MOTIVATING CITIZENS TO REDUCE THEIR MOBILITY EMISSIONS THROUGH PERSONAL CARBON TRADING

Transportation is responsible for almost one fourth of the total greenhouse gas emissions in the EU. Improved infrastructure and public transportation as well as renewable energy options provide possibilities to reduce emissions but often involve costly and slow processes. Personal carbon trading has been seen as an interesting policy tool to motivate users to reduce greenhouse gas emissions from their mobility using economic incentives, information on mobility emissions and peer pressure. In 2020, the European Green Capital Lahti piloted personal carbon trading in the World's first city-wide experiment using ICT technology, providing insights that can be utilized and replicated elsewhere.

INTRODUCTION

Personal carbon trading (PCT) is a dynamic incentive system that encourages users to reduce their mobility greenhouse gas (GHG) emissions via: 1) financial incentives through CO_2 pricing; 2) providing information on users' emission and their reduction possibilities; and 3) peer pressure for transforming social norms. PCT may also create demand for low-carbon services and products.

A core target of PCT is that participants reduce their GHG emissions. Each participant has a certain amount of emission allowances, and the amount depends on the chosen emission allowance allocation method and on the total GHG emission reduction target (emission cap). Allowances can be allocated by giving each participant the same amount of allowances (equal), the same reduction target compared to the participant's baseline emissions (relative) or a citizen-specific amount of allowances, which takes into account participants' life situation (citizen-specific). Participants who stay below the set allowance level can sell extra allowances to other participants. On the other hand, participants who exceed their allowances must purchase additional ones from other participants. The allowance price varies depending on the supply and demand. If the supply of allowances surpasses the demand, the allowance price decreases, and vice versa. In the long term, the price of allowances will most likely increase as the carbon cap becomes stricter and the amount of allowances in the market decreases.

Previous research and pilots have considered PCT as a policy ahead of its time. Increased interest among individuals to take climate action, ambitious climate targets of cities and improved ICT technology provide a good opportunity to execute a large scale PCT pilot. The aims of the mobility PCT pilot in the city of Lahti were:

- to create a PCT model and to pilot it using mobile phone technology;
- to promote sustainable urban mobility and to analyze how a selected PCT model impacts users' mobility emissions;
- to gather knowledge of what motivates citizens towards sustainable mobility;
- to provide an example that can be utilized to develop and implement PCT models in different cities around the world.

APPROACH AND RESULTS

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The CitiCAP project started in 2018 and concentrated first on the development of a PCT model and on its technical implementation via a mobile phone application. Emission factors for different transport modes specific to Lahti were defined and a 25% reduction target was set for mobility emissions. The PCT model was co-created with residents of Lahti and other interest groups through events, interviews and surveys. Based on the co-creation process, a citizen-specific allocation method was selected for emission allowances. In the citizen-specific allocation method, a citizen's life situation, e.g. the number of children, health issues affecting mobility, and distance to services, would affect the amount of emission allowances. It was also decided that the pilot was voluntary and concentrated on the incentivizing aspects of PCT. In the implemented PCT system, a participant could earn virtual euros in a four-week period and use them to purchase discounts on products or services on the application's marketplace. Participants did not have to pay for extra emissions if they exceeded their emission allowances during the four-week period, but surpassing emission allowances impacted demand and therefore also the price of allowances.

The CitiCAP application is based on technologies provided by three Finnish companies: Moprim, Goodsign and Future dialog. The application automatically recognizes users' mobility modes (car, bus, train, metro, tram, bicycle and walking) and distances. The detection technology is based on GPS and accelerator sensors of phones. This makes the use of the application easy and automatic. The Android application was released for open testing in September 2019 and the iOS version at the beginning of 2020. The actual PCT pilot and research part of the project started in June 2020 and lasted until the end of 2020.

Approximately 2 500 IDs were registered in the application, which exceeded the original target of 1 300 users. In addition, approximately 150 users participated in a reference group where mobility was recorded but who did not take part in PCT. The number of active users of the CitiCAP application during the PCT pilot varied weekly from 100 to 350. Figure 1 presents the average recorded mobility modes and distances.

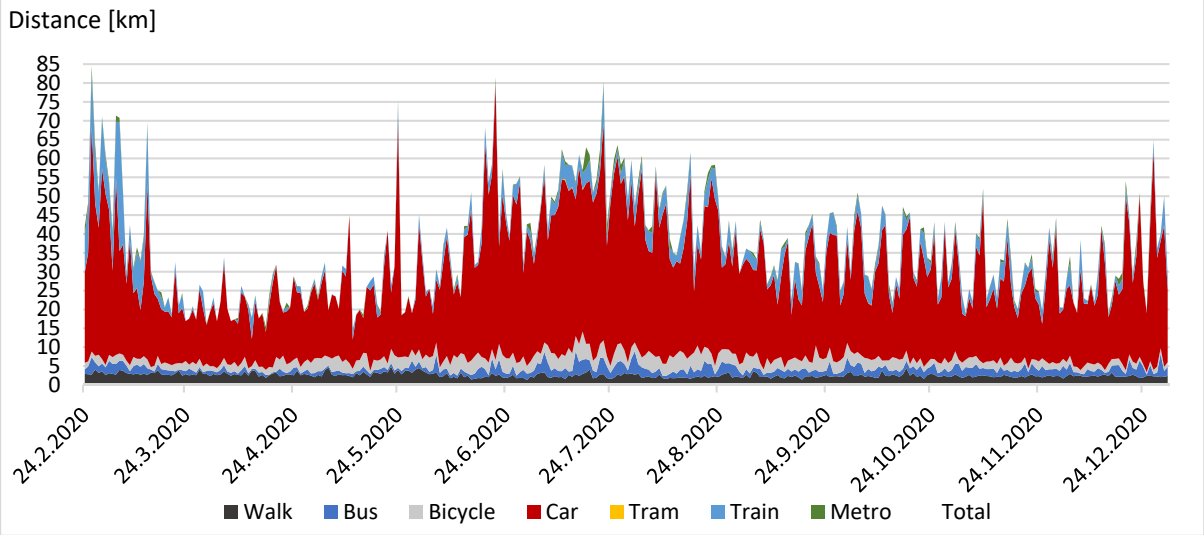

Figure 1. Average daily mobility modes and distances during the pilot

The PCT system worked as planned: user specific emission allowances were allocated based on initial background questionnaires, participants' mobility modes and distances were automatically recognized, and information on mobility emissions was provided almost in real time. By staying within

the limits of the personal allowances, the user was able to earn virtual euros, and allowance prices fluctuated based on the demand and supply. According to the final survey, 91% of respondents considered the implemented user-specific emission allowance allocation method as a fair way to implement PCT. Some challenges occurred e.g. when users turned off their mobile phone GPS. This was solved by adding average daily emissions for users from whom no data was received to keep the supply and demand of emission allowances in balance.

The COVID-19 outbreak from spring of 2020 onwards was one of the main challenges in the CitiCAP pilot, but it also provided interesting data on mobility changes during the pandemic. As Figure 1 shows, mobility rates decreased significantly during March 2020 when the first wave of COVID-19 hit Finland. Mobility rates rose again during the subsequent summer holiday season and started to decrease slowly in the autumn at the start of the second wave of COVID-19. This also impacted mobility emissions. During the first wave, mobility emissions decreased by 40%.

The application data shows a gradual decrease in mobility emissions in autumn 2020 when COVID-19 was slowly intensifying. However, there is significant variation between weeks. A similar but lower decrease can also be seen in the data from reference users who did not participate in PCT. Also mobility measuring points in Lahti show a decrease in mobility rates during the autumn of 2020. It is not clear whether participation in the PCT pilot drove the decrease in users' emission levels; most likely, the main factor was the intensification of COVID-19.

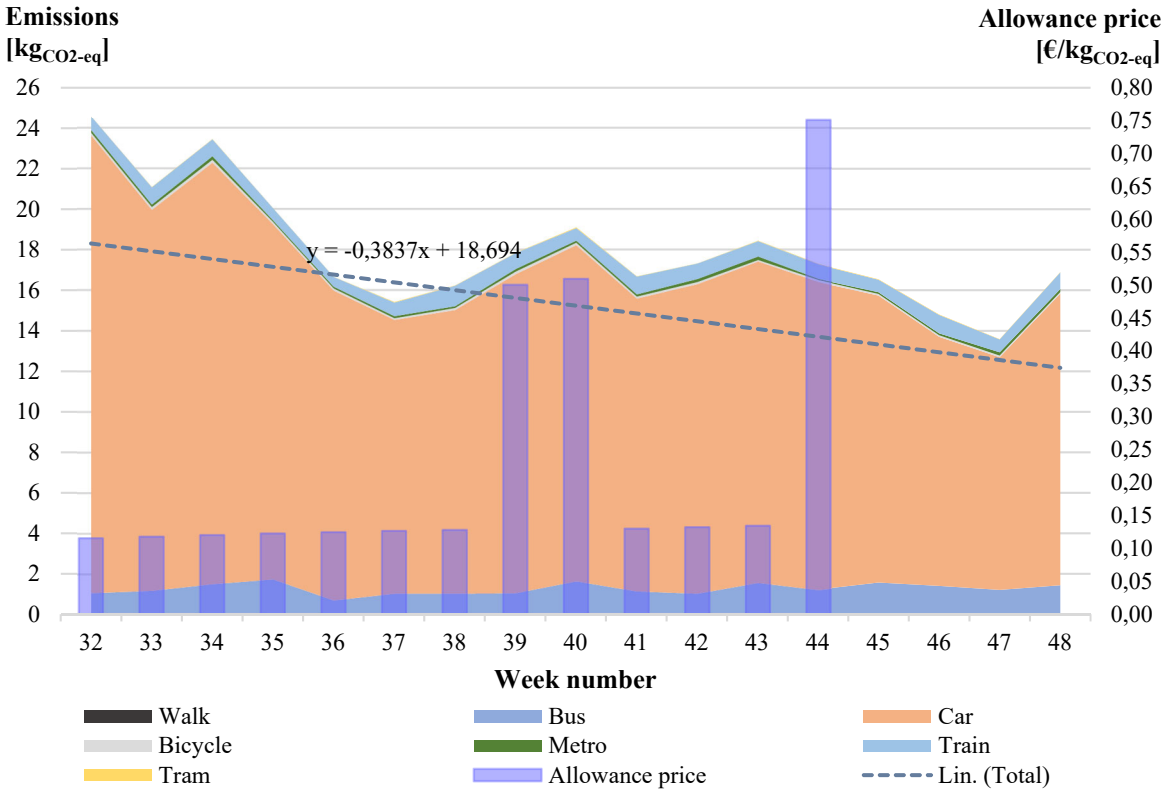

Figure 2. Emission levels of PCT participants and allowance price changes during autumn 2020

In the final participant survey, 36% stated that their mobility became more sustainable due to the use of the application. The answers indicate that the key reasons for this were information on the users' own mobility emissions and the users' willingness to challenge themselves. The third reason was incentives through PCT. This can be also explained by the fact that many participants considered that

they already move sustainably. Residents under the age of 50 were more likely to start using the application. In addition, the application users were characterized by a higher education and income, lower car ownership and a perceived pre-existing sustainable level of mobility emissions.

The base level for emission allowance prices in the pilot was € 0.1/kg_{CO2}, which rose to € 0.5 and € 0.75/kg_{CO2} for certain weeks. However, higher prices did not seem to have an impact on users' average weekly emissions. According to the final survey and user interviews, only 37% of users noticed the higher prices. It was also concluded that understanding different price levels was rather challenging for the majority of the users. In general, complex environmental policy instruments, such as tradable permit systems, can be cognitively demanding for laypersons. In fact, up to a third of the participants expressed uncertainty about the concept of PCT in general even after participation. The total amount of redeemed vouchers during the test and pilot phases was 175, and their economic value was approximately € 2 400.

According to the final survey, many users considered the application clear and easy to use. On the other hand, some of the users called for a clearer user interface. The accuracy of mobility mode recognition could also have been improved. Based on testing, the mobility mode recognition accuracy was typically over 80%, but approximately 40% of recognitions were "stationary actions", and therefore, the actual accuracy was lower.

Technically, it was possible to cheat in the PCT pilot. Some of the users (21% of end survey respondents) confessed that they either turned their GPS off, left their phone at home or untruthfully changed a recognized mobility mode to gain more virtual euros.

The PCT was voluntary, and no personal information was gathered from users. However, it should be noted that money, prizes and discounts that can be earned through PCT may be subjects to taxation. This would require the collection of more specific user information, which would necessitate stronger data security.

CONCLUSIONS, IMPLICATIONS AND RECOMMENDATIONS

The PCT pilot in Lahti shows that it is possible to implement a voluntary PCT system using ICT technology. According to the final survey, 36% of users changed their mobility behavior into a more sustainable direction, which can be regarded as a good result. The final survey also indicates that information on one's own emissions and one's willingness to challenge oneself were more important than the CO_2 price. However, magnitude of the decrease in emission levels could not be clearly separated from the impacts of COVID-19.

User specific emission allocation was considered fair, but for users with high mobility emissions, it was challenging to stay within the allocated emission allowances. Therefore, a relative allocation method should be also considered especially in PCT pilots which only include incentivizing features. Now it could be seen that it is relatively challenging to keep users interested in using the application, which is a common challenge with most applications. The pilot also shows that many users may find PCT and emission price levels difficult to understand.

Further technical improvements are still needed e.g. to the accuracy of mobility mode recognition. It is also possible to cheat the system by e.g. turning the GPS off, and 21% of users confessed that they somehow cheated in the system.

Based on the Lahti pilot, it can be concluded that voluntary PCT aiming to provide information on mobility emissions and providing small incentives can be a good tool to support the transition to more sustainable mobility for some of the citizens. However, a mandatory PCT system with penalizing features would make it easier to establish actual emissions trading between users, but its implementation is still challenging. In addition, if there are valuable incentives, related taxation issues as well as data protection should be carefully considered.

The approach strengthened cooperation between cities, researchers and companies, but a larger-scale roll-out would require clear productization of the PCT application. Future pilots could include different allocation and implementation models as well as other sectors of household consumption than mobility to deepen common knowledge on PCT. The optimal carbon price should also be analyzed in future research. The PCT pilot stirred a great deal of interest among individuals, cities and global media. PCT has now been reintroduced into public dialogue, and related research and pilots should continue alongside critical evaluation and discussion.

Additional information

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