x * CO2 - a * x * CO2_{min}.$$

ERP = Emission reduction potential

a = share of days in use defined as days in drive / 365

x = average daily distance the vehicle was driven in 2022

CO2 = CO₂ emissions of the vehicle in g/km

CO2_{min} = minimum CO₂ emissions of a vehicle with same model in g/km

This data I then combined with the Finnish registry data to gain information on the drivers of the vehicles, mainly the income and gender data. From this combination data I aggregated the individuals' total emissions and emission reduction potential during 2022 by combining the emissions of all the vehicles for which they are defined as drivers (vehicles controller and if unavailable vehicles owner). Some of the vehicles change ownership during the year of study, which causes some error in the allocation of emissions from the vehicle to individuals. However, some of this error was mitigated by allocating the emissions after the change in ownership to the new controller of the vehicle.

This aggregate dataset (N=1442136) of natural persons was used to study the distribution of emissions across income deciles and gender to give better understanding of emission reduction potential in the Finnish personal vehicle base. Main methodology in comparing the emission reduction potential between genders and income deciles was comparing the share of groups emissions reduction potential to the share of groups total emissions. This methodology was selected as it gives a broad understanding if the different groups of drivers have higher emission reduction potential than suggested by their share of emission. I also calculated the shares of groups own emissions

they can potentially reduce and the share of emission possible to reduce from the total emissions of all driver groups. By using all these metrics to better understand the environmental friendliness of the vehicle base of different driver groups to create enhanced insights to the conflicting result found in the literature on the gender and income differences in vehicle choices and vehicle usage behaviour.

The main downside of this method is the loss of other factors besides gender and income influencing vehicle usage and choice. Also, as the data is aggregated to compare the shares of emissions and emissions reduction potential, individual level differences and possible outliers are obscured.

4 Results

4.1 Emission Distribution Across Income and Gender

In 2022 the Finnish drivers emitted over 12 million tons of CO₂. Based on literature (Ng & Acker, 2018; Vajjarapu & Verma, 2022) females tend to drive less and would be expected to emit smaller share of total emissions than their share of total drivers (24,83 %). When looking at the total emissions and the potential emission reduction in 2022 (Fig. 1), we see that this is not the case and female drivers are responsible for a larger portion of total emissions than their share of drivers would suggest. However, we also notice that the male drivers' emission reduction potential is three times the emission reduction potential of the female drivers. This would suggest that females tend to drive less emitting cars within their chosen models of vehicle. This is both supported by literature (Nayum et al., 2013) and in contradiction with males being more likely to drive electric vehicles (Sovacool et al., 2018).

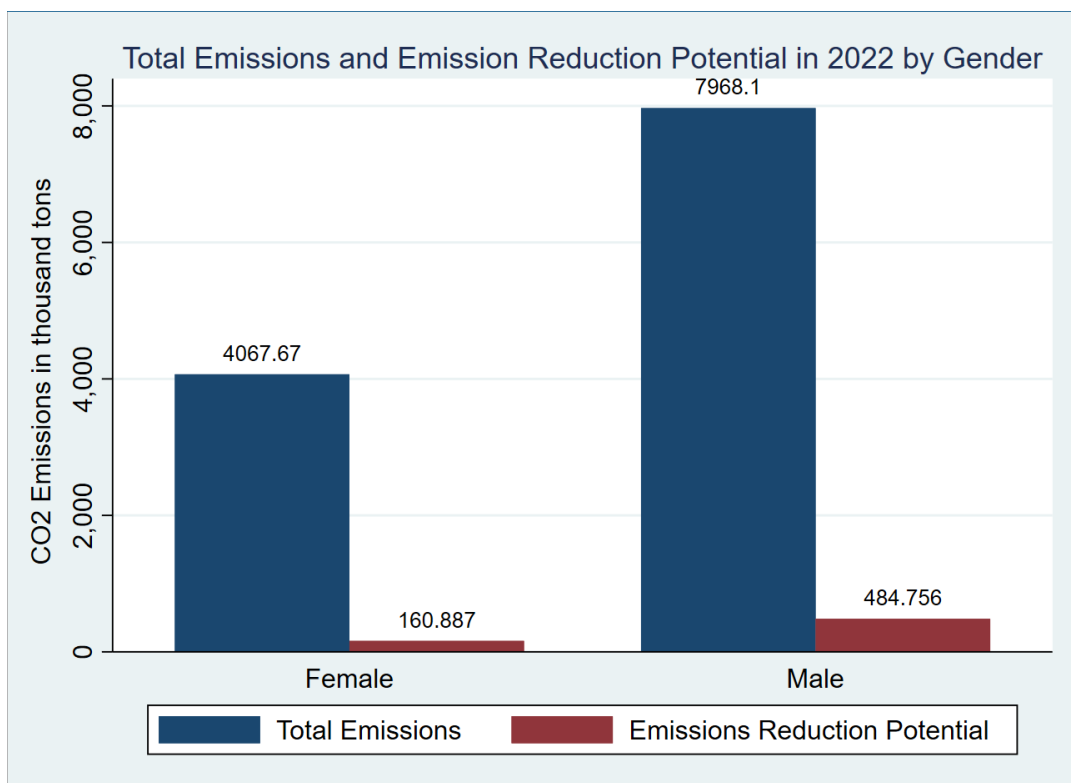


Figure 1: Total CO₂ emissions from vehicle usage and the emission reduction potential in 2022 by gender.

When looking at the total emissions and emission reduction potential by the income deciles of drivers (Fig. 2), those with below median income have higher total emissions than those with above median income. The emissions seem to rise towards the median income group and have a drop for 6th and 10th deciles. The 10th deciles reduction in total emissions and low emission reduction potential could be explained by higher income groups interest in more expensive cars such as electric vehicles and newer less emitting models of vehicles. This is in line with studies that show more highly educated people, who often have higher income, are more interested in electric vehicles, new technology and environmental friendliness (Oliveira & Dias, 2019; Sovacool et al., 2018).

What is interesting is the low emission reduction potential in the lower income groups. One possible reason for this could be lack of less emitting vehicles in the models of vehicles available to lower income groups but further study would be required to confirm this. From total emissions perspective the below median income group is responsible for most of the emissions from vehicle usage but the income deciles around median and above it, with the exception of the highest (10th) income decile, have the highest potential to reduce emissions by changing their vehicle to less emitting version of the same model.

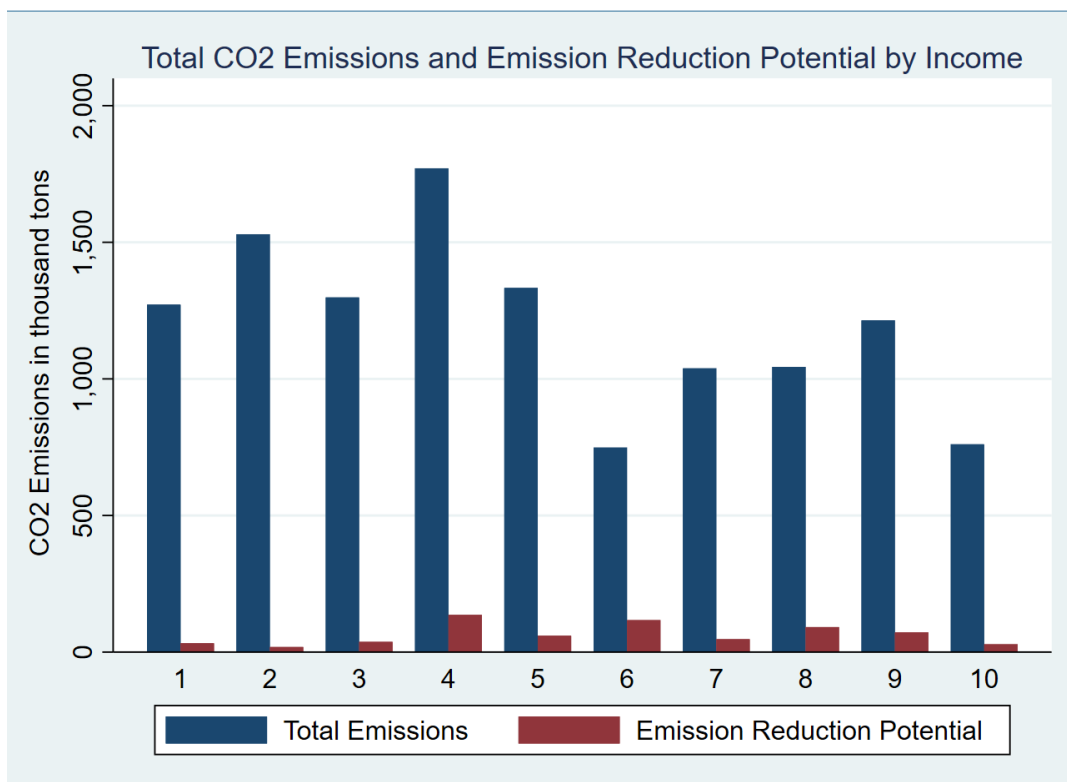


Figure 2: Total CO2 emissions from vehicle usage and emission reduction potential in 2022 by income deciles of all drivers.

To increase the clarity of the emission distributions it is sensible to look how the total emissions are distributed within the income groups within both genders. The total emission distribution of male drivers (Fig. 3) follows more similarly the distributions of emissions by income for both genders, which is understandable as male drivers constitute around 75,17 % of all drivers and 66,2 % of all emissions in the data, the lowest three income deciles have high total emissions but low emission reduction potential. However, for male drivers the 6th income decile differs from the distribution of all drivers by having low emission reduction potential. Reason for this could be that as females have lower median income than men, some high emitting individuals that earn around median income are pushed to higher income deciles by inclusion of female drivers in the data.

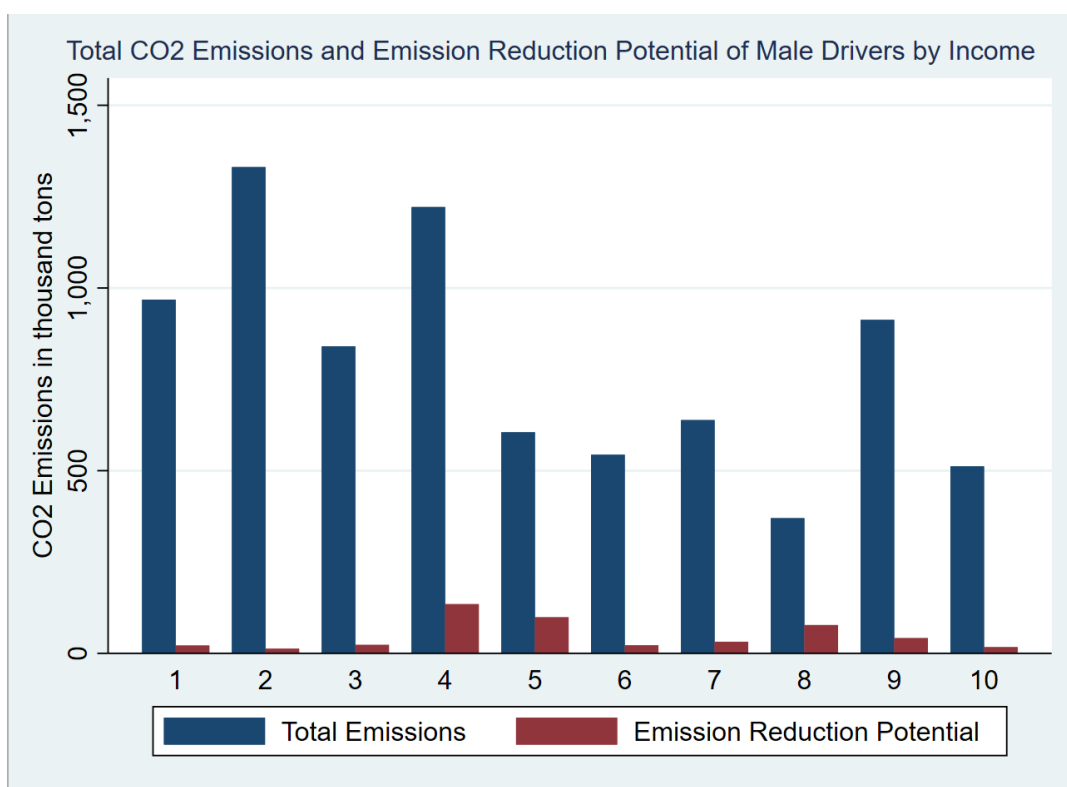


Figure 3: Total CO2 emissions from vehicle usage and emission reduction potential for male drivers by male drivers' income deciles.

When looking at the total emission distribution of female drivers (Fig. 4), a pattern of increasing emissions as the income grows can be seen. At the 7th and 10th income deciles there is a sharp drop in total emissions in otherwise growing emissions. One possible reason for this observed fall in total emissions could be that in these income groups some less emitting vehicle types such as electric or alternative fuel vehicles become available for an agreeable

price. The female drivers' emission reduction potential also seems to increase as the emissions increase but stay more stable than for male drivers.

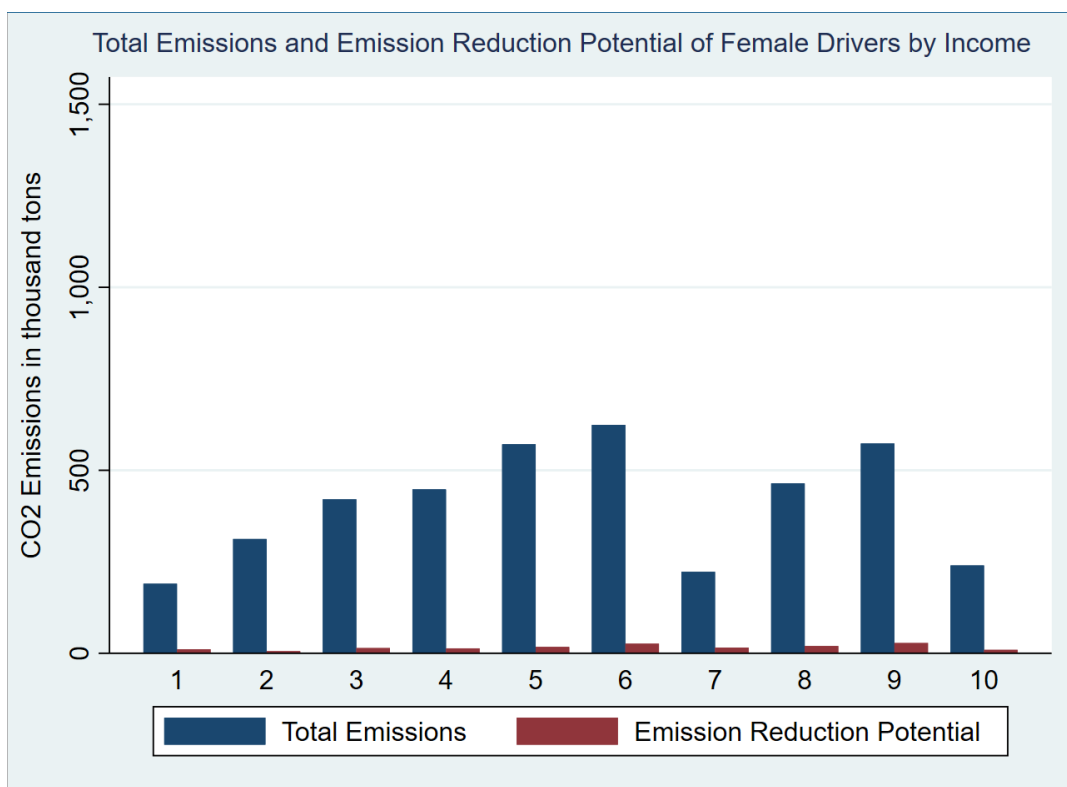


Figure 4: Total CO2 emissions from vehicle usage and emission reduction potential for female drivers by female drivers' income deciles.

Overall, the total emission and emission reduction potential data would suggest that the total emissions of females are lower than males, which could be explained by variety of reason. One large contributor is the lower number of female drivers in Finland but other factors such as choice of less emitting vehicles or usage of public transportation could be contributing to this difference.

4.2 Analysing the Emission Distribution and Reduction Potential

The total emissions and emission reduction potential tell us that males emit more and have more potential to reduce their total emissions by changing to less emitting vehicles of same model which could imply that their vehicles of

choice are more emitting. However, as the share of male drivers is much larger than the share of female drivers (around three times as large) this could largely be explained by their larger population. For this reason, it is much more logical to compare the shares of emissions and emission reduction potentials of the groups. Just when looking at the shares of total emissions and emission reduction potentials by gender (Fig. 5) we can see that female drivers are responsible from 33,7965% of total emissions while their share of drivers is only 24,83%. However, their share of emission reduction potential is much closer to their share of drivers in 24,9189%. More interestingly female drivers would be able to reduce only 3,95526 % of their own vehicle emissions by changing to different vehicle when as for males this amount is 6,08371% which is around 1,5 times that of the females. This would suggest that as in the case of total emissions females drive less emitting versions of their car models of choice but overall drive more which could explain their larger share of total emissions but lower share of emission reduction potential and share of own emissions potential to reduce.

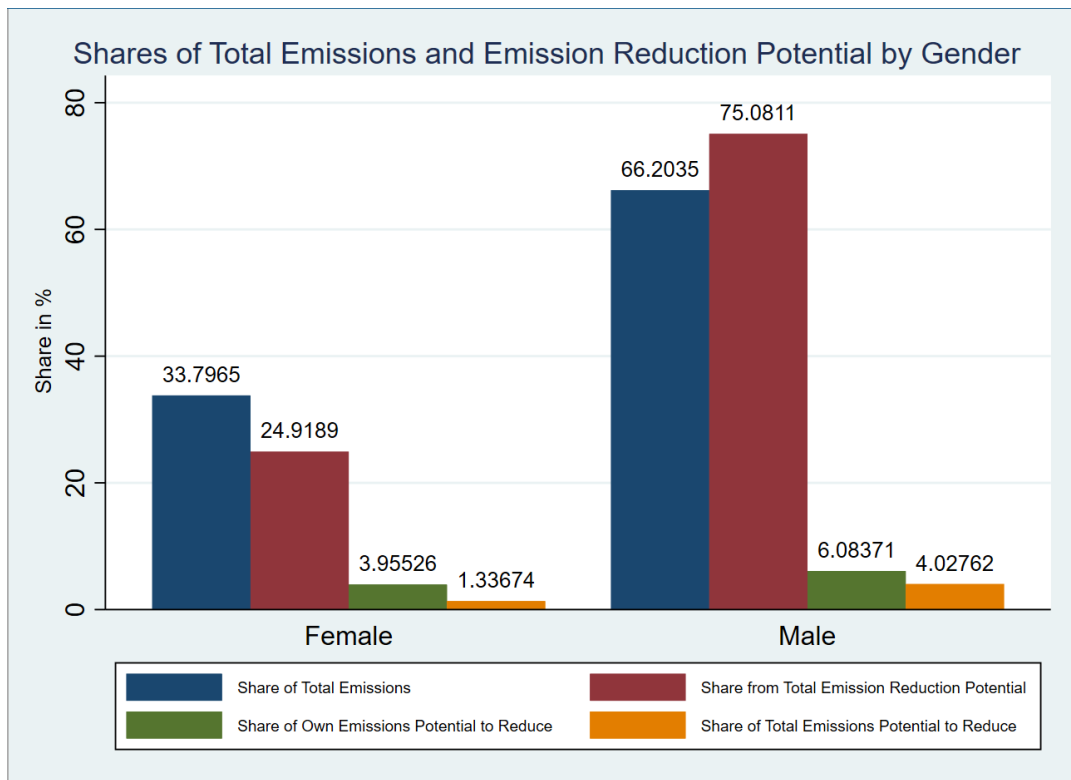


Figure 5: Shares of total emissions, share of total emission reduction potential, share of own emissions potential to reduce and share of total emission potential to reduce by gender.

The shares by income (Fig. 6) paint a similar picture as the distribution of total emissions. Interestingly most of emission reduction potential is concentrated for the 4th, 6th and 8th income deciles. Especially 6th income decile has also the highest share of their own emissions potential to reduce by changing vehicles. First three income deciles are very similar to each other and have lower emission reduction potential as also seen with total distribution. These shares support that those with low or very high income have lower reduction potential, and those with medium to high income have higher emission reduction potential. The stark difference in the potential to reduce one's own emissions could suggest that those with lower income could be more affected by the increase in cost of emitting CO₂ as they have lower potential to reduce their emissions without changing the model of their vehicle. An alternative explanation could also be that the models of choice for drivers with lower income have no less emitting vehicles available or their difference within the model's emissions is smaller.

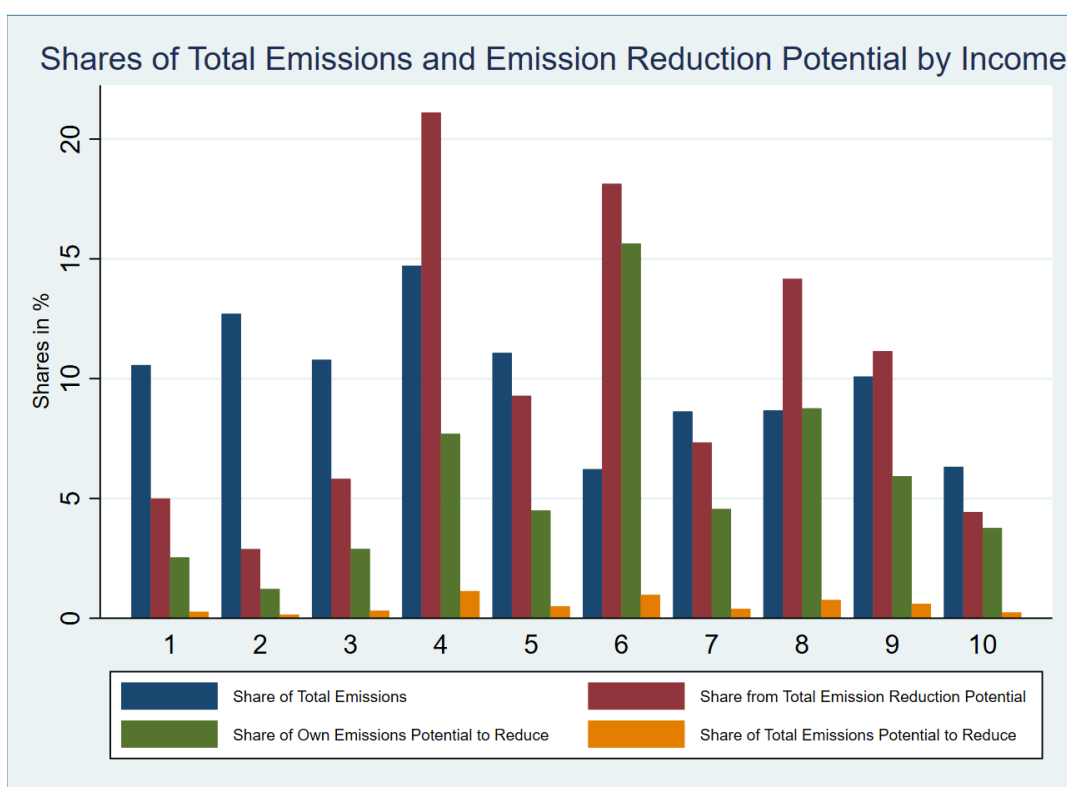


Figure 6: Shares of total emissions, share of total emission reduction potential, share of own emissions potential to reduce and share of total emission potential to reduce by income deciles.

The shares under study for the income deciles of male drivers (Fig.7) and female drivers (Fig. 8) show results similar to expected from total emission

distributions. Most interesting groups from male drivers are the 4th, 5th and the 8th income deciles. These groups have potential to reduce much larger shares of their own emissions than other groups (11,02%, 16,31% and 20,94% respectively) this is more than twice the next highest male income group (7th income decile with 4,97%) and nearly twice that of the highest female decile (7th income decile with 6,93%).

Most vulnerable groups for price increase of fuel, would be the lowest income deciles with high emissions but low reduction potential. These groups have fewer options as they can't reduce their emissions as much by changing into same model of vehicle and they already emit larger shares than some higher income groups. Also, as they have less disposable income, changing vehicles to different less emitting models might not be feasible.

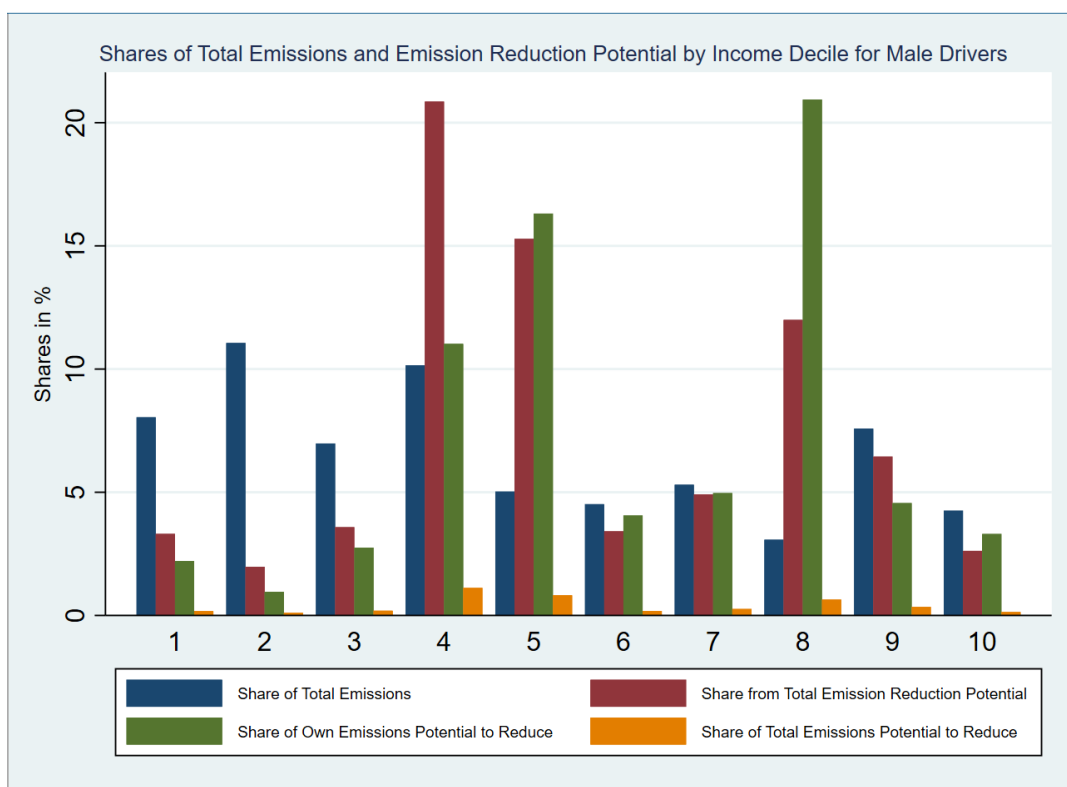


Figure 7: Shares of total emissions, share of total emission reduction potential, share of own emissions potential to reduce and share of total emission potential to reduce by income deciles for male drivers.

For female drivers the possibility to reduce own emissions is much more even than for males. The groups with highest potential to reduce own emissions (1st, 7th and 9th income deciles) have share similar to most male driver deciles and on the lower end as the highest share is 6,93% of emissions. The shares of own emissions possible to reduce for females seems to increase as the

income increases, suggesting that those with higher income drive more emitting vehicles. This seems to contradict studies (Sovacool et al., 2018) that show that educated people are more interested in less emitting vehicles. One possibility could also be that female drivers are more interested in environmental friendliness and the income groups play a smaller role for them as their shares are more even than for the male drivers.

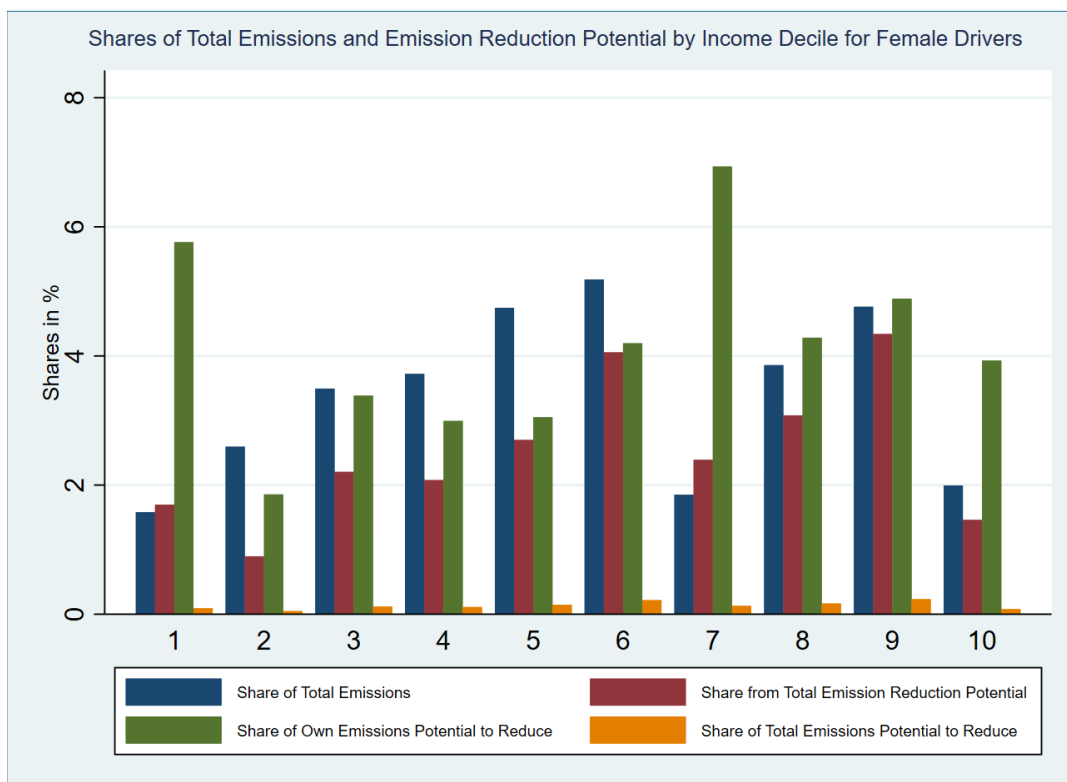


Figure 8: Shares of total emissions, share of total emission reduction potential, share of own emissions potential to reduce and share of total emission potential to reduce by income deciles for female drivers.

For male drivers the differences between the shares from total emissions and from emission reduction potential are between -10,71 percentage points and 9,08 percentage points and for females -0,54 percentage points and 2,05 percentage points. Females shares of reduction potential is closer to their shares of emissions than for males which would suggest that there are no groups with especially much or little emitting vehicles. For males there are the three groups with high emissions that have a large difference in their shares which would suggest they drive more emitting vehicles. Interesting group on this perspective for male drivers is the 2nd income decile as they have much lower share of emissions possible to reduce than their share of emissions.

Based on these numbers the group driving most emitting vehicles within their model of choice are male drivers in the 4th, 5th and 8th income deciles. For females these more emitting vehicles are in 1st and 7th income deciles but these differences for females seem much smaller than for male groups.

The total emissions seem to increase until they fall around median income. One possible reason for this could be increase in vehicle usage as income rises and then change to less emitting vehicles when income reaches the tipping points around median income, but this is pure speculation, and more research is needed. The main result of this research seems to be interesting numbers around median incomes for drivers and the high emissions reduction potential of certain male groups. The results also highlight large differences in the distribution of emissions across both income and gender.

Even though females emit larger share of total emissions than their share of drivers would suggest, they also have lower emission reduction potential than their share would suggest. This could suggest females drive more than males but drive less emitting vehicles. Other possible explanations could also be less availability within the models of choice for females resulting in smaller emission reduction potential. For both genders the drivers with highest emission reduction potential when compared to their share of emissions seem to be around median income and above it. These groups with high emission reduction potential have more choices available to them without changing their vehicle model of choice and seem less vulnerable to increase in fuel prices when combined with their high income.

5 Discussion

This study reached both similar outcomes as expected and some interesting results differing from expectations based on the literature. As in the literature males tend to drive longer distances and emit more, it is somewhat surprising that in Finland females are responsible 33,8% of total emissions while being 24,83% of all drivers. However, when looking at the emission reduction potential this is higher for males as expected. This seems to confirm the expectations set by earlier literature in which females were more interested in the environmental aspects of their transportation. Also, the interest in environmentally friendly vehicles seemed to be high in high income groups which could be caused by higher education or income, but based on literature the reason would likely be the interest more educated people hold towards electric vehicles and new technology, as in previous studies with more controlled variables the income has seemed to have no effect on interest in environmentally friendly vehicles.

More interesting groups found in this study are the low-income males who have a low emission reduction potential and the groups around median income with very high emission reduction potentials. For the low-income males one possible explanation could be a lack of choice for less emissions within the models they drive as they still cause a large share of total emissions. This group would also be more likely forced to change their model of choice to reduce their emissions. For future research and for higher total emission reduction focus on policies could be in the median and high-median income groups as they have a large emission reduction potential and to identify the reasons behind their high emissions and the choice of less environmentally friendly models. Also, the tipping point in total emissions that is observable in groups after median and highest income decile is worth looking into. If this drop in emissions explainable by electric and other alternative fuel vehicles having more agreeable price for drivers in those groups or other unknown reasons remains to be seen.

6 Conclusion

Overall, the findings in the Finnish vehicle emissions seems to follow the expectations drawn from the existing literature but the higher-than-expected emission share of females is unexpected and warrants further study. The low-income males and the median and high-median income groups also warrant further study. The low-income group as unexpected group with high emissions but low emission reduction potential likely vulnerable to price increase in emissions, and the median and high-median income groups as groups with high emissions and high emissions reduction potentials as groups with more available options when reducing total vehicle emissions in Finland.

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