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What are the impacts on well-being and climate change of a four-day workweek for The Netherlands?

A time-use and consumption-based scenario analysis of the impacts of a four-day workweek

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Abstract

The time we spend on activities has consequences for consumption and related emissions. A four-day workweek is assumed by some to have an improved effect on well-being and reducing emissions, however, the consumption from additional leisure time could counteract the benefits. Therefore, this research looks at the impact of a four-day workweek on well-being and climate change for The Netherlands. Time-use survey data and Environmentally Extended Multi-Regional Input-Output (EE MRIO) consumption data for full-timers are linked to create carbon footprints per activity. Well-being data is added to also see what the effects of a change in time-use on consumption, its emissions, and happiness are. Five leisure time scenarios are picked to predict the consequences of a four-day workweek, with a sixth control scenario, being working one day from home.

The findings of this research are that changing towards a four-day workweek could increase well-being in all investigated scenarios. Household emissions are also increasing for all scenarios, however, if the intermediate emissions for commuting are taken into account, ‘Relaxing’, ‘Media’, and ‘Working from home’ show positive monetary results, while only the latter shows positive environmental results. The higher emitting scenarios of ‘Social contact’, ‘Sports’, and ‘Holiday’ are also intertwined with high costs, making it difficult to pursue continuously with average budgets. Reducing wages could be a consequence of decreasing work hours, which will lead to a decrease in consumption and their emissions already at a few percent. Whether a reduction in work hours is favourable for the competitive position on the global market is up for debate.

A mix of multiple scenarios is likely to be the real-world result, but this research has the potential to aim individuals toward a less costly, higher well-being, and more sustainable mix. Policymakers could use this consumption/time-use matrix to calculate their predicted scenarios to see whether to pursue the four-day workweek. The results of their input can in addition be used to steer society towards higher well-being and fewer emissions by promoting low carbon-intensive activities and demoting high carbon activities, which are usually involved with large travel distances. Lowering wages seems to be the most effective in reducing emissions, however, the effect on well-being of this sanction is not known. ‘Working from home’ is found to have both positive impacts on climate change and well-being.

Keywords

Four-day workweek

Time-use

Consumption

Well-being

Sustainability

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List of abbreviations (In order of appearance)

Abbreviation	Meaning
EE MRIO	Environmentally Extended Multi-Regional Input-Output
GDP	Gross Domestic Product
QOL	Quality Of Life
GHG	Greenhouse Gas
DANS	Data Archiving and Networked Service
CBS	Centraal Bureau Voor de Statistiek/ Statistics Netherlands
SCP	Sociaal en Cultureel Planbureau/ The Dutch Social and Cultural Planning bureau
R&D	Research and development
NPISH	Non-profit organisations serving households

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1. Introduction

Society has a profound impact on our climate. Our production technologies and consumption patterns cause large amounts of carbon emissions. The links between consumption and well-being are being researched more frequently to figure out their correlation. (Iyer & Muncy, 2016). Nowadays, society increasingly tends to emphasize living the best life we can (Noll, 2004). Many studies suggest that various societal issues can be improved by reducing work hours, causing a shift in time-use. Druckman and Gatersleben (2019) show, for example, that low-carbon activities have a positive effect on well-being. Working and commuting are known to be some of the least favourable ways of spending our time (Kahneman et al., 2004). Together, this suggests that a reduction in the number of working days could potentially result in increased well-being. While fewer working hours would also mean reduced emissions from commuting, it would also provide extra time for consumption. If the reduced working hours would also translate into a lower income, this would in turn lower the ability to consume, but the scale on which this happens is unknown and is therefore tested both with and without reduction. As presented, there are many factors at stake in the nexus of time-use, well-being, and consumption. This study aims to contribute to the debate regarding whether or not to decrease work hours by providing an answer to the research question:
What is the impact of a four-day workweek on human well-being and carbon emissions in The Netherlands?

To compare the emissions from consumption of working five days with four-day workweek scenarios, the connection between consumption and time-use is made using a matrix. This gives insight into how much consumption is done per activity per hour and will serve as a contribution to current literature. A four-day workweek causes shifts in time-use, which changes consumption and well-being. The focus will be on the four-day work week, which will be represented in several scenarios. These will be compared to the five-day workweek in order to see the impacts.

In the literature chapter, the underlying concepts for this research will be identified. The literature research will elaborate on the concepts of the history of the workweek, consumption, well-being, time-use, and the four-day workweek concept. In the methods chapter, the applied methodology will be explained. The methods used to process consumption and emission data, time-use data, linking well-being, and the alternative scenarios are also discussed. In the results chapter, the outcomes of the applied methodology will be presented and later verified in a sensitivity analysis. The discussion and conclusions follow thereafter.

2. Literature review

The literature review will narrow the scope of the research and dive into the important theories for this research. The history of the workweek will be discussed to give background information on the previous changes in the labour hour intensity. Previous literature findings on the concepts of consumption, time-use, and well-being will be elaborated. These will provide insight into the foundations and current knowledge of these topics for the research model. An introduction of what a four-day workweek could entail is given at the end of the literature review.

2.1 Scope

How we use time in our daily lives differs. Some have jobs, others study or are retired. We have different networks and close friends who require various forms of attention. Our personal hobbies change over the years and are different for everyone, but they make us unique. However, our daily lives seem to be guided by the shape of our agendas; we sleep at night, we have several workdays, and some weekend days. Tradition dictates that people work from the morning until the evening with a lunch break in between, and a meal when arriving back home. There are many variations of this tradition, but these patterns give structure to life and manage expectations. Because of cultural, governmental, and institutional differences, changes in time-use seem unrealistic or even impossible to test on a global level. However, domestically, the impacts of time-use changes could be predicted more accurately and used in national policies. The aforementioned limitations mean that this study will solely focus on a single country, being The Netherlands.

2.2 History of the workweek in The Netherlands

Because of how the Bible was interpreted, centuries ago Sunday was considered to be a day of rest in The Netherlands. The other six days were meant for working. This division of time remained for a very long time (De Koning, 2016). The first idea of a five-day workweek appeared after World War II. At this time, however, there was so much work to do for reconstruction that no reductions in workdays were implemented (De Koning, 2016). Later, in 1960, Saturday was officially designated as a non-mandatory workday, causing a decrease in work hours from 48 to 40 due to the new Dutch CAO (collective employment agreements) (De Groot, 2021).

In the seventies, part-time work subsequently became a new option for people who wanted to participate in the labour force but also had other time-consuming obligations, such as caretaking (De Groot, 2021). Figure 1 shows the changes in average hours worked per worker from 1970 until 2020, compared to the OECD countries and EU27. Part-time work is more prevalent among the Dutch population than in other countries (OECD, 2022a). Currently, only half of the Dutch labour force works full-time (CBS, 2020). One-quarter of the male labour force works part-time (meaning less than 36 hours a week) and three-quarters of the female labour force works part-time. These are the highest rates in Europe, both are almost three times as high as European averages (OECD, 2022a). This results in an average Dutch workweek of around 31 hours before the corona pandemic (CBS, 2020). Though the 40-hour workweek is still the full-time norm, some branches, like the government, have started offering 36-hour full-time contracts.

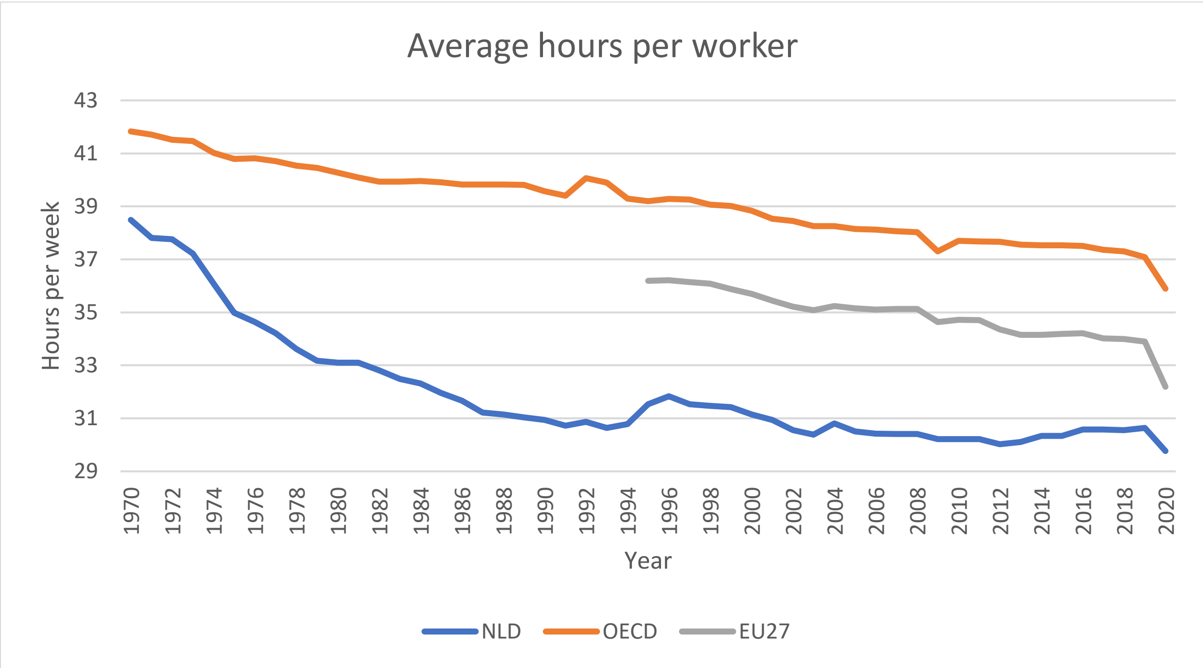

Figure 1: Average hours per worker for The Netherlands (OECD and EU27 for comparison) (OECD, 2022b)

According to Keynes (1933), developments in technology will lead to the automation of manual labour, resulting in less required labour for the same output. Keynes (1933) envisioned the possibility of a fifteen-hour workweek by the end of this century. This has not been realized yet. Possibly not because of the lack of technological advancement, but (amongst other reasons) because people did not use the growth of their production purely for leisure time, but also for increased wealth. Leisure time remains scarce, while there is more consumption to spend, resulting in obsessive consumption of as much as possible in the little time available.

Shifts in labour force participation and their consequences are still debated by politics and labour parties on a regular basis (Hartog & Salverda, 2018). The pros and cons of longer and shorter workweeks keep the discussion ongoing. Therefore, this study aims to find answers to the impacts of a four-day workweek, which, once again, could change the labour force participation in The Netherlands.

2.3 Consumption

Working is primarily done to earn an income. These wages cause the ability to buy and consume food and water to be able to stay alive. The sum of total hours worked by society as a whole has a profound effect on many economic statistics, such as unemployment rates and Gross Domestic Product (GDP). Growth in GDP is interpreted as societal progress, for which our society strives, however, some important arguments are sometimes overlooked. Factors such as human well-being are not calculated into GDP but would make the statistic a broader representation of our needs (Wilson et al., 2013). Because of our society's desire for economic growth and (over)consumption, the current global carbon emissions exceed the levels associated with a sustainable way of life, resulting in overexploitation and increased climate change (Davis & Caldeira, 2010). Already in 1989, Wachtel (1989) mentions that the consumer way of life is highly flawed in terms of both psychological and ecological perspectives. According to Jackson and Marks (1999), the growth in our consumption over the period from 1959 to 1999 seems largely focused on non-material consumption and is expected to remain like this. Examples are social interactions and activities, instead of physical products like food products or tools.

This growth, however, does not result in an increased quality of life (QOL); in fact, several studies point out that it can prevent some potential satisfaction while simultaneously overexploiting the planet (Jackson & Marks, 1999). Easterlin (1974) has shown that consumption positively correlates with well-being, but only to a certain point and only for the short term. The effect of non-correlation in the long term between consumption and well-being is the largest on the European continent (Apergis, 2018). Dutch society has already reached the proverbial 'critical mass', meaning that additional consumption will not further improve the quality of life (Stelzner, 2022). These downsides of consumption seem to suggest that less consumption would be better for society, but this is very difficult to prove. Only by connecting consumption and well-being, the simultaneous effects can be measured.

To dive even further into the effects of consumption, increased consumption has also been linked to an increase in greenhouse gas emissions (GHG) (Wiedmann & Minx, 2008). The associated emissions have different factors of impact, but they can be related to CO_2 (CO_2 equivalent (CO_2-eq)), which is the current standard to measure climate impact (IPCC, 2022). If the emissions are known, a carbon footprint can be calculated. Household energy, burning petrol, and energy used along supply chains are among the pieces of information needed for the calculations (Druckman & Gatersleben, 2019). These environmental effects could also change when the consumption patterns are adjusted.

2.4 Time-use

Each activity has a distinct basket of consumption with its own carbon footprint (Jalas and Juntunen, 2015). However, there is no substantial correlation between time-use-related carbon emissions and quality of life (Andersson et al., 2014). Time is highly constrained, which results in the idea that there can be an enormous range of expenditure per time spent on an activity, since the very rich are ought to consume way more in the same lifetime as a poor person (Piketty, 2018). This suggests that income is a strong factor for consumption, which is related to work. However, when the work hours are increased, less free time will be available to consume the income. On average, people spent around 5,7 hours of leisure time a week (Druckman & Gatersleben, 2019). During this time, walking in the park in silence can be a very low carbon activity, while catching a plane to go skydiving generates a lot of emissions. Variations in time-use may be an encouraging complementary approach to decreasing GHG emissions (Wiedenhofer et al., 2018).

To be able to understand where and why potential changes in time-use will come from, it is important to understand our underlying needs. Maslow (1943) visualized our needs in a triangular hierarchy, based on physiological, safety, love, esteem, and self-actualization needs. Maslow (1943) theorized that, when a certain layer of the pyramid is satisfied, one is to proceed to the next level to seek further challenges to satisfy our subjective well-being. A person's well-being originates from satisfying needs, therefore, in his vision, gratified needs are not active motivators. This hierarchical approach, however, was later revised by Max-Neef (1991), who stated that there are multiple human needs that all need to be satisfied, without any specific hierarchy. Max-Neef's approach is fundamental to research on the quality of life and could even be connected to consumption as Vita et al. (2019) showed.

When connecting needs and time-use, however, the hierarchical structure that Maslow (1943) created does have added benefits. Lower layers in the hierarchy become a nearly fixed pattern in daily life since the needs (e.g., eating, resting, and personal care) are already adequately satisfied (King & van den Bergh, 2017). The time spent on the lower layers of the pyramid will remain stable when people change their time-use for other needs in the pyramid. The upper layers are the ones where conspicuous consumption is being done, even though there is a limit in additional satisfaction due to diminishing returns to scale (Jackson & Marks, 1999). A shift in the number of working hours also means a shift in other time-use, which could have its own effects on well-being and sustainability. Therefore, the implications of the Maslow pyramid are that changes in time-use are more likely to happen in leisure-time activities, instead of the fixed daily life patterns. This paper will link time-use and consumption to see what effects worktime-related changes have on human well-being and climate change, based on leisure-time activities.

2.5 Well-being

As mentioned before, well-being would be a valuable addition for all kinds of research, but to consumption studies in particular. One of the reasons this is not common yet, has to do with the complexity of doing research on (subjective) well-being. An in-depth analysis of the nature and the length of people's experiences in their day-to-day life can add to the understanding of subjective well-being.

One of the methods used to gather data on well-being is self-reported experiences. Even though there are other prevalent well-being surveys, those are not linked to time, which makes them more difficult to use for this time-use-based research. After an activity or time span, a person is asked to report on their feelings at that moment (Kahneman et al., 2004). These reports are subjective, meaning that a 7 for one person can actually be the same as a 9 for another person, making the comparison of results difficult. In addition, multiple factors such as the weather or other activities on that particular day can influence these ratings. (Kahneman et al., 2004). This framing bias is hard to overcome, but Kahneman et al. (2004) have produced a method that deals with these biases, namely the U-index.

The U-index focuses on unhappiness or unwanted feelings since these occur less than positive feelings. According to the research of Kahneman et al. (2004), the correlation between 'happy' and 'enjoying myself' is 0.73, while the correlation between 'criticized' and 'feeling worried' is 0.32, meaning that it is easier to distinguish what exactly causes the unhappiness, compared to being happy. These findings led to a focus on emotion in the novel approach of Kahneman et al. (2004). Policymakers are more at ease with decreasing a well-defined perception of discomfort than with increasing a vague perception of contentment (Kahneman et al., 2004), making the novel approach suitable for this time-related study.

Even though there can be seasonal fluctuations in the perceived unhappiness for activities, the yearly averages are representable for a full year. Since fewer unhappiness, or more happiness, is preferred, the index could be interpreted counterintuitively. With this index, data can be created depicting the amount of time a person is experiencing discomfort for specific activities. What could be done from here is either the activity is to be changed (for the better), or avoided (replaced with an activity with a lower U-index) in order to decrease the overall U-index.

This means that the quality of life can be influenced by changes in the distribution of time (Kahneman et al., 2004). We live hurried lifestyles which cause dangers to our well-being, such as burn-outs (Reisch, 2001). In addition to this danger, there is a phenomenon called the hedonic treadmill effect (Brickman, 1971), which entails that earning a higher salary does not improve well-being in the long run. If money does not buy happiness, the question '*what does'* remains.

2.6 The four-day workweek

At the beginning of this chapter, trends across the last century for the Dutch standards for the amount of work have been discussed. The decreasing trend in work hours and the impacts of different time allocations on emissions and well-being can be used to evaluate the effects of a possible future of the workweek; a four-day workweek.

Disputes about whether there needs to be more focus on decreasing labour hours instead of increasing income still continue today. Albertsen (2008) has investigated the disadvantages of extensive labour on psychological well-being and stress. Working is already experienced as less pleasant compared to other activities (Kahneman et al., 2004). Shorter workweeks can result in less fatigue and absence, improved morale, and more focus (LaJeunesse, 1999; Shao & Rodríguez-Labajos, 2016). Experiments in e.g., Iceland (Laker, 2022) have shown that when working less, the effectiveness of the labour force increases, causing the output to remain constant or even increase. These results are only achievable for certain types of jobs where factors like motivation, time pressure, or efficiency can improve the output. For jobs that are closely dependent on time, a reduction in labour hours will most likely decrease output instead. Since the exact overall output change is unknown, and therefore the income level changes are unknown too, they are assumed to remain either untouched, or could decrease due to less output. The Iceland experiments assume working less could be favourable, but lack the approach of consumption and well-being combined, plus the rebound effect of consumption from the replacement activity.

The phenomenon of a four-day workweek generates additional hours (about 8) to be spent on other activities. The effect of a shorter workweek on human well-being and the climate is highly dependent on which activities replace working (Gunderson, 2019). Multiple attempts have been made to link consumption and well-being, but never through time-use. This novel approach possibly has positive consequences in reaching several economic, social, and environmental targets (King & van den Bergh, 2017).

Implementation of the four-day workweek will result in changes in human well-being and climate change, however, how the four-day workweek will be implemented is especially important for calculating the effects. King and van den Bergh (2017) took the approach of formulating five different ways of what a four-day workweek could look like. The scenarios they researched are a three-day weekend, a free Wednesday, workforce minimalization, shorter working days, and a holiday increase. The first three were found to be effective in reducing greenhouse gas emissions since they contribute to less commuting and less use of the offices in general. The latter two were scenarios that did not have a significant impact. Out of the three stronger scenarios, the three-day weekend option is the most promising for GHG emission reductions and will therefore be used as the benchmark for this paper. These were tested before working from home was mainstream due to the Covid-19 pandemic, so a revision of this paper with current data might result in other scenarios and findings.

In addition to the dilemma of '*how*' to implement the four-day workweek, the question of '*what*' to do with our time is also important. If people have about 8 hours more to spend on non-working activities, what alternatives they choose determines the effects a four-day workweek will have. A Swedish study showed that when working less, the proportion of time spent on energy-intensive activities will increase, leading to an increase in energy consumption of 0.06% for every 1% reduction in working time (Nässén et al., 2009). Going for an outside run during an extra day off will have a different carbon footprint than going on a short holiday, by plane, during an extended weekend. To be able to figure out which activities are beneficial for GHG emissions, and which are not, this study will look at the effect of different activities that could replace about 8 hours of work. Looking back at the hierarchy of Maslow (1943), we assume only activities higher up in the pyramid will be applicable for this study. Replacing the 8 hours with sleeping or eating, for example, would not be possible and therefore not relevant for this study.

3. Methodology and data

To be able to build the model for answering the research question, data from several sources is required. This chapter will elaborate on which datasets have been used and why. An explanation for what is done with the time-use and consumption data and where these are used will be given. After that, the link between both of these datasets is explained in the connecting matrix, which is the basis for the model. Later, the well-being data is added to complete the matrix. Thereafter, the scenarios which will be tested by the model will be introduced. Finally, the financial changes for the model will be explained. In Figure 3 below, a schematic overview is given to show how the different topics are related that are discussed in this chapter.

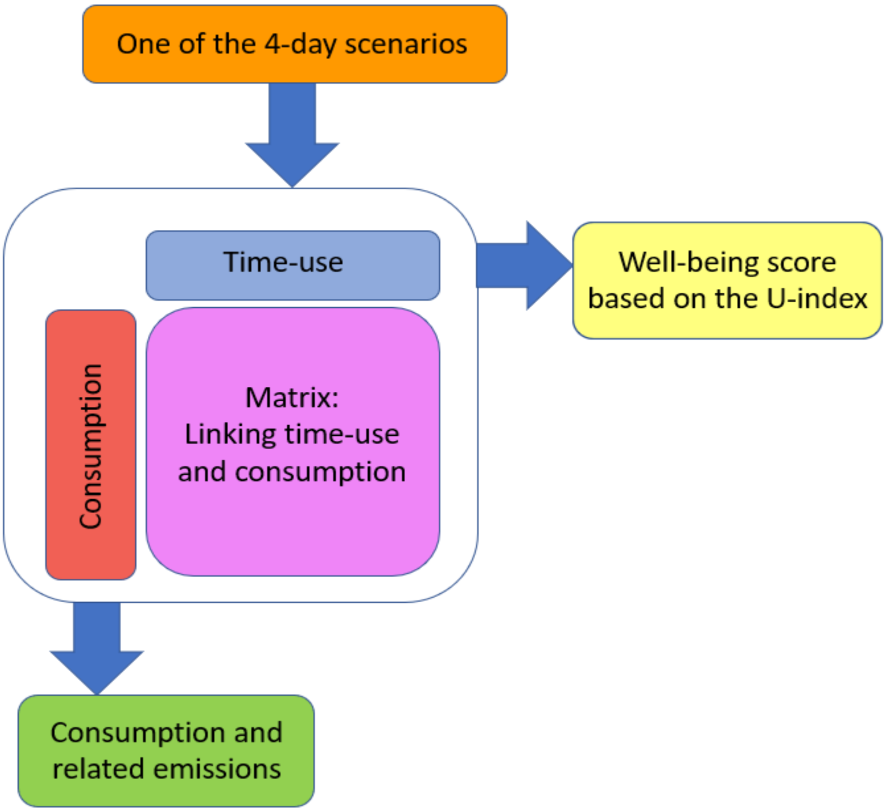

Figure 2: Schematic overview of the theoretical linkages

3.1 Time-use data

In order to analyse an average person's week, it is important to know what the Dutch time-use data looks like. The Dutch Social and Cultural Planning bureau (SCP) conducted a household time-use survey, which was published at the Data Archiving and Networked Services (DANS). This dataset was chosen because it is the largest and most detailed time-use survey in The Netherlands. The most recent dataset is from 2016, which is why that year has been chosen for this research. Not only was 2016 a relatively stable year (in terms of financial situations, crises, etc.), but datasets for the other parts of this research are also available for the year 2016. Using the data from the Dutch time-use model, it is possible to gain insight into who works how many hours, and how people spend their leisure time.

The household time-use survey has 2243 respondents who each reported on their activities during a full week. Every 10 minutes the main activity was written down, for a total of 1008 results that week. Using follow-up questions about the individual person, Statistics Netherlands (CBS) was able to calculate how representative the respondents are of Dutch society. Each survey is given a representing factor, so that all answers, when multiplied by this factor, would give a representative weekly time-use indication for the population between the age of 15 and 65. However, since this study is investigating replacing working hours with other leisure time, not all respondents are relevant. From these 2243 surveys, people working full-time were selected and, together with their representing factor, combined to create a subset of 897 respondents. These respondents represent the 4.584.000 full-time workers in The Netherlands in 2016. The reason for creating this subset is that moving to a four-day workweek is only relevant for people working full-time, not for people who do not work at all. This way, a solid representation of the full-time workforce in the Netherlands was created with their weekly time-use, including all main activities.

The Dutch Social and Cultural Planning Bureau (SCP), clustered the reported activities by the respondents into 56 categories to be able to draw conclusions from their data. They suggested further aggregating of the activities with the densest option being 10 activity categories and another less dense option including 28 categories. For this research, based on a four-day workweek and leisure activities, a novel and more applicable clustering was created with a total of 19 categories. This was done because it allows not only for a more convenient overview, but also causes a reduction in rounding errors and missed details of niche activities. These 19 categories will later be used to be linked with consumption. Details about the division of the activities per category can be found in Appendix A. By adding the total time used on the activities belonging to the new aggregated activities, the time spent in each of the new 19 activities is calculated.

The holiday activity is not included in the time-use survey. ‘Holiday’ is a significant part of people’s lives seeing as the average number of days being away on holiday in the Dutch population, in general, is 21.7 days per year (CBS, 2021)(data from 2017). This implies that on average 10.08 hours per week are spent on holiday. The average of the Dutch population was taken since no specification could be found for full-timers. Since the survey only has respondents who are having a normal week, an average representation of a full year can be created by reducing the amount of time spent on all other activities by about 6%, making space for the holiday. The addition of ‘Holiday’ to the 19 activities makes for a total of 20 activities.

3.2 Consumption and emission data

When forming a consumption profile for a subset of a population, macro consumption data is necessary. This research used the national accounts data for the Netherlands in 2016, which depicts, among others, the national GDP, its components, and the specifications for imports and exports. The domestic consumption and trades between the global regions are processed by EXIOBASE. This dataset contains Environmentally Extended Multi-Regional Input-Output analysis. The data is gathered from Zenodo (2021). In this dataset, there is data on industry-to-industry trade, but also product-to-product. The latter one is relevant for this research since, in contradiction to industries, products are directly consumed by households and can therefore be attributed to activities directly.

Consumption

First, the Environmentally Extended Multi-Regional Input-Output model will be explained. According to Miller & Blair (2009) the fundamentals of Input-Output analysis are depicted in Figure 2. The model has multiple regions. Some are countries such as The Netherlands, but other regions are larger parts of the world, adding up to a total of 49 regions representing the whole world. Each region has 200 product categories which are further specified by CPA goods Eurostat EU and CPC goods of the United Nations (Eurostat, n.d.). The complete list of the products can be found in Appendix B. For simplicity purposes, all products are clustered in 19 consumption categories based on the clustering method used by Vita et al. (2019). This allows not only for a more convenient overview, but also causes reduced mistakes for misinterpreted products. These regions with their products are situated in the A-matrix of the model (see Figure 2). The A-matrix is the technology matrix showing Multi-Regional requirements of direct and indirect factor inputs for efficient production. The red squares represent the domestic input-output, while the orange squares are the bilateral trade between two regions (3 out of 49 regions are shown for simplicity reasons). On the right-hand side, the Y-matrix is situated. This matrix still has the regions and products on the y-axis, but is summed up on the x-axis to show the final use of a product in a region. Yellow is the final use of domestic production, while brown is the final use of imported produce. To get the total household consumption for The Netherlands, the domestic consumption plus all imports are aggregated (shown by the darker area in the Y-matrix).

With this data, the number of euros spent on each product is known, which can be divided by the Dutch population to get an average of the complete consumption for an individual. The assumption here is that the share of products is the same for everyone, which is only changing the quantity, not the composition, when income is changed.

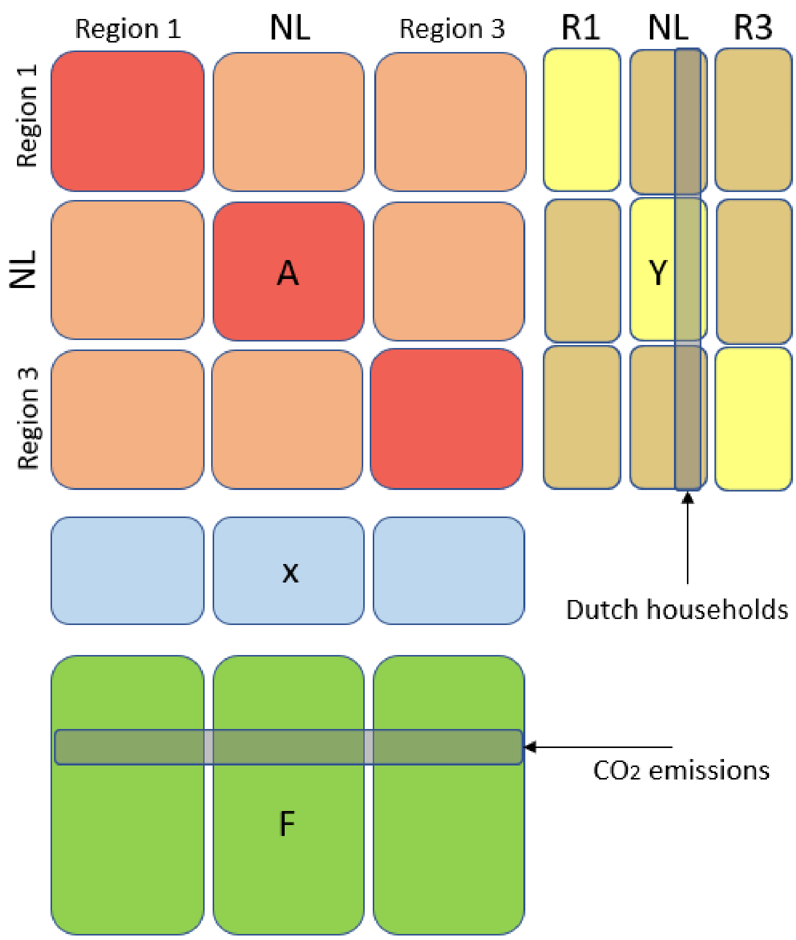

Figure 3: *Schematic overview of data gathered from the IO model*

Emissions

The x-matrix represents the factor inputs table. This factor is used to transform the direct and indirect factor inputs in the A-matrix into the environmental indicators in the F-matrix. This F-matrix contains a vast amount of environmental indicators such as pollution to water, air, earth, and humans. For this study the global warming emissions are of interest, being CO_2, CH_4, and N_2O, since these are the GHGs that are available in the EXIOBASE data. These are made equivalent to CO_2 by multiplying the amount of CH_4 and N_2O emissions by 28,5 and 273 respectively according to the most recent convergence method of AR6 (IPCC, 2022). These emissions are represented by the darker area in the F-matrix.

To calculate the indirect emissions of the Dutch households, several calculations have to be done with the matrices. First, the F-matrix is divided by the x-matrix to create the S-matrix which gives the kilogram CO_2-eq per million euros. This only has to be done for the grey area, being the CO_2-driven environmental indicators. The equation (1) for the Dutch indirect household emissions is the following:

$$M = \left(S(CO_2)\right) * \ (I - A)^{-1} * \ (\hat{Y}(NL, hh)) \tag{1}$$

The middle section of the equation is the Identity-matrix, which is used to calculate the Leontief inverse matrix. This calculates the multipliers which represent the initial input and shows all changes in the input-output matrix. For example, if The Netherlands imports a car from Germany, that transaction is not the only impact in the model alone. It causes additional demand for car parts and materials all over the world. This Leontief inverse gives the factors to calculate this in reverse. The final section of the equation is the grey area in the Y-matrix, being the total aggregated Dutch household consumption. The matrix is diagonalized to fit the equation.

For the direct household emissions, the data from the S-matrix and Dutch household consumption from the Y-matrix are multiplied directly. These are the emissions in kilograms per direct consumed household product. Multiplied with the AR6 convergence method, a list of all direct emissions per product of the Dutch household is generated (Zhou, 2021). For the total Dutch household emissions both indirect and direct emissions are aggregated. Now the total emissions for all products are known.

Accounting share

The previously calculated consumption and emission data are based on all Dutch household consumption. This study only focussed on full-timers, so from these national data, a subsection needs to be made. The consumption spent on products comes from both part-time and full-time workers. According to CBS (n.d.b.), the share of part-time and full-time employees was 4.054.000 vs 4.584.000, being 46,92% and 53,68% of the total labour force respectively. This is an age bracket for people between 15 and 65, meaning that young people and retirees are excluded from consumption in this model, which is unfortunately inevitable due to the way the consumption and time-use data is presented. In 2016 the average income for part-timers came down to 1427 euros per month. For full-timers that were 3546 euros per month. And the total labour force average was 2404 euros per month (CBS, 2022b). This results in the full-timers income to be 66,13% of the total income and related consumption. Therefore, from the national consumption and linked emissions, 66,13% will be attributed to the full-timers. The monetary consumption and emissions serve as input to the model and are given in Appendix C.

3.3 The matrix

To further create the model, the consumption and time-use data are connected by a matrix. The connection between products and activities does not always come naturally since many products are not attributed directly to a specific activity only, but multiple, all in a different share. The strategy for solving this was to make a logical assumption for the distribution, when possible based on literature. Others products are divided over the amount of time spent on the activity to represent an equal accounting over time.

Several links seem obvious, for example, food products are linked with the 'Eating' activity. However, a question could arise about what 'consumption' actually is. Purchasing the product, preparing the product, consuming the product, or benefiting from the energy of the food products after consumption. While an argument could be made for each option, for this model food products will be linked to 'Eating' since this is as correct as the other methods and came as the first instinctive thought. Also, this will not affect the later explained scenarios. Similar specific well-matching product categories are 'Air mobility' being related to 'Holiday', since flying for business is not part of household consumption. Additionally, 'Research and development', is related to 'Education', also because Research and Development (R&D) for business is not part of household consumption.

Some products are almost constantly used, meaning their consumption data have to be attributed proportionally to the activities in which they are used. If 1 hour is spent on 'Shopping', and 2 hours on 'Social contact', products from the 'Clothing' category are accounted for twice as much on 'Social contact' because these products are used twice the amount of time. An adjustment has been made for the 'Sleep' activity, which is taking the most time per week but has relatively low 'Clothing' consumption. Product categories with similar properties are; 'Housing', 'Construction materials', 'Electricity', 'Broad category', and 'Protection related services'. No matter the shift in time-use, housing rents or mortgages always have to be paid. 'Electricity' is used constantly by stand-by functions and a fridge that always stays cool. Here, adjustments have been made for low-consuming activities like 'Sleep', and high-consuming activities like 'House work'. Based on information from Directenergy.com(n.d.) an estimation has been made on which activity uses how much electricity for 'Air conditioning and heating' (46%), 'Water heating' (14%), 'Appliances' (13%), 'Lightning' (9%), 'TV and Media Equipment' (4%), and 'Other' (14%). The 'Broad category' is difficult to allocate to a specific activity because it holds products like 'Other services'. Other difficulties include final and intermediate goods, such as 'Construction materials' and 'Housing'. The emissions of the 'Construction materials' should also be accounted for in 'Housing', which is where the products are eventually consumed, however, the consumption for generating the 'Construction materials' is not generated at the same time as 'Housing' itself.

Other product categories are linked based on situations. Mostly whether the activity is taking place at home, or not. These product categories are; 'Furniture', 'Household fuels', 'Household materials', 'Non-shelter household products', 'Communication', 'Tobacco', and 'Waste treatment'. There are some deviations between these categories. For example, it is assumed that ‘Sports’ is done away from home, meaning no use of ‘Furniture’, but the heater stays on, meaning the use of ‘Household fuels’. The latter will be turned off during ‘Sleep’, even though this activity takes place at home.

Additionally, ‘Health’ and ‘Paid domestic work’ are not linked to time because ‘Health’ consumption is skewed towards elderly people, which are not part of this model. Also, ‘Being sick’ is not an activity that was reported in the time-use data, which would be the designated activity for ‘Health’ consumption. ‘Paid domestic work’ is consumed by people who have staff, for example, for cleaning the house. This is earned as an income, and spent on consumption by the staff, which therefore does not impact the results since it remains in the loop. Therefore, this additional step is not considered for the model and is therefore not linked directly to any activity.

The final product category ‘Non-air mobility’ is linked according to data on traveling by Statistics Netherlands (CBS, n.d.c.). The majority is used for ‘Social contact’, followed by ‘Holiday’, ‘Shopping’, ‘Going out’, and ‘Hobbies’. Other issues appear in durable goods versus non-durable goods, such as cars and gasoline, which are both in ‘Non-air mobility’. The use of the car is expressed through its consumption of gasoline. However, the car’s footprint is caused by production in the supply chain. The production of the car is not consumed completely in the first year, however, all these emissions are reported in the Input-Output analysis of 2016. This should not matter if the consumption of cars was equal for all years of depreciation, but the sales of cars fluctuate over the years due to business-cycle dependency. For simplicity reasons, both durable and non-durable emissions for cars are clustered in ‘Non-air mobility’.

A footprint of the activity can be calculated by multiplying the number of emissions by the share of the product in a certain activity. By combining the impacts of all included products, a total emission per activity is calculated. For further information about these calculations and linked shares, see Appendix D. When dividing the emission per activity by the time spent on this activity, the footprint per hour arises. For all activities, the footprint is available and can be used to estimate the total impact of changing the time used on that activity.

Once all product categories are linked to activities, the consumption-time-use matrix emerges. The usage for this matrix in general is versatile. It can be used to predict changes in consumption patterns and their emissions when the supply and/or demand of certain products change. In addition, it can predict how changes in behaviour can influence consumption patterns and their emissions. This matrix could be able to help in future research on all kinds of time-use and consumption studies. In this case, the four-day workweek will be the implementation of the matrix.

3.4 Linking well-being

After the completion of the consumption and time-use matrix, the well-being component was included. To achieve this, the 20 activities used in this model are linked to the U-index. This index is based on data from the United States, but the assumption is that these are also applicable to the Dutch population. Since the U-index data is not known for all activities, the activities without a U-index will not be used in changing time-use, since a change in well-being cannot be computed. Activities for which a U-index is available have been linked accordingly. The U-index represents a share of time in which a person experiences unhappiness or unpleasant feelings. Therefore, multiplying the U-index with the time spent on a certain activity will result in a total time feeling unhappy during the time spent on that activity. When changing with the number of hours per activity, changes in the total time being unhappy during a week can also be calculated. This will be used as an indicator of change in human well-being.

The only U-index which is imputed is for 'Holiday'. This is a relevant scenario and therefore will be included. Kahneman (2004) only focussed on people that are at home, however, so no specific U-index for 'Holiday' is available. To be able to produce a well-being result for 'Holiday', it is assumed that a 'Holiday' is a combination of the different leisure time activities (e.g., 'Socializing', 'Relaxing', 'Media', and 'Exercising'). The U-index will therefore be a weighted average of this U-index, accounting for the regular time which is being spent on these activities.

3.5 Scenarios

The model, containing time-use, consumption, and well-being, can be used to test the impacts of a four-day workweek. To do this, several scenarios will be used to see what their results would be. The basic human needs are already gratified in The Netherlands, therefore additional leisure time will likely not be spent on those activities. Activities such as 'Sleep' and 'Eating and drinking' will not be affected by a reduction in work time, so those will therefore not be a part of the scenarios for the four-day workweek. Activities without a known U-index, with the exception of 'Holiday', have also been excluded, since no fundamental change in well-being can be calculated for those. With these restrictions based on the available data from Maslow and the U-index, the remaining leisure time activities which will serve as scenarios are: 'Socializing', 'Relaxing', 'Media entertainment', 'Exercising', and 'Holiday'. These will be compared to the reference scenario of a regular five-day workweek. Since commuting is expected to be a significant part of the environmental impacts of a workday, an additional control scenario was added in the form of working one day from home. Commuting without working does not make sense, so therefore this will not be added as an extra control variable for working. Table 1 gives an overview of the scenarios, their underlying activities from the time-use survey, the current total time spent per week on these scenarios, and each U-index. The U-index for commuting has both a morning and an evening commute score. To make it representative for commuting on a daily basis, the average was taken.

Table 1: Breakdown and well-being factors for each scenario

	Consists of (activities)	Time used (h)	U-index
Five-day workweek	1. Exercise of a profession 3. Training during working hours 4. Commuting transport	Work: 34.16 Commute: 4.31	Working: 0.211 Commute: 0.209 + 0.287 / 2 = 0.248
Socializing	30. Face-to-face contact 31. Mediated contact (call, text, chat, social media) 33. Party, going out 42. Leisure and social life on the go	8.15	0.073
Relaxing	40. Relax, laze 41. Free time unspecified	0.56	0.078
Media entertainment	43. Radio and music 44. Listening via internet, computer 45. Television and movies 46. Watching via internet, computer 49. News on the internet 52. Other mass media 53. Gaming 54. Internet 55. Computers	15.83	TV: 0.095 Phone: 0.126 Computer: 0.165 Average used: 0.129
Exercising	34. Excursions, hiking, cycling 35. Sports participation	1.79	0.088
Holiday	Imputed	10.08	Weighted average: 0.10
Work one day from home	1. Exercise of a profession 3. Training during working hours 4. Commuting transport 40. Relax, laze 41. Free time unspecified	Work: 34.16 Commute: 3.44 Relaxing: 0.86	Working: 0.211 Commute: 0.248 Relaxing 0.078

As mentioned before, the five-day workweek is the reference scenario. To transform to a four-day workweek, the time spent on working and commuting was reduced by 20%. The released time will be spent entirely on one of the new scenarios to reach a full week again. The one day from home scenario accounts for a full week of work, but a 20% reduction in commuting. To reach a full week of time, the released time was allocated to 'Relaxing', since this is the most likely activity done with these additional minutes.

The scenarios are extreme in their nature because they are intended to illustrate the effects of that specific activity and can therefore be compared between other scenarios. The scenarios are not realistic scenarios per se but will provide guidance when choosing between leisure time activities once a four-day workweek is implemented.

3.6 Budget cap

Since monetary consumption is linked differently for each activity, all activities have different costs per hour for performing that activity. This implies that, when changing the time-use towards more expensive activities, the total monetary value consumed goes up. Since there is a maximum that can be afforded due to wages, there should be a defined monetary limit. According to Hypotheek.nl (2021) the average Dutch savings per month are 216 euros. Even though it is very dependent on every household's financial situation whether this is possible or not, a household average would be suitable as a check for the plausibility of the additional expenditure. Besides the current modeled consumption, on average there are 216 euros per month available for additional consumption. Therefore, this is assumed to be the cap above current consumption expenditure.

The side effects of adjusting the savings rate are that it alters financial security. One of the main reasons for savings is to be able to counter a financial setback. To have savings means being more financially stable. Taking away this certainty by spending all savings, will most likely have a negative effect on well-being. Since it is unknown what the actual effects are on the U-index, any changes to this are not considered. To create a model where these additional savings are untouched, any additional monetary consumption should be scaled down towards the default consumption rate. This means that both time and money spent are fixed, leaving only emissions and well-being to be able to change.

Even though there are several experiments being done on the four-day workweek where the five-day wages are maintained, this model assumption is most likely the upper bound. The lower bound will be a reduction in wages of 20%, countering the reduction in worked hours. This is the bandwidth of income that allows for consumption. Since consumption is the driver of this model, it will be tested twice to calculate this bandwidth and see what the effects are of a 20% reduction in pay on consumption and related carbon emissions.

Concluding

To build the research model, different sources of data have been used. The relevant data is selected and processed to represent average full-time workers. Both the time-use and the consumption data are transformed into workable categories and added to the model matrix. Certain parts are added such as the ‘Holiday’ activity and budget caps. Additionally, well-being data is linked for a complete model. Next, scenarios have been created to use in the model framework to find results for answering the research question. Finally, due to the uncertainty of wage changes, the model will be used twice for the upper and lower bound.

4. Results

To analyse the results, first, the outcome of the time-use surveys is checked to see what the average Dutch week for full-timers looks like. The consumption results per hour for each activity give an insight into the consumption and their emissions in CO_2 -eq. Then, the activities are compared to see which have high costs and/or emissions. With the aforementioned results clear, the scenario results are presented to see the effects of a four-day workweek, both for current and reduced wages. Finally, a sum-up of the results is given.

4.1 Time-use results

From the time-use surveys, the number of hours spent on each activity per week can be found in Table 2. The table shows that a full-time worker spent on average 34.16 hours on work per week. This is lower than expected for a regular week, but not when considering that holidays are included, driving the average down. ‘Commuting’ is on average 4.31 hours per week in total, meaning almost 26 minutes per trip. The actual time spent will be somewhat longer, again due to holiday time that is already calculated. Respondents sleep an average of 53 hours per week, about 7.5 hours per night, which is in line with expectations. ‘Eating and drinking’ comprises 7.88 hours per week, translating to just over 1 hour a day. This is logical, assuming three meals a day of about 20 minutes each.

Table 2: Activities and their hours per week

Activity	***Time used (h)***	***Activity***	***Time used (h)***
Paid work	*34.16*	*Care for others*	*1.97*
Commuting	*4.31*	*Shopping*	*2.20*
Social contact	*8.15*	*Use of services*	*1.40*
Relaxing	*0.56*	*Personal care*	*6.16*
Media	*15.83*	*Education*	*1.25*
Sports	*1.79*	*Volunteering*	*1.30*
Holiday	*10.08*	*Religious activities*	*0.06*
Sleep	*53.06*	*Going out*	*2.71*
Eating and drinking	*7.88*	*Hobby’s*	*2.39*
House work	*9.72*	*Other*	*3.01*

4.2 Consumption results

Table 3 shows the ratio of monetary consumption and their emissions per activity expressed in grams of CO_2 per euro, which is done by dividing the emissions by the monetary consumption. It can be seen that 'Paid work' and 'Commuting' have very low grams of CO_2 per euro, while 'House work' has very high grams of CO_2 per euro, which will be explained later. Per activity and per product profiles in absolute terms for monetary consumption and CO_2 emissions can be found in Appendix E.

The per activity profile in absolute terms for monetary consumption shows that the Dutch full-timers spend the most money on 'Paid work', 'Social contact', 'Media', 'Holiday', 'Sleep', and 'Eating and drinking'. This might seems unexpected, but can be explained by the fact that these are the activities on which the most time is spent. Expensive products like 'Housing' are attributed more to these activities since it is equally divided over time. After all, housing rents and/or mortgages have to be paid for an entire month, even when people sleep or are working. Other product profiles which are consumed a lot in absolute terms are 'Non-air mobility', 'Communication', and 'Food', explaining other high activity profiles.

The per activity profile in absolute terms for CO_2 emissions shows high emissions for 'House work', 'Media', 'Social contact', and 'Holiday'. These can be explained because of the high product profiles of 'Household fuels', 'Electricity, and 'Non-air mobility', which are consumed heavily during these activities.

Table 3: Consumption results for grams of CO_2 per euro of each activity

Activity	***Grams of CO_2 per euro***	***Activity***	***Grams of CO_2 per euro***
Paid work	35	*Care for others*	638
Commuting	29	*Shopping*	287
Social contact	323	*Use of services*	103
Relaxing	889	*Personal care*	749
Media	519	*Education*	508
Sports	343	*Volunteering*	572
Holiday	185	*Religious activities*	913
Sleep	158	*Going out*	305
Eating and drinking	275	*Hobby's*	288
House work	1.667	*Other*	864

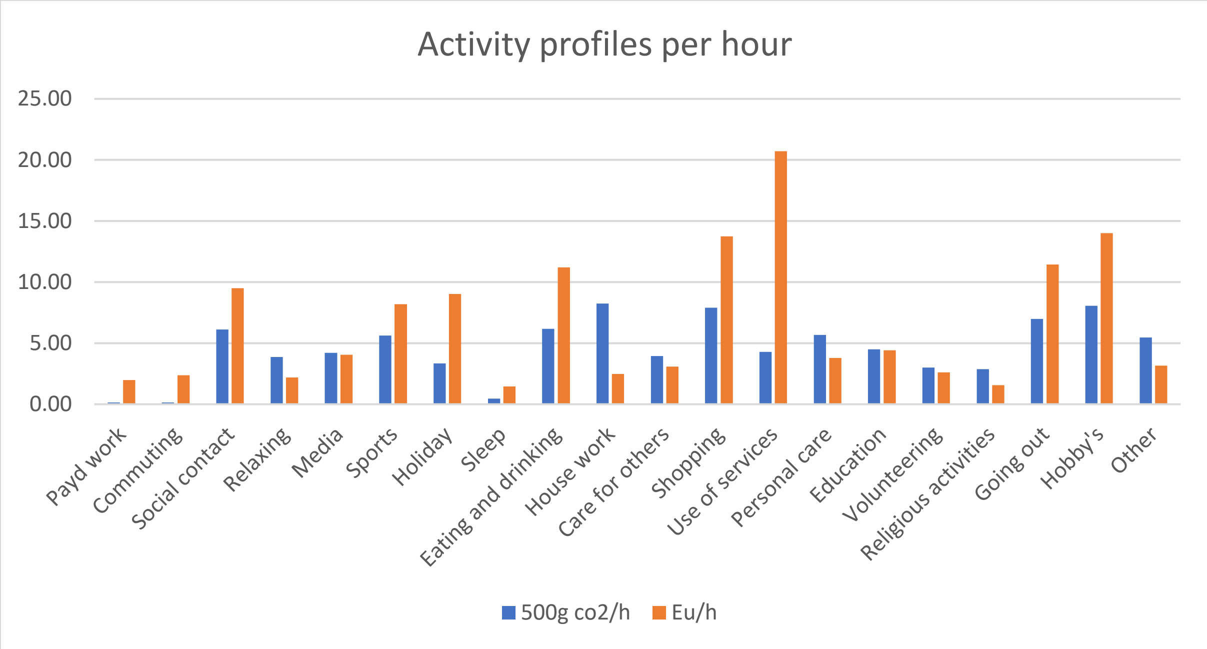

Figure 4: Activity profiles for all activities. Consumption-based on euros and 500g CO_2 emissions per hour

In Figure 4 the consumption results per hour of each activity are shown. The second column displays the amount of money in euros per hour, spent on consumption of the activity. The third column shows the emissions in CO_2-eq per hour, caused by the consumption during the activity. To be able to compare the ratio between both columns better, CO_2 is given in 500 grams instead of the usual kilogram.

The implication that activities that are done for more hours result in higher consumption is removed by calculating the consumption and emissions per hour. These can be found in Figure 4, from which several observations can be made:

1. ‘Use of services’ is the most expensive activity per hour. This has to do with a high monetary expenditure while there is little time spent on it, making the costs per hour very high. This is also the activity with the highest costs compared with its emissions. This can be explained because products like business services or social security services are costly, but have relatively low emissions.

2. Other costly activities such as ‘Hobby’s’, ‘Going out’, and ‘Social contact’ are involved with ‘Non-air mobility’, which is one of the most costly consumption, while the activities are not done for a long time.

3. ‘Paid work’ and ‘Commuting’ score low on both indicators. This is caused by the fact that work-related emissions are not part of household consumption, but fall under business expenses. Therefore, the household consumption during these activities is very low, even extra compared to the time spent on them.

4. 'Sleep' scores, as expected, both on costs and emissions very low. Here, only the fixed consumption products apply such as stand-by electricity, rents, etc.

5. 'House work' has the highest emissions per euro ratio. This has to do with the fact that relatively little monetary consumption is done when doing chores, but it has very high emissions due to the use of 'Electricity' and 'Household fuels' products. Therefore, it also scores the highest on grams of CO_2-eq per euro.

4.3 Scenario results

In table 4 the results for each scenario are given. The second column presents the alteration per week schedule. The third column shows the additional emissions per week per person in kg CO_2-eq. The fourth column shows the number of euros required per week and per person if the scenario is executed. This calculation does not account for current wages or changes in wages. The calculation is solely based on the number of euros spent per hour on an activity. The final column shows the reduced unpleasant minutes per week. For ease of comparison, Figure 5 shows the percentual changes for all three indicators per scenario.

Table 4: Scenario results compared to the reference scenario. Time-use, costs, emissions, and well-being respectively

	Time-use changes in hours spent per week	**Additional Kg CO_2-eq emissions per week for an individual**	**Additional euros required per week for an individual**	**Reduced unpleasant minutes per week**
Five-day workweek	No changes	0	0	0
Social contact	Work -6.83 Commuting -0.86 Socializing +7.69	23.06	57.13	65.58
Relaxing	Work -6.83 Commuting -0.86 Relaxing +7.69	14.38	0.82	63.28
Media	Work -6.83 Commuting -0.86 Media +7.69	15.67	15.28	39.74
Sports	Work -6.83 Commuting -0.86 Exercising +7.69	21.07	47.11	58.66

Holiday	Work -6.83 Commuting -0.86 Holiday +7.69	12.33	53.42	53.12
Work one day from home	Commuting -0.86 Relaxing +0.86	1.61	-0.47	8.77

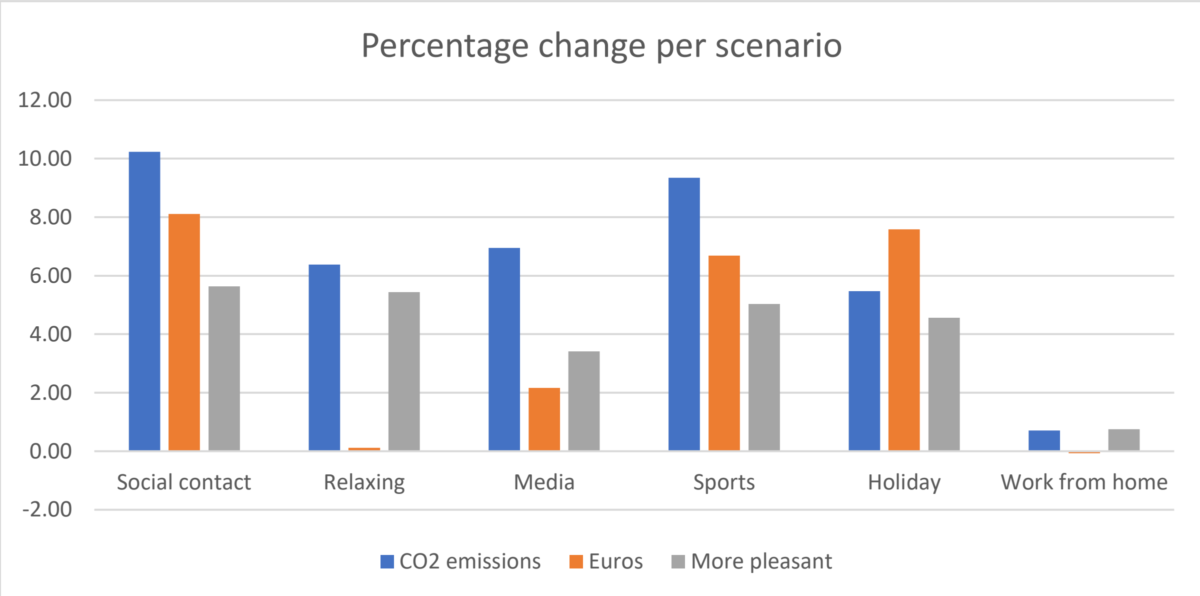

Figure 5: Percentage scenario results compared to the reference scenario. Emissions, costs, and well-being respectively

First of all, the results for emissions are higher for all scenarios. This has to do with the result of both 'Working' and 'Commuting' having very low consumption per hour. Replacing those with higher consuming scenarios results in increased emissions. 'Work from home' is by far the lowest since the only change in this scenario is the replacement of 'Commuting' with 'Relaxing'. Other scenarios are between 12.33 and 23.06 additional kilograms of CO_2. This is an increase of 5.47% and 10.23% respectively in total carbon emissions.

Secondly, the noticeable monetary result to consider is the negative value for the costs of 'Work from home', being -0.47. This means that if this scenario is pursued the weekly savings increase by 47 cents for 'Work from home'. The other scenarios are more expensive than the regular five-day workweek, ranging from 15.28 euros for 'Media' to 57.13 euros for 'Social contact'. The individual will be worse off financially if they choose to pursue this alternative.

Finally, in terms of the U-index, all results are positive. Both 'Working' and 'Commuting' score the highest on the U-index, meaning the most unpleasant moments. When reducing the number of hours for these activities and replacing them with activities that have a lower U-index score, the results for all scenarios are an improvement in well-being. Once again, 'Work from home' shows the least improvement, which makes sense due to the fact that this scenario has the least hours changed. The other scenarios range from a 3.41% increase for 'Media' up to a 5,63% increase for 'Social contact'. These represent 39 minutes and 44 seconds, and 1 hour, 5 minutes, and 34 seconds respectively of unpleasant time which is replaced with pleasant time.

Budget cap

Taking into account the budget cap for the monetary results of the scenarios is having an effect on the possibility of the outcomes. The maximum amount of additional consumption which can be afforded due to wages and the average savings is set at 216 euros per month. Converging the monthly savings to weekly savings results in a budget cap of 49.84 euros per week. This means that the additional costs for the scenarios 'Social contact' and 'Holiday' exceed that cap. This implies that, based on the average wages, savings, and consumption, it is financially not possible to fill all free days in the four-day workweek scenario with 'Social contact' or 'Holiday'. For 'Social contact' the maximum time would be 6 hours and 56 minutes, and 7 hours and 22 minutes respectively of the total of 7 hours and 41 minutes. This comes down to 90.23% and 95.87% of the time, assuming the remaining time will be spent on a cost-neutral activity.

Wage decrease

To tackle the imbalance of the savings being used, the share of additional monetary consumption is corrected back to the default. With this correction, all scenarios have the same money spent, but different emissions. This is done for both wage scenarios, to see what the effects of the differences in income are. In Table 5 below, the results for the percentage change in emissions are given. First, the original emissions are shown, followed by the change in monetary value, which is the factor of change to consumption. In the third column, the corrected changes in emissions are given. This is done for the current wages and the 20% decreased wages. Then, the difference between the emission results is given, which is the effect of the 20% decrease in wages. With these effects known, the elasticity of the scenarios is shown.

From Table 5 it can be seen that, after the budget correction, the emissions are lower in general. For the current wages, 'Holiday' is negative, since this scenario is more costly than it has emissions. A reduction because of the correction resulted in less consumption in this scenario, which causes the emissions to drop. 'Holiday' also shows more than a 20% decrease in emissions at the 20% reduced wage scenario. The other scenarios have an elasticity, larger than 1, meaning that a reduction in wages will result in a larger reduction in emissions. Another result is that in the 20% decrease in wages case, with and without a budget cap, all scenarios have reduced emissions compared to the reference scenario.

Table 5: Scenario results for lower wages and adjustments in costs

Scenario	**Current wages**			**20% decrease in wages**			**Difference**	
	% change in emissions	% change in costs	% change in emissions adjusted for change in costs	% change in emissions	% change in costs	% change in emissions adjusted for change in costs	Difference in change of emissions	Elasticity
Social contact	10.213	8.306	1.760	-11.830	8.306	-18.592	20.352	1.018
Relaxing	6.367	0.119	6.240	-14.907	0.119	-15.008	21.248	1.062
Media	6.940	2.222	4.615	-14.448	2.222	-16.308	20.923	1.046
Sports	9.332	6.850	2.323	-12.534	6.850	-18.141	20.465	1.023
Holiday	5.460	7.768	-2.142	-15.632	7.768	-21.713	19.572	0.979
Work from home	0.713	-0.068	0.782	-19.430	-0.068	-19.375	20.156	1.008

Results change if wages are decreased by 20%. A reduction in wages causes a reduction in emissions. The break-even points for emissions on a reduction in wages per scenario are given below in Table 6. This shows by which average percentage the wages should decrease in each scenario, to have no changes in emissions. This means that all scenarios, except 'Holiday' with savings correction, have higher emissions than the reference scenario. A reduction in wages needs to happen to remove these additional emissions. A further decrease in wages than the percentages given in Table 6, however, means that there will be a reduction in emissions compared to the reference scenario. All required reductions are below 10%, which means half of all full-timers receive a 20% reduction and others do not, or everything between that for an average of 10%. More than this average 10% reduction in wages results in a reduction in emissions for all scenarios compared to the reference scenario.

Table 6: Break-even points on emissions for all scenarios on a reduction in wages

Scenario	Wage reduction to break even without savings correction	Wage reduction to break even with savings correction
Social contact	9.27%	1.73%
Relaxing	5.99%	5.87%
Media	6.49%	4.41%
Sports	8.54%	2.27%
Holiday	5.18%	-2.19%
Work from home	0.71%	0.78%

Additional consumption

The model is relying on multiple assumptions. One of these is the use of household consumption only and not considering other consumption, which is intertwined in our time-use as well. In this research, only the emissions of direct and indirect household expenditure are used. This means that emissions that can be linked to personal time-use, but are not paid for by the individual, are outside the scope of household emissions. If an individual decides to spend more time on activities that are (partly) paid for by, for example, their employer, the actual emissions would increase, even though these are not visible in the household emissions. A great example would be 'Commuting'. This is an activity that is done by an individual, but the emissions are accounted for by intermediaries instead of households.

'Commuting' is seen as the largest polluter for a workday and is therefore expected to be the most prominent intermediary consumption representing the five-day workweek scenario. There are other emissions to consider, for example, business emissions from offices which also come into play with a four-day workweek. These are very complex to calculate and are therefore not part of this research. To be able to also take these intermediate emissions into account for commuting, these are imputed to this additional part of the model. In 2016, people in The Netherlands lived on average 22.5km away from their work (CBS, 2022a), therefore, a single day less commuting would result in 45 km saved per person. One liter of gasoline emits 2269g CO_2 (Rijksoverheid, 2019), and with gasoline prices of about 1.60 euros in 2016 (CijferNieuws.nl, n.d.). Gasoline cars drive on average at an efficiency of 1 liter for 15 km (Holmatov & Hoekstra, 2020), meaning 3 liters of gasoline for 4.80 euros and 6.8kg CO_2 per day. Assuming that 63,7% of full-timers are taking the car to work (CBS, n.d.a.) this is on average 3.06 euros and 4.34 kg CO_2 per day.

The share of consumption in the 'Non-air mobility' which is allocated to fuel adds up to 20.92% in monetary terms, while this is 90.93% in terms of emissions. When taking the whole product category into account, the new values are on average 14.62 euros and 4.77 kg CO_2 per day. When these additional costs and emissions are taken into consideration for commuting, the results for the scenarios change. The adjusted results are given in Figure 6. It can be seen that the emissions and costs for all scenarios decrease. For 'Social contact', 'Relaxing', 'Sports', and 'Holiday', there are no tipping points. However, 'Media' is suddenly less expensive than the five-day workweek scenario, resulting in a favourable financial outcome for this scenario.

The final change is that 'Working from home' is now linked to fewer emissions and fewer costs, while well-being is increasing. Therefore, taking into account the commuting consumption, 'Working from home' is favoured for all three indicators.

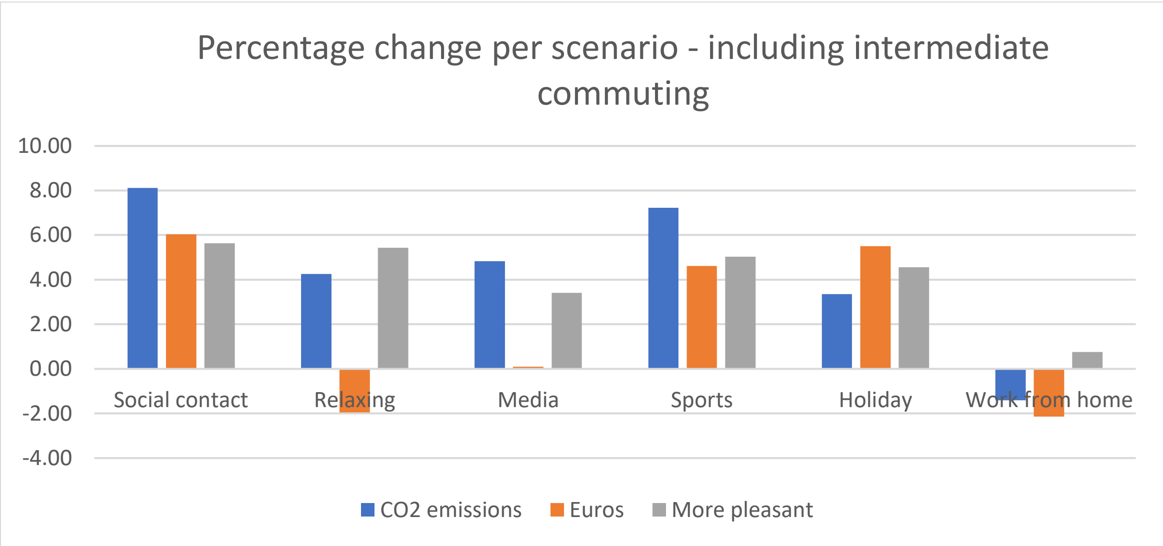

Figure 6: Percentage scenario results compared to the reference scenario including intermediate commuting. Emissions, costs, and well-being respectively

4.4 Results summary

The expensive activities are 'Paid work', 'Social contact', 'Media', 'Holiday', 'Sleep', and 'Eating and drinking'. This is caused by expensive products like 'Housing', 'Non-air mobility', 'Communication', and 'Food' which are attributed more to these activities since it is equally divided over time. The high emission activities are 'House work', 'Media', 'Social contact', and 'Holiday'. These are caused by high product profiles of 'Household fuels', 'Electricity, and 'Non-air mobility'. 'Use of services' is the most expensive activity per hour, while 'House work' has the highest emissions per euro ratio. 'Paid work' and 'Commuting' score low on both indicators because work-related emissions are not taken into account.

For all the scenarios the emissions increase. For the five regular scenarios, this is between 5.4% and 10.3%. For all scenarios the U-index improves, meaning fewer unpleasant moments. For the five regular scenarios, this is between 3% and 6%. In terms of money only ‘Relaxing’ and ‘Work from home’ are a little bit cheaper, but the other scenarios have more expenses due to more household consumption. When the budget cap is considered, ‘Social contact’ and ‘Holiday’ exceed that cap, meaning that it is financially not possible constantly pursue these scenarios.

Results change if wages are decreased. A reduction in wages causes a reduction in emissions. For all scenarios, the reduction in wages which needs to happen to break even is below 10%. This means that, during the four-day workweek scenario, if the average reduction in wages is 10% or higher, fewer carbon emissions will be present. If intermediary consumption is taken into account for commuting there is a further decrease in both emissions and costs compared to the reference scenario.

5. Sensitivity analysis

In this section, the results of this model are compared with other literature to check its validity. In addition, the model will be checked for the difference between fixed and variable consumption to see the effect of these two kinds of consumption on the model.

5.1 Comparing results

There are more studies that looked at finding emissions per hour for weekly activities. Although their approach was different, it is interesting to evaluate their results and compare them with the results of this study. Research done by Druckman et al. (2019) and Nässén et al. (2009) were chosen for comparison. Both studies include results for activities this study also investigated. The overlapping activities are: ‘Commuting’, ‘Social contact’, ‘Relaxing’, ‘Media’, ‘Sports participation’, ‘Sleep’, ‘House work’, ‘Care for others’, ‘Personal care’, ‘Going out’, and ‘Hobby’s’. Activities that were not investigated by all three studies were excluded from the comparison. Using the total household emissions per study, the share of emissions per activity is calculated. Figure 7 shows the results for these shares of emissions.

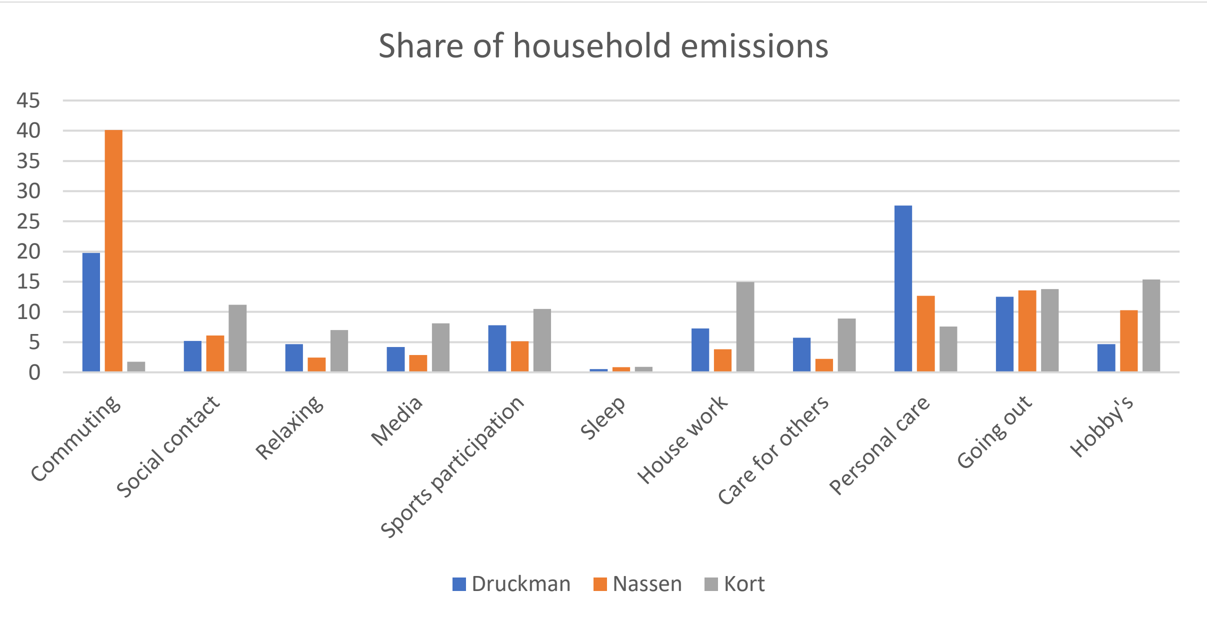

Figure 7: Share of household emissions per activity. Findings by Druckman et al., Nässén et al., and Kort respectively

At first glance the results of all studies look similar, however, after closer evaluation, significant differences appear. ‘Commuting’, for example, is the largest emitting activity cited by Nässén, but not by Druckman. This could be because Druckman included biking and walking in the commuting activity, driving the average emission down. Both took all emissions into account, not just household consumption. Therefore, the commuting results from this study are very low. As a result of this, the other activity shares are slightly higher than the Druckman and Nässén results. The only activity deviating from this is 'Personal care' which is significantly higher in Druckman's research, compared to the others. This can be due to the fact that in Druckman's study clothing is integrated into personal care, which is distributed over many other activities in Nässén's and this study. Overall, the results of all three studies are comparable since any significant differences can be explained. With this comparison, the results of this research seem rigid.

5.2 Constant consumption removed

As shown in chapter 3.3 'The matrix', some product categories are attributed to all activities because they are constantly consumed or not really clearly connected to time. This holds for 'Housing', 'Construction materials', 'Clothing', 'Protection related services', and 'Broad category'. To see what the impact of these categories are on the model, a sensitivity test is constructed leaving out the consumption and emissions of these categories. The differences in the results show the impact these constant consumption categories have.

In Figures 8 and 9, the results per activity are given for with and without constant consumption, for costs and emissions respectively. The new results for costs are changed drastically, mostly for the activities which are done for longer periods of time. All new results are lower, but mostly in terms of money, not on emissions. This implies that the removed data from the constant consumption is mostly linked to money, and not emissions. This causes most emissions to remain in the model. This makes sense since 'Housing', for example, is a significant share of our spending, but is not connected to many emissions, while mostly attributed over the activities on which also much time is spent.

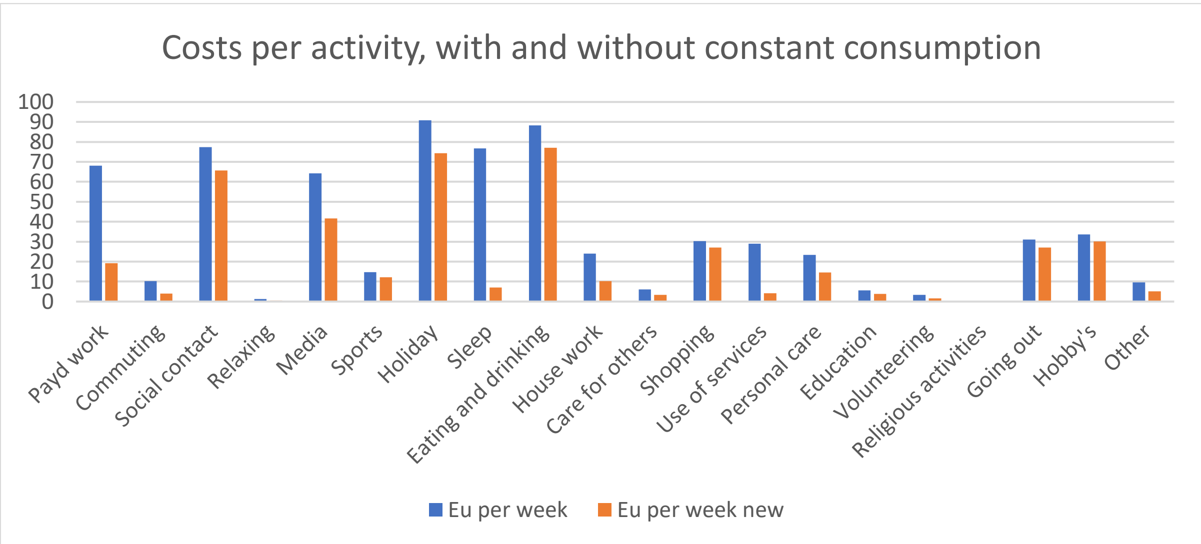

Figure 8: Costs per activity, with and without constant consumption

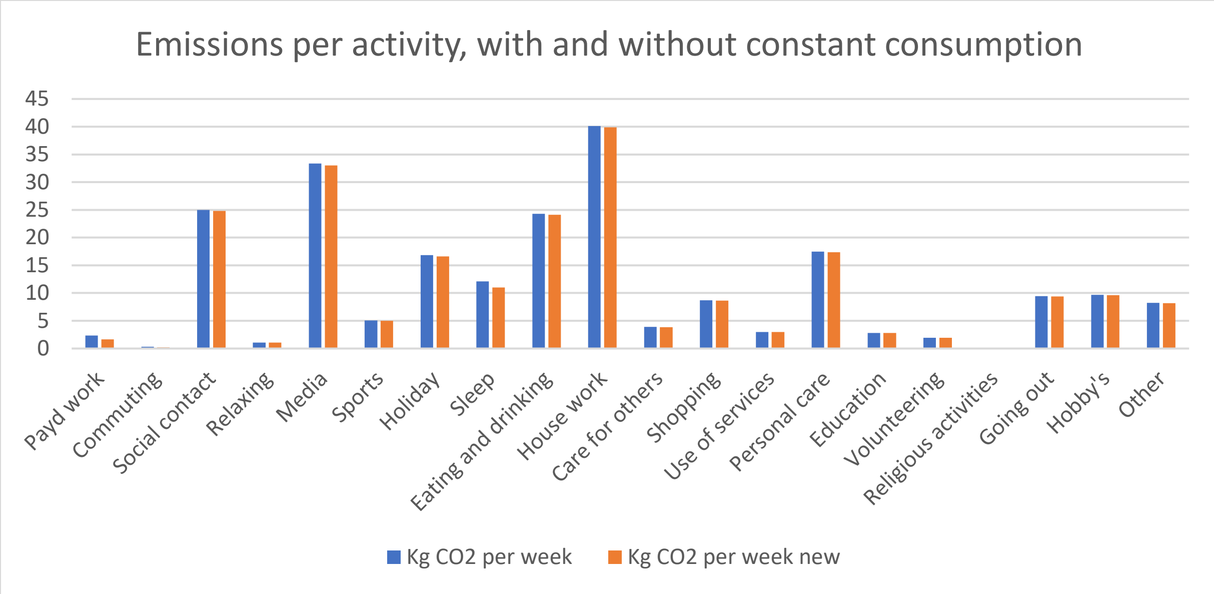

Figure 9: Emissions per activity, with and without constant consumption

In Table 7 below, the new results are given in percentage change compared to the reference scenario for all scenarios. The percentage changes for the emissions are relatively small, however, the changes in costs are quite substantial. This means that the constant consumption categories, which can be seen as fixed costs, have some impact on the modeling of wages and costs in the model. Without them, the changes in leisure time activity show large differences in the variable costs when another scenario would be pursued.

Table 7: Percentage scenario results compared to the reference scenario with and without constant consumption for emissions and costs respectively

	All consumption		**Constant consumption removed**	
	Percentage change in emissions	**Percentage change in euros**	**Percentage change in emissions**	**Percentage change in euros**
Social contact	10.23	8.11	10.37	15.30
Relaxing	6.38	0.12	6.47	14.76
Media	6.95	2.17	7.05	9.27
Sports	9.35	6.69	9.48	13.68
Holiday	5.47	7.59	5.55	12.39
Work one day from home	0.71	-0.07	0.72	2.05

6. Discussion

In this section, the real-world relevance of this model is discussed. Both the implications for society as well as the possible implications for policymakers will be addressed. In addition, the contribution to the academic literature is discussed, based on the academic quality of this research.

6.1 Societal and managerial relevance

The scenarios are extreme in their nature to be able to isolate them and make comparisons between activities. The scenarios are not realistic scenarios per se but are meant to inform about the impact of that activity on sustainability and well-being in a four-day workweek situation. An additional day off will probably not result in an individual doing a different, single activity for those eight hours, but rather a mix of different activities. For example, it is not realistic to expect that people will go from 1.5 hours of exercising a week to over 9 hours. The scenarios are intended to give guidance when considering how to spend the newly available hours after a four-day workweek has been implemented. By defining which activities are good for well-being and reducing emissions, policies, and applications can be designed using this information. Further research could be about: '*What will people do with their when they have an additional day off?*'

If there is a well-defined answer for that question that fits into the time-use data of this model, that real-world scenario can be tested to see what effects this scenario has on sustainability and well-being. Policymakers could wait on the research for this real-world scenario, or produce one themselves. With this scenario and the model created in this research, predictions could be made about the impacts of a four-day workweek. Policymakers can then decide whether the implementation of a four-day workweek is in line with the results they want to accomplish. The model can therefore be seen as a policy tool indicating what the future of the workweek could be. It is however based on a relatively stable year, being 2016, and does not take into account external factors like economic recessions, or war driving up the prices. There will be other long-term factors such as the transition of petrol cars towards electric cars. This will slowly shift the emissions from travel from gasoline towards electric energy, changing the carbon footprint.

In the end, it is up to the individuals to decide what they will do with their additional time. They have to make their own choices based on their budget, the pleasure they receive from certain activities, and the impact they want to make on the environment. This model is based upon macro-data where big estimations are made and a lot of averages are taken. The actual implementation of the four-day workweek and the outcomes in terms of scenarios are different for each individual. Some might feel that commuting is actually not that bad, or really dislike sports. Others might only use their car to go to family, while others use it solely to do groceries, which will change the attribution of the fuel consumption. These differences would drastically change the results presented in this research. However, the fundament of the model can still be used for an individual case to calculate the personal results for their consumption and well-being, if their input data is used.

Seasonal fluctuations are a phenomenon which is relevant to this model. Averages are used to say something about the whole year, but for consumption and well-being, there are differences throughout the year. During spring and fall, the household fuel use would most likely be lower than in the winter for heating, or in summer for cooling. In terms of the U-index, it is common to enjoy certain seasons more than others. Longer days and warmer temperatures could cause activities to be enjoyed more than dark and cold days, or the other way around.

One of the conclusions that can be drawn from the results is that activities that include a large travel component are bigger polluters. It is therefore advisable for policymakers to promote local activities so that individuals are steered towards favourable outcomes when making decisions. This could encompass promoting holidays in your own country, reducing commuting time to work, or even trying to scale the travel distances in supply chains down. While these might seem like difficult steps to take, traveling is a very high polluter and results in the largest unhappy timeshare. Considering this, an almost guaranteed improvement in emissions and well-being could be to focus on providing local facilities for activities or locally produced goods. To incentivize people and companies to participate in this transition, governments could increase taxes on carbon-intensive activities, such as transport. 'Working from home' is a relatively simple improvement in reducing emissions and improving well-being. Employers could promote employees to work one or more days from home, in addition to or instead of a four-day workweek, to reduce commuting.

Another conclusion is that a reduction in wages causes a decrease in emissions, but maybe also in the U-index. It is easy to solve the climate change problems by reducing wages so less consumption is being done, however, this has impacts on the U-index and overall well-being of people. Therefore, further research should be done on the impacts of wage reductions on well-being before this measure should be implemented.

If 'Working from home' is done for one of the five workdays, the results show that there are favourable outcomes. If people start to work four days, doing those (partly) from home still has expected benefits based on the findings of this research. However, a reduction in labour hours can keep the output at the same level in some cases (like the Iceland example), but will overall result in a need for more employees. This is highly dependent on the type of sector/institution/environment, since the productivity difference for a four-day workweek is different for every kind of job, even the employee.

The experiments being done are favourable in terms of efficiency, but it is uncertain how representative this is for the whole economy, based on which share of the economy falls under this type of job.

Currently, there is already a very high demand for employees, so a four-day workweek is contradictory to current societal needs. Since there are not enough employees to make up for the reduction in work hours, the national output will decrease, putting our competitive position on the global market in a worse position. Multinationals currently stationed in The Netherlands are likely to lose interest in operating from here when the four-day workweek becomes mandatory. This is not favourable for the economy and will result in additional problems besides the environment and well-being.

Despite the labour market situation, wages are also a strong limiting factor in consumption. The budget cap has made an indication whether it would be financially possible to pay for the scenarios, but it is up to the consumer whether they want to spend part or all of their savings on pursuing a certain scenario. The monetary results from this research could indicate that more or less money is being spent on consumption, but the individual has to decide for himself whether this is financially possible or not. However, to make it possible to compare the scenarios on the same savings level, a correction on the changes in costs is implemented. In addition, it might seem logical to reduce wages by 20% when the number of hours worked also decreases by 20%. As stated in the literature review, for some jobs the productivity actually increased instead of decreased when moving towards a four-day workweek. Since this result is different per type of profession, it is up to the employer to estimate how the new productivity of working 20% less is valued and therefore changed in the wages, which will be within the calculated bandwidth of this model. A decrease in wages would mean that employees have to rethink their consumption and consider what is important to them. This study could provide guidance with this decision in terms that the results give insight into the costs, emissions, and well-being per activity. This also holds for policymakers or employers to have a well-founded opinion about whether to move towards a four-day workweek or not. If companies open the discussion with their employees with this research in mind, a more preferred equilibrium could be the outcome, benefiting the well-being of employees and possibly also the environment we live in.

6.2 Academic quality and contribution to the literature

In this model, it is assumed that when additional hours are spent on an activity, the consumption will increase with the same share. For some activities, an increase in time doesn't actually mean an increase in consumption, or at least not with the same factor. Going to the gym more for sports usually does not impact monthly subscription costs, so in monetary terms, more time at the gym will not increase the consumption costs. The consumer however does make use of the facility more, resulting in larger emissions. Similar trends apply to eating and drinking; spending twice the amount of time at the dinner table will not result in twice the amount of food consumption. These examples might seem somewhat extreme, but they also hold for tiny changes in time-use. These changes are also very likely to have an effect on the U-index since the way the activity is experienced changes. Further research could evaluate what the elasticities are for each activity when changing the amount of time of consumption. '*What are the elasticities on consumption for each activity?*' When having this information, further improvements can be made to the model. This can be used to calculate more precise changes to consumption when time-use is changed.

The 'Non-air mobility' consumption is expected to be a relatively large portion of 'Commuting', but there is other business-related consumption that can be linked to 'Working' and 'Commuting' like business consumption. Additionally, there is data available on Final consumption expenditure by non-profit organisations serving households (NPISH), and Final consumption expenditure by the government to make up for all national consumption. Further research can be done including these categories as well, accounting not only for households, but the country as a whole.

The consumption patterns used in this model are the same for all full-time workers in The Netherlands. This is based on averages, but is not in line with the real world. Even though it is very complex to account for all different consumption patterns in a macro model, several diversifications can be made. An example would be to specify for each income segment what their average consumption pattern is. This allows for further detail in the model and creates possibilities to analyse the effects of changes in wages, also per income segment. This would allow the researcher to see what the different results per income segment are. This is important because the average consumption pattern for lower-income classes is expected to be completely different than for higher-income segments. 'Holiday', for example, is done less by plane for lower-income segments than for higher-income segments. Now the aviation emissions are distributed evenly, but the actual consumption is not done equally. Further research could be on: *'What are the consumption patterns for each income segment?'*

The time-use data is also incomplete. As mentioned, and implemented, holidays are not part of the time-use surveys. This holds for more activities, such as health. Sick days are something we all have now and then, which causes a shift in our time-use that week. The impact of illness is difficult to measure and implement, partially because most costs and carbon emissions for medical care are made for elderly people, who are out of the scope of this study. Expanding the time-use data set to different age groups within the population, creating a more realistic version of life, could prove beneficial to, and interesting for, future studies.

Holiday as an activity is imputed to the time-use data. This was done because it was not available in the time-use surveys, but consumption, such as flying, is being done for holidays. Additionally, it is found to be a likely implementation of the additional day off in the four-day workweek situation. The 'Holiday' scenario, however, has several more assumptions compared to the other scenarios. The time spent on it is assumed from other data, the U-index is assumed on the basis of other activities, and there were some implementation difficulties since it overlaps with other activities like 'Eating and drinking' and 'Sleeping'. The links from consumption to the activity also had debatable assumptions, such as implementing the consumption of these overlapping activities in the scenario as well. This was not done, because there will be double counting on consumption such as eating, but resulted in slight double counting for the weekends. Despite these shortcomings, this approach is assumed to be an added value to the model. Further research can be done on the impact of holidays specifically, to generate a scenario that can be implemented more easily into this model in a later version.

The categorisation of both time-use and consumption data is done for simplification of the model. If more time is available, it is possible to not cluster the time-use and consumption data, and find all links between those. Not only is this an immense amount of work, but there is also a higher chance for misinterpretation, due to niche products and activities not clearly known by the researcher. On the other hand, it could also cause more detail in the model which makes the results more significant. For example, in the categorisation for this model, there are multiple types of media that are all put into the 'Media' activity. There could, however, be large differences in time spent on 'Gaming' and 'Checking my phone', and also differences in the amount of electricity used for these activities. Further research could look into what the ideal level of detail is for the model. *'Which parts of the categorisations could be separated, or further aggregated, for improved detail in the model?'*

Changes in time-use will also change the U-index. Exercising has a U-index of 0.088, but we assume this is based on the time people are exercising right now, which is about 1.5 hours per week. When this is increased to, let us say, five hours a week, it starts to become less pleasurable which increases unhappiness, thus increasing the U-index. The phenomenon is the same for the relationship with work, but then in reverse. When working five days a week, the constant participation on the job can feel overwhelming, causing people to feel relieved when the workweek is changed to a four-day workweek. In contrast, people who have a one-day workweek might feel unchallenged and bored, therefore, an additional day of work would probably increase the amount of satisfaction from it, improving well-being. Not to forget about the increase in wages here, which could give many other opportunities at these lower work hours a week. Here further research could also look into the elasticities of the U-index and figure out the optimal duration of activities for the highest well-being. *'What are the elasticities on the U-index for each activity?'* This can also be used for further improvements to the model. It can be used to calculate the non-linear changes to the U-index when time-use is changed. Perhaps there will even be findings of activities that have a lower U-index when the time on that activity is increased, because the individual can become better at the activity, making it more enjoyable.

The U-index was not present for all activities of the week, making calculations on the percentage change in unpleasant times difficult. The average of the known U-indexes was taken and used for the whole week for these calculations, but it might be that the unknown parts of the week are significantly higher or lower in terms of unpleasantness, making the current percentage results incorrect. The U-index was, for example, not available for ‘Holiday’, however, it was estimated to be a weighted average of current U-index values for ‘normal’ activities. It could be argued that being on holiday makes these same activities more joyful because they are executed during a holiday, reducing the U-index for Holiday.

Well-being is illustrated through the U-index, accounting for pleasant and unpleasant emotions for an individual. However, well-being can be used in a broader term. To give a more in-depth meaning to well-being, the model could be deepened, because more well-being indicators will be considered when formulating the results. Examples of this are the physical health situation in terms of fitness or being sick often. The scenario of ‘Sports’ would probably score higher if this was also incorporated. Future research could add to the interpretation of well-being and deepen the results and debate on creating the best possible outcome for physical and mental well-being.

6.3 Discussion summary

The scenarios were chosen to compare them, but the real-world implication for individuals and policymakers will more likely be a mix of activities that is distinct for each individual. Both can use the results from this research to guide them in making decisions, but the underlying model can be used to recalculate the outcomes for any specific consumption or time-use input. Despite the differences, one overlapping theme is the reduction of travel. Working from home could be a suitable solution to reduce consumption and increase well-being. However, working four days will potentially further increase the labour shortage and could cause unwanted situations for the national competitive position. This would be caused by a decrease in wages, which on the other hand, will result in a decrease in emissions.

The model, as presented in the research, is novel and not perfect yet. Further deepening of the time-use data, consumption data, their linkages, and the well-being definition could further improve the model.

7. Conclusion

When investigating the impacts of a four-day workweek in terms of sustainability and well-being, data from time-use, consumption, and well-being are aggregated by a matrix for a complete model. The fundament of this model is a novel approach to linking these three concepts, which can be used by policymakers for finding answers about the effects of changes in consumption or time-use.

For this research, the four-day workweek is chosen to see the performance of the model in practice. 'Social contact', 'Relaxing', 'Media', 'Sports', and 'Holiday' are selected as scenarios to see how they behave when an individual chooses to pursue this activity. An additional control scenario of 'Working one day from home' is chosen to see the effects of commuting alone.

Expensive products in absolute terms are 'Housing', and 'Non-air mobility', while 'Non-air mobility', 'Household fuels', and 'Electricity' are the highest emitters. Since 'Non-air mobility' is both expensive and has high emissions, activities related to this should be avoided for improved consumption-related results.

Activities that are both expensive and have high emissions in absolute terms are 'Social contact', 'Media', and 'Holiday'. This is because they are highly associated with expensive and high-emitting products. Therefore, these three high-consuming scenarios show negative results in terms of costs and emissions compared to the five-day workweek scenario. When the budget cap, based on savings, is considered, 'Social contact' and 'Holiday' exceed that cap, meaning that it is financially not possible constantly pursue these scenarios. 'Relaxing', 'Media', and 'Work from home' score better or even lower in terms of costs for the monetary indicator.

In terms of emissions 'Relaxing' and 'Media' still score worse than the reference scenario of 'Working' and 'Commuting'. For the five regular scenarios, there is an emission increase between 3% and 11%. Only 'Work from home' has a favourable result in terms of emissions and is, therefore, the only scenario for which both consumption indicators are positive. In terms of well-being, all scenarios have positive results since the reference scenario has the highest U-index score, meaning most unpleasant moments. This entails that all scenarios are beneficial for well-being.

When cost-increasing corrections are done, the additional emissions are reduced. Measures such as taking into account intermediary consumption will result in even lower costs and emissions. In addition, a reduction in wages for fewer work hours is expected and will most likely be between 0 % and 20%, therefore this bandwidth is used. Depending on the scenario, reductions up to 10% are required to have a break-even point for emissions. A higher wage reduction will result in a reduction in emissions compared to the current situation.

The real-world implication for these scenarios is more likely to be a mix of activities. Policymakers can use the results from this research to guide them in making decisions about the implementation of the four-day workweek. Since travel is having a profound impact on both consumption indicators, policymakers should try to minimize this activity and its connected consumption. Working from home could be a suitable solution to reduce consumption and increase well-being, this being the most favourable scenario. However, working four days will potentially further increase the labour shortage and could cause unwanted situations for the national economic competitive position.

The model, as presented in the research, is in its infancy. Further deepening of the time-use data, consumption data, their linkages, and the well-being definition could further improve the model to increase the accuracy of predicting the impacts of a four-day workweek for sustainability and well-being.

References

Albertsen, K. (2008). *Working Time Arrangements and Social Consequences: What Do We Know?*. Nordic Council of Ministers.

Andersson, D., Nässén, J., Larsson, J., & Holmberg, J. (2014). Greenhouse gas emissions and subjective well-being: An analysis of Swedish households. *Ecological economics*, *102*, 75-82.

Apergis, N. (2018). The impact of greenhouse gas emissions on personal well-being: Evidence from a panel of 58 countries and aggregate and regional country samples. *Journal of Happiness Studies*, *19*(1), 69-80.

Brickman, P. (1971). Hedonic relativism and planning the good society. *Adaptation level theory*, 287-301.

CBS. (2020). More than half of Dutch people work full-time. Retrieved at 5-7-2022, from: https://www.cbs.nl/en-gb/news/2020/08/more-than-half-of-dutch-people-work-full-time

CBS. (2021). Vakanties van Nederlanders; kerncijfers. Retrieved at 5-7-2022, from: https://opendata.cbs.nl/#/CBS/nl/dataset/84363NED/table

CBS. (2022a). Banen van werknemers naar woon- en werkregio. Retrieved at 5-7-2022, from: https://opendata.cbs.nl/#/CBS/nl/dataset/83628NED/table

CBS. (2022b). Werkgelegenheid; geslacht, dienstverband, kenmerken werknemer, SBI2008. Retrieved at 5-7-2022, from: https://opendata.cbs.nl/statline/#/CBS/nl/dataset/81434ned/table?dl=5093B

CBS. (n.d.a.). Hoeveel reisden inwoners van Nederland van en naar het werk? Retrieved at 5-7-2022, from: https://www.cbs.nl/nl-nl/visualisaties/verkeer-en-vervoer/personen/van-en-naar-werk

CBS. (n.d.b.). Deeltijd. Retrieved at 5-7-2022, from: https://www.cbs.nl/nl-nl/visualisaties/dashboard-beroepsbevolking/deeltijd

CBS. (n.d.c.). Hoeveel reisden inwoners van Nederland van en naar het werk? Retrieved at 5-7-2022, from: https://www.cbs.nl/nl-nl/visualisaties/verkeer-en-vervoer/personen/van-en-naar-werk

CijferNieuws.nl. (n.d.). Benzineprijs Shell. Retrieved at 5-7-2022, from: http://www.cijfernieuws.nl/benzineprijs-januari-februari-2016/

Davis, S. J., & Caldeira, K. (2010). Consumption-based accounting of CO2 emissions. *Proceedings of the National Academy of Sciences*, *107*(12), 5687-5692.

De Groot, T. (2021). Making Part-Time Work a Fully-Fledged Alternative: How the Dutch social partners responded to a dual labour market, 1966–1993. *Labor History*, *62*(5-6), 762-780.

De Koning, J. (2016). The reduction of life hours of work since 1850: estimates for Dutch males.

Directenergy.com. (n.d.). What uses the most electricity in my home? Retrieved at 23-7-2022, from: https://www.directenergy.com/learning-center/what-uses-most-electricity-in-my-home

Druckman, A., & Gatersleben, B. (2019). A time-use approach: High subjective wellbeing, low carbon leisure. *Journal of Public Mental Health*.

Easterlin, R. A. (1974). Does economic growth improve the human lot? Some empirical evidence. In *Nations and households in economic growth* (pp. 89-125). Academic Press.

Eurostat. (n.d.). CPA 2008 – Statistical classification of products by activity. Retrieved at 5-7-2022, from: https://ec.europa.eu/eurostat/web/cpa/cpa-2008

Gunderson, R. (2019). Work time reduction and economic democracy as climate change mitigation strategies: or why the climate needs a renewed labor movement. *Journal of Environmental Studies and Sciences*, *9*(1), 35-44.

Hartog, J., & Salverda, W. (2018). The labor market in the Netherlands, 2001-2016. *IZA World of Labor*, (418).

Holmatov, B., & Hoekstra, A. Y. (2020). The environmental footprint of transport by car using renewable energy. *Earth's Future*, *8*(2), e2019EF001428.

Hypotheek.nl. (2021). Hoeveel sparen per maand? Retrieved at 5-7-2022, from: https://www.hypotheek.nl/nieuws/geld/hoeveel-sparen-per-maand/#:~:text=Uit%20cijfers%20blijkt%20dat%20dit,van%20wat%20ze%20netto%20verdienen

IPCC. (2022). Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press. In Press.

Iyer, R., & Muncy, J. A. (2016). Attitude toward consumption and subjective well-being. *Journal of Consumer Affairs*, *50*(1), 48-67.

Jackson, T., & Marks, N. (1999). Consumption, sustainable welfare and human needs—with reference to UK expenditure patterns between 1954 and 1994. *Ecological economics*, *28*(3), 421-441.

Jalas, M., & Juntunen, J. K. (2015). Energy intensive lifestyles: Time use, the activity patterns of consumers, and related energy demands in Finland. *Ecological Economics*, *113*, 51-59.

Kahneman, D., Krueger, A. B., Schkade, D. A., Schwarz, N., & Stone, A. A. (2004). A survey method for characterizing daily life experience: The day reconstruction method. *Science*, *306*(5702), 1776-1780.

Keynes, J. M. (1933). Economic Possibilities for our Grandchildren (1930). In *Essays in persuasion* (pp. 321-332). Palgrave Macmillan, London.

King, L. C., & van den Bergh, J. C. (2017). Worktime reduction as a solution to climate change: five scenarios compared for the UK. *Ecological Economics*, *132*, 124-134.

LaJeunesse, R. (1999). Toward an efficiency week. *Challenge*, *42*(1), 92-109.

Laker, B. (2022). What does the four-day workweek mean for the future of work?. *MIT Sloan Management Review*.

Maslow, A. H. (1943). A theory of human motivation. *Psychological review*, *50*(4), 370.

Max-Neef, M. A. (1991). Human scale development: conception, application and further reflections.

Miller, R. E., & Blair, P. D. (2009). *Input-output analysis: foundations and extensions*. Cambridge university press.

Nässén, J., & Holmberg, J. (2009). Quantifying the rebound effects of energy efficiency improvements and energy conserving behaviour in Sweden. *Energy Efficiency*, *2*(3), 221-231.

Noll, H. H. (2004). Social indicators and quality of life research: Background, achievements and current trends. In *Advances in sociological knowledge* (pp. 151-181). VS Verlag für Sozialwissenschaften, Wiesbaden.

OECD. (2022a). Part-time employment rate. Retrieved at 5-7-2022 from: https://data.oecd.org/emp/part-time-employment-rate.htm

OECD. (2022b). Hours worked (indicator). Retrieved at 5-7-2022 from: https://data.oecd.org/emp/hours-worked.htm

Piketty, T. (2018). Capital in the twenty-first century. In *Capital in the twenty-first century*. Harvard University Press.

Reisch, L. A. (2001). Time and wealth. *Time & Society*, *10*(2-3), 367-385.

Rijksoverheid. (2019). CO2-emissie per voertuigkilometer van nieuwe personenauto's, 1998-2017. Retrieved at 5-7-2022, from: https://www.clo.nl/indicatoren/nl0134-koolstofdioxide-emissie-per-voertuigkilometer-voor-nieuwe-personenautos#:~:text=In%20Nederland%20is%20de%20CO,)%20volgens%20EEA%20(2018)

Shao, Q. L., & Rodríguez-Labajos, B. (2016). Does decreasing working time reduce environmental pressures? New evidence based on dynamic panel approach. *Journal of cleaner production*, *125*, 227-235.

Stelzner, M. (2022). Growth, consumption, and happiness: modeling the easterlin paradox. *Journal of Happiness Studies*, *23*(2), 377-389.

Vita, G., Hertwich, E. G., Stadler, K., & Wood, R. (2019). Connecting global emissions to fundamental human needs and their satisfaction. *Environmental Research Letters*, *14*(1), 014002.

Wachtel, P. L. (1989). *The poverty of affluence: A psychological portrait of the American way of life*. New Society Publishers.

Wiedenhofer, D., Smetschka, B., Akenji, L., Jalas, M., & Haberl, H. (2018). Household time use, carbon footprints, and urban form: a review of the potential contributions of everyday living to the 1.5 C climate target. *Current opinion in environmental sustainability*, *30*, 7-17.

Wiedmann, T., & Minx, J. (2008). A definition of 'carbon footprint'. *Ecological economics research trends*, *1*, 1-11.

Wilson, J., Tyedmers, P., & Spinney, J. E. (2013). An exploration of the relationship between socioeconomic and well-being variables and household greenhouse gas emissions. *Journal of Industrial Ecology*, *17*(6), 880-891.

Zenodo. (2021). Exiobase 3. Retrieved at 5-7-2022, from: https://zenodo.org/record/5589597#.YsQ5YHZBy3A

Zhou, T. (2021). New physical science behind climate change: What does IPCC AR6 tell us?. *The Innovation*, *2*(4).

Appendix A: Activities per time-use category.

Time-use categories	Activities
Paid work	1. Exercise of a profession 2. Looking for a job 3. Training during working hours
Commuting	4. Commuting transport
Social contact	30. Face-to-face contact 31. Mediated contact (call, text, chat, social media) 33. Party, going out 42. Leisure and social life on the go
Relaxing	40. Relax, laze 41. Free time unspecified
Media	43. Radio and music 44. Listening via internet, computer 45. Television and movies 46. Watching via internet, computer 49. News and newspapers over the internet 52. Other mass media 53. Gaming 54. Internet 55. Computers
Sports participation	34. Excursions, hiking, cycling (incl. visiting sports competitions) 35. Sports participation
Holiday	Imputed
Sleep	21. Sleeping
Eating and drinking	20. Eating and drinking at home
House work	5. Cooking and baking 6. Set the table, wash dishes, clean and wash 7. Administration 8. Chores, pets, garden 9. On the go for housework 10. Other household
Care for others (also child)	11. Childcare 12. Child guidance 13. Caring for/helping an adult roommate
Shopping	14. Food purchase 15. Other shopping
Use of services	16. Personal services 17. Commercial and administrative services 18. Waiting or on the go for groceries
Personal care	19. Personal care
Education	22. General & vocational education 23. Learning leisure 24. On the go for education
Volunteering	25. Volunteering for/in an organization 26. Informal help and informal care, other households 28. Participatory activities 29. Unspecified and travel time volunteering and meetings
Religious activities	27. Religious activities

Going out	32. Food and drink, catering facility 36. Culture participation
Hobby's	37. Creative activities 38. Individual and board games 39. Other hobbies 47. Books 48. Newspapers 50. Magazines 51. Read other
Other	56. Other

Appendix B: Products per consumption category.

Category	Products
Air mobility	Aviation Gasoline Gasoline Type Jet Fuel Kerosene Type Jet Fuel Air transport services (62)
Broad category	Other business services (74) Other services (93) Public administration and defence services; compulsory social security services (75)
Clothing	Wearing apparel; furs (18) Leather and leather products (19)
Construction materials	Anthracite Stone Sand and clay Chemical and fertilizer minerals, salt and other mining and quarrying products n.e.c. Ceramic goods Bricks, tiles and construction products, in baked clay Cement, lime and plaster Ash for treatment, Re-processing of ash into clinker Other non-metallic mineral products Basic iron and steel and of ferro-alloys and first products thereof Secondary steel for treatment, Re-processing of secondary steel into new steel Precious metals Secondary preciuos metals for treatment, Re-processing of secondary preciuos metals into new preciuos metals Aluminium and aluminium products Secondary aluminium for treatment, Re-processing of secondary aluminium into new aluminium Lead, zinc and tin and products thereof Secondary lead for treatment, Re-processing of secondary lead into new lead Copper products Secondary copper for treatment, Re-processing of secondary copper into new copper Other non-ferrous metal products Secondary other non-ferrous metals for treatment, Re-processing of secondary other non-ferrous metals into new other non-ferrous metals Foundry work services Fabricated metal products, except machinery and equipment (28)
Electricity	Electricity by coal Electricity by gas Electricity by nuclear Electricity by hydro Electricity by wind Electricity by petroleum and other oil derivatives Electricity by biomass and waste Electricity by solar photovoltaic Electricity by solar thermal Electricity by tide, wave, ocean

	Electricity by Geothermal Electricity nec Transmission services of electricity Distribution and trade services of electricity
Food	Paddy rice Wheat Cereal grains nec Vegetables, fruit, nuts Oil seeds Sugar cane, sugar beet Crops nec Cattle Pigs Poultry Meat animals nec Animal products nec Raw milk Fish and other fishing products; services incidental of fishing (05) Products of meat cattle Products of meat pigs Products of meat poultry Meat products nec products of Vegetable oils and fats Dairy products Processed rice Sugar Food products nec Beverages Fish products
Health	Medical, precision and optical instruments, watches and clocks (33) Health and social work services (85)
Furniture	Chemicals nec Furniture; other manufactured goods n.e.c. (36)
Household fuels	Coking Coal Other Bituminous Coal Sub-Bituminous Coal Patent Fuel Lignite/Brown Coal BKB/Peat Briquettes Peat Crude petroleum and services related to crude oil extraction, excluding surveying Natural gas and services related to natural gas extraction, excluding surveying Natural Gas Liquids Other Hydrocarbons Uranium and thorium ores (12) Iron ores Copper ores and concentrates Nickel ores and concentrates Aluminium ores and concentrates Precious metal ores and concentrates

	Lead, zinc and tin ores and concentrates Other non-ferrous metal ores and concentrates Coke Oven Coke Gas Coke Coal Tar Kerosene Refinery Gas Refinery Feedstocks Ethane Naphtha White Spirit & SBP Lubricants Bitumen Paraffin Waxes Petroleum Coke Non-specified Petroleum Products Nuclear fuel Charcoal Coke oven gas Blast Furnace Gas Oxygen Steel Furnace Gas Gas Works Gas Biogas Distribution services of gaseous fuels through mains Steam and hot water supply services Collected and purified water, distribution services of water (41) Construction work (45) Secondary construction material for treatment, Re-processing of secondary construction material into aggregates Transportation services via pipelines
Household materials	Plant-based fibers Wool, silk-worm cocoons Manure (conventional treatment) Manure (biogas treatment) Products of forestry, logging and related services (02) Textiles (17) Wood and products of wood and cork (except furniture); articles of straw and plaiting materials (20) N-fertiliser P- and other fertiliser
Housing	Real estate services (70)
Non-air mobility	Liquefied Petroleum Gases (LPG) Motor Gasoline Gas/Diesel Oil Heavy Fuel Oil Additives/Blending Components Biogasoline Biodiesels Other Liquid Biofuels Motor vehicles, trailers and semi-trailers (34) Other transport equipment (35)

	Railway transportation services Other land transportation services Sea and coastal water transportation services Inland water transportation services Supporting and auxiliary transport services; travel agency services (63) Sale, maintenance, repair of motor vehicles, motor vehicles parts, motorcycles, motor cycles parts and accessoiries Retail trade services of motor fuel Wholesale trade and commission trade services, except of motor vehicles and motorcycles (51) Retail trade services, except of motor vehicles and motorcycles; repair services of personal and household goods (52)
Non-shelter household products	Plastics, basic Rubber and plastic products (25) Glass and glass products Secondary glass for treatment, Re-processing of secondary glass into new glass Machinery and equipment n.e.c. (29) Electrical machinery and apparatus n.e.c. (31) Secondary raw materials Bottles for treatment, Recycling of bottles by direct reuse Renting services of machinery and equipment without operator and of personal and household goods (71)
Paid domestic work	Private households with employed persons (95)
Protection related services	Financial intermediation services, except insurance and pension funding services (65) Insurance and pension funding services, except compulsory social security services (66) Services auxiliary to financial intermediation (67)
Research and Development	Research and development services (73)
Communication	Paper and paper products Printed matter and recorded media (22) Office machinery and computers (30) Radio, television and communication equipment and apparatus (32) Post and telecommunication services (64) Computer and related services (72) Membership organisation services n.e.c. (91) Recreational, cultural and sporting services (92) Extra-territorial organizations and bodies Education services (80) Hotel and restaurant services (55)
Tobacco	Tobacco products (16)
Waste treatment	Wood material for treatment, Re-processing of secondary wood material into new wood material Pulp Secondary paper for treatment, Re-processing of secondary paper into new pulp Secondary plastic for treatment, Re-processing of secondary plastic into new plastic Food waste for treatment: incineration

	Paper waste for treatment: incineration Plastic waste for treatment: incineration Intert/metal waste for treatment: incineration Textiles waste for treatment: incineration Wood waste for treatment: incineration Oil/hazardous waste for treatment: incineration Food waste for treatment: biogasification and land application Paper waste for treatment: biogasification and land application Sewage sludge for treatment: biogasification and land application Food waste for treatment: composting and land application Paper and wood waste for treatment: composting and land application Food waste for treatment: waste water treatment Other waste for treatment: waste water treatment Food waste for treatment: landfill Paper for treatment: landfill Plastic waste for treatment: landfill Inert/metal/hazardous waste for treatment: landfill Textiles waste for treatment: landfill Wood waste for treatment: landfill

Appendix C: Model input per product in terms of million euros and kg CO_2 emissions.

Product	***M euro***	***Kg CO_2 emissions***
Paddy rice	0.222928287	357456218.9
Wheat	184.7115911	294536660.3
Cereal grains nec	365.2317731	9530521.599
Vegetables, fruit, nuts	2692.938765	4907982.178
Oil seeds	0	17808100.13
Sugar cane, sugar beet	0	23408689.64
Plant-based fibers	23.96602044	57883883.12
Crops nec	1234.256131	3505999.607
Cattle	0	5678867.724
Pigs	0	113053824.1
Poultry	815.8316141	4398803.729
Meat animals nec	0	9296020.585
Animal products nec	0	7684022.833
Raw milk	0	3800295.053
Wool, silk-worm cocoons	0	1510126187
Manure (conventional treatment)	0	0
Manure (biogas treatment)	0	0
Products of forestry, logging and related services (02)	1.739380309	5284369.43
Fish and other fishing products; services incidental of fishing (05)	403.6648712	11710451.48
Anthracite	0.472117818	16251259.2
Coking Coal	0	43297617.02
Other Bituminous Coal	0	20513119.89
Sub-Bituminous Coal	0	16882962.35
Patent Fuel	0	23254893.45
Lignite/Brown Coal	0	511568961.6
BKB/Peat Briquettes	1.68496E-07	24434252.37
Peat	0	26680146.57
Crude petroleum and services related to crude oil extraction, excluding surveying	0	14149248.51
Natural gas and services related to natural gas extraction, excluding surveying	0	6417884892
Natural Gas Liquids	0	79284981.79
Other Hydrocarbons	0	97316728.02
Uranium and thorium ores (12)	0	1951466421
Iron ores	0	8866746888
Copper ores and concentrates	0	245483417.4
Nickel ores and concentrates	0	215423103.6
Aluminium ores and concentrates	0	35737205.53
Precious metal ores and concentrates	0	2419235972

Lead, zinc and tin ores and concentrates	0	387490413.9
Other non-ferrous metal ores and concentrates	0	233764229.5
Stone	0	15218530.78
Sand and clay	0	469332943.6
Chemical and fertilizer minerals, salt and other mining and quarrying products n.e.c.	12.81717408	22975364.49
Products of meat cattle	1379.867882	9175631.619
Products of meat pigs	0	6625882.5
Products of meat poultry	1530.400722	3835343.678
Meat products nec	1546.052454	2545919.025
products of Vegetable oils and fats	146.3923619	5355641.103
Dairy products	1056.711388	2379762.162
Processed rice	51.54373319	38250359.85
Sugar	120.8668831	6106189.748
Food products nec	4279.398977	1668193.979
Beverages	758.1220502	2569199.39
Fish products	0	3599189.138
Tobacco products (16)	2131.883834	8223950.013
Textiles (17)	1626.759556	4997966.43
Wearing apparel; furs (18)	2824.172252	11157820.55
Leather and leather products (19)	724.9907236	1856609.793
Wood and products of wood and cork (except furniture); articles of straw and plaiting materials (20)	154.8866618	7583265.942
Wood material for treatment, Re-processing of secondary wood material into new wood material	0	0
Pulp	0	17750753.69
Secondary paper for treatment, Re-processing of secondary paper into new pulp	0	0
Paper and paper products	204.082518	4324729.684
Printed matter and recorded media (22)	3704.024312	3146925.472
Coke Oven Coke	0	78581405.95
Gas Coke	0	1544093.641
Coal Tar	0	44538028.11
Motor Gasoline	5409.709809	5040802249
Aviation Gasoline	0.532339517	8614392.691
Gasoline Type Jet Fuel	0	2006121388
Kerosene Type Jet Fuel	39.92811788	21650728.91
Kerosene	72.99637572	71752753.18
Gas/Diesel Oil	2900.740339	2427346778
Heavy Fuel Oil	0	11835287.99
Refinery Gas	0	17726185.02
Liquefied Petroleum Gases (LPG)	285.6681159	152865752.9
Refinery Feedstocks	0	10348250.79
Ethane	0	126842272.4

Naphtha	0	11956102.81
White Spirit & SBP	0	13105955.81
Lubricants	0	12205083.17
Bitumen	0	13137425.5
Paraffin Waxes	0	11263907.98
Petroleum Coke	0	23352521.58
Non-specified Petroleum Products	0	20422742.8
Nuclear fuel	0	239608732.8
Plastics, basic	0	9398076.366
Secondary plastic for treatment, Re-processing of secondary plastic into new plastic	0	0
N-fertiliser	7.964430449	108439937
P- and other fertiliser	11.43331473	46877975.3
Chemicals nec	0	8884034.996
Charcoal	3.881731863	25803120.74
Additives/Blending Components	0	10340287.09
Biogasoline	31.96031585	11028977.66
Biodiesels	74.47407357	14140386.15
Other Liquid Biofuels	0	6810640.841
Rubber and plastic products (25)	1800.47955	1215124.954
Glass and glass products	0	16875238.82
Secondary glass for treatment, Re-processing of secondary glass into new glass	0	0
Ceramic goods	0	23987437.47
Bricks, tiles and construction products, in baked clay	0.85674306	58685738.18
Cement, lime and plaster	6.119419705	27113310.56
Ash for treatment, Re-processing of ash into clinker	0	0
Other non-metallic mineral products	199.5416417	27911944.6
Basic iron and steel and of ferro-alloys and first products thereof	0	18036508.04
Secondary steel for treatment, Re-processing of secondary steel into new steel	0	0
Precious metals	0.003646926	13040944.39
Secondary preciuos metals for treatment, Re-processing of secondary preciuos metals into new preciuos metals	0	0
Aluminium and aluminium products	0.001390051	19398046.68
Secondary aluminium for treatment, Re-processing of secondary aluminium into new aluminium	0	0
Lead, zinc and tin and products thereof	0	16655164.67
Secondary lead for treatment, Re-processing of secondary lead into new lead	0	0
Copper products	0	7248218.346
Secondary copper for treatment, Re-processing of secondary copper into new copper	0	0

Other non-ferrous metal products	0.001571481	55955051.48
Secondary other non-ferrous metals for treatment, Re-processing of secondary other non-ferrous metals into new other non-ferrous metals	0	0
Foundry work services	9.09761E-05	23252635.24
Fabricated metal products, except machinery and equipment (28)	838.1123471	1966508.474
Machinery and equipment n.e.c. (29)	105.568344	1167997.272
Office machinery and computers (30)	26.70578353	2545267.035
Electrical machinery and apparatus n.e.c. (31)	900.7644524	3837459.368
Radio, television and communication equipment and apparatus (32)	4298.082518	4025910.751
Medical, precision and optical instruments, watches and clocks (33)	2044.699167	4163529.513
Motor vehicles, trailers and semi-trailers (34)	4504.777683	2031396.159
Other transport equipment (35)	1591.464818	5908150.992
Furniture; other manufactured goods n.e.c. (36)	2606.297104	5604399.754
Secondary raw materials	0	658909173
Bottles for treatment, Recycling of bottles by direct reuse	0	0
Electricity by coal	494.6374175	515433297.3
Electricity by gas	1055.960795	193679805.3
Electricity by nuclear	0	1561228.587
Electricity by hydro	1.317542672	5171543.186
Electricity by wind	0	276849486.4
Electricity by petroleum and other oil derivatives	0	194936836.2
Electricity by biomass and waste	0	151645382.4
Electricity by solar photovoltaic	0	2221780750
Electricity by solar thermal	0	1679534308
Electricity by tide, wave, ocean	0	7120642180
Electricity by Geothermal	0	1067323703
Electricity nec	0	1356951957
Transmission services of electricity	0	9794135.582
Distribution and trade services of electricity	708.0788824	2823151.661
Coke oven gas	0	81510309
Blast Furnace Gas	0	74517335.19
Oxygen Steel Furnace Gas	0	36732243.64
Gas Works Gas	0	24249289.94
Biogas	1.77065E-07	45729851.27
Distribution services of gaseous fuels through mains	1636.314548	69282020.05
Steam and hot water supply services	0.068736672	816665764
Collected and purified water, distribution services of water (41)	0	24701632.25
Construction work (45)	428.5406262	1630034.382
Secondary construction material for treatment, Re-processing of secondary construction material into aggregates	0	0

Sale, maintenance, repair of motor vehicles, motor vehicles parts, motorcycles, motor cycles parts and accessoiries	5194.819586	1245030.455
Retail trade services of motor fuel	33.73676896	14626593.04
Wholesale trade and commission trade services, except of motor vehicles and motorcycles (51)	1761.779366	1838518.896
Retail trade services, except of motor vehicles and motorcycles; repair services of personal and household goods (52)	1240.68306	1960422.167
Hotel and restaurant services (55)	4.95023E-07	1205933.546
Railway transportation services	1714.125843	13183058.94
Other land transportation services	10357.79648	1625164.557
Transportation services via pipelines	4.650595263	76833892.45
Sea and coastal water transportation services	237.3605602	65127804.42
Inland water transportation services	717.0974655	653612928.3
Air transport services (62)	2587.713944	31458649.7
Supporting and auxiliary transport services; travel agency services (63)	5533.942122	4295290.658
Post and telecommunication services (64)	12806.05831	1148178.63
Financial intermediation services, except insurance and pension funding services (65)	0	1214330.62
Insurance and pension funding services, except compulsory social security services (66)	8196.138994	3717109.883
Services auxiliary to financial intermediation (67)	604.2609369	1534163.681
Real estate services (70)	37334.23746	1374938.243
Renting services of machinery and equipment without operator and of personal and household goods (71)	341.9498028	5054910.56
Computer and related services (72)	12.84105503	1629373.688
Research and development services (73)	0	1646615.179
Other business services (74)	5466.32431	1606574.952
Public administration and defence services; compulsory social security services (75)	883.9213183	655692.7953
Education services (80)	2370.943242	618394.8092
Health and social work services (85)	17.12072139	725568.1845
Food waste for treatment: incineration	126.2540146	6456560.616
Paper waste for treatment: incineration	137.0293871	6262437.519
Plastic waste for treatment: incineration	89.92524673	132499236.9
Intert/metal waste for treatment: incineration	77.04359059	114745857.6
Textiles waste for treatment: incineration	26.10575252	173730479.7
Wood waste for treatment: incineration	36.10265789	9483771.709
Oil/hazardous waste for treatment: incineration	85.17979288	68338688.56
Food waste for treatment: biogasification and land application	17.77538767	10934993.44
Paper waste for treatment: biogasification and land application	2.125174002	6411048.605
Sewage sludge for treatment: biogasification and land application	71.7540978	28933451.54

Food waste for treatment: composting and land application	472.5894888	23700575.61
Paper and wood waste for treatment: composting and land application	0	4780210.504
Food waste for treatment: waste water treatment	95.38661915	4747379.39
Other waste for treatment: waste water treatment	58.9877862	3630784.925
Food waste for treatment: landfill	8.529162073	4559556.551
Paper for treatment: landfill	5.732153696	3419009.119
Plastic waste for treatment: landfill	3.091382508	3982624.552
Inert/metal/hazardous waste for treatment: landfill	107.0023399	2595928.929
Textiles waste for treatment: landfill	1.095399872	7417482.011
Wood waste for treatment: landfill	3.724798946	4697885.963
Membership organisation services n.e.c. (91)	46.45908357	994367.5616
Recreational, cultural and sporting services (92)	2400.605672	1767530.324
Other services (93)	4643.453975	972513.5157
Private households with employed persons (95)	2166.776634	1383729.122
Extra-territorial organizations and bodies	0	0

Appendix D: Linked consumption products to time-use categories. The number represents the share of consumption belonging to that activity. (Row should add up to 1, however, the presented numbers are rounded, so there might be some small deviations).

	Paid work	**Commuting**	**Social contact**	**Relaxing**	**Media**	**Sports participation**	**Holiday**	**Sleep**	**Eating and drinking**	**House work**	**Care for others**	**Shopping**	**Use of services**	**Personal care**	**Education**	**Volunteering**	**Religious activities**	**Going out**	**Hobby's**	**Other**
Air mobility							1.000													
Broad category	0.102	0.013	0.024	0.002	0.047	0.005	0.030	0.158	0.023	0.029	0.006	0.007	0.500	0.018	0.004	0.004	0.000	0.008	0.007	0.013
Clothing	0.285	0.036	0.068	0.005	0.134	0.015	0.085	0.032	0.067	0.082	0.017	0.019	0.012	0.052	0.011	0.011	0.000	0.023	0.020	0.026
Construction materials	0.203	0.026	0.048	0.003	0.094	0.011	0.060	0.316	0.047	0.058	0.012	0.013	0.008	0.037	0.007	0.008	0.000	0.016	0.014	0.018
Electricity	0.026	0.003	0.066	0.005	0.170	0.006	0.013	0.177	0.133	0.142	0.016	0.008	0.011	0.124	0.010	0.004	0.000	0.010	0.013	0.061
Food									1.000											
Health																				
Furniture			0.076	0.005	0.148			0.496	0.074	0.091	0.018			0.058	0.012				0.022	
Household fuels			0.102	0.007	0.198	0.022			0.098	0.293	0.025	0.027	0.017	0.077	0.016	0.016	0.001	0.034	0.030	0.038
Household materials			0.143	0.010	0.278				0.138	0.171	0.035			0.108	0.022				0.042	0.053
Housing	0.203	0.026	0.048	0.003	0.094	0.011	0.060	0.316	0.047	0.058	0.012	0.013	0.008	0.037	0.007	0.008	0.000	0.016	0.014	0.018
Non-air mobility			0.252			0.068	0.192					0.152	0.015	0.015	0.010			0.148	0.148	
Non-shelter hh products			0.143	0.010	0.278				0.138	0.171	0.035			0.108	0.022				0.042	0.053
Paid domestic work																				
Protection related services	0.192	0.024	0.046	0.003	0.089	0.010	0.113	0.298	0.044	0.055	0.011	0.012	0.008	0.035	0.007	0.007	0.000	0.015	0.013	0.017
Research and Development															1.000					
Communication	0.146	0.037	0.139		0.270		0.258				0.017		0.012	0.053	0.011	0.011			0.020	0.026
Tobacco	0.358		0.085	0.006	0.166		0.106			0.102		0.023		0.065		0.007		0.057	0.025	
Waste treatment			0.100				0.123		0.289	0.119	0.024			0.151	0.015	0.016		0.066	0.059	0.037

Appendix E: Activity and product profiles in monetary and environmental terms.

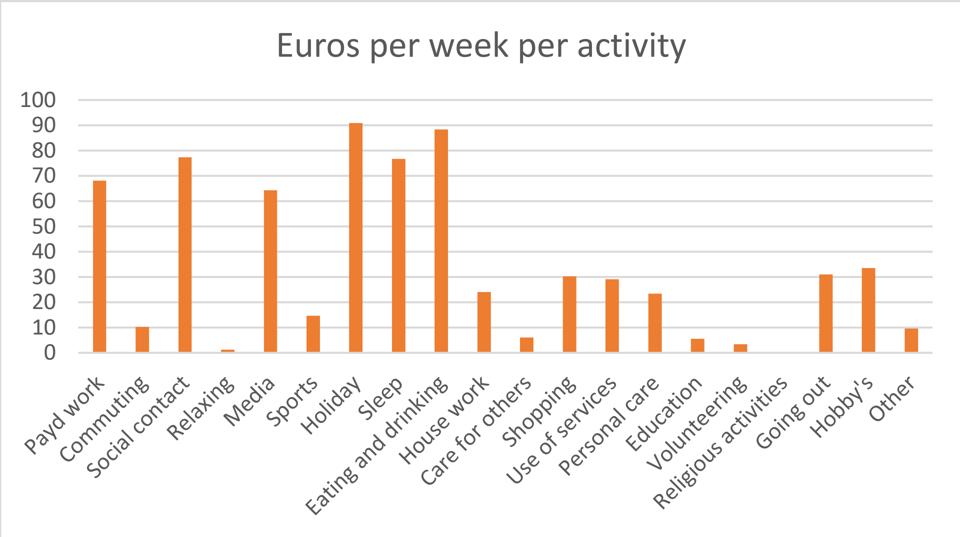

Figure E1: Absolute spending per week for an individual on different activities in euros

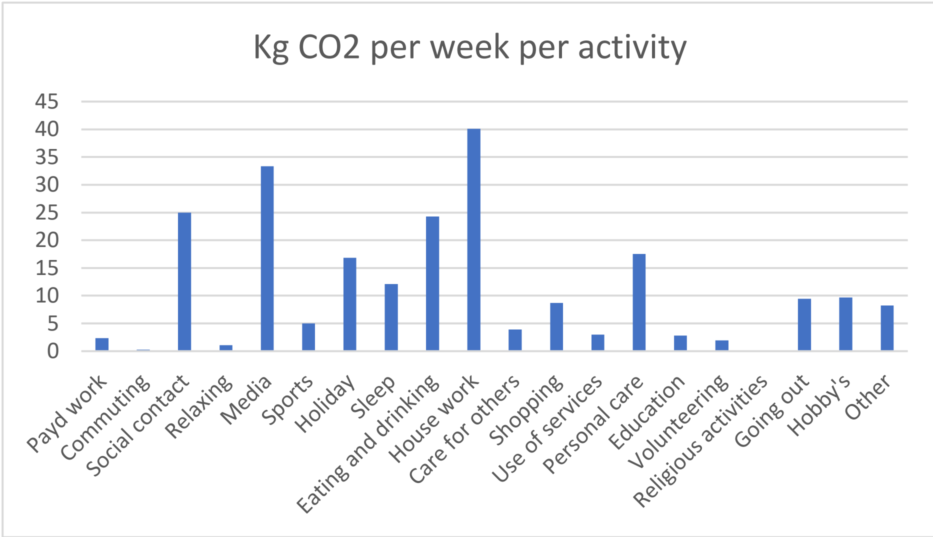

Figure E2: Absolute emissions per week for an individual of different activities in kg CO_2

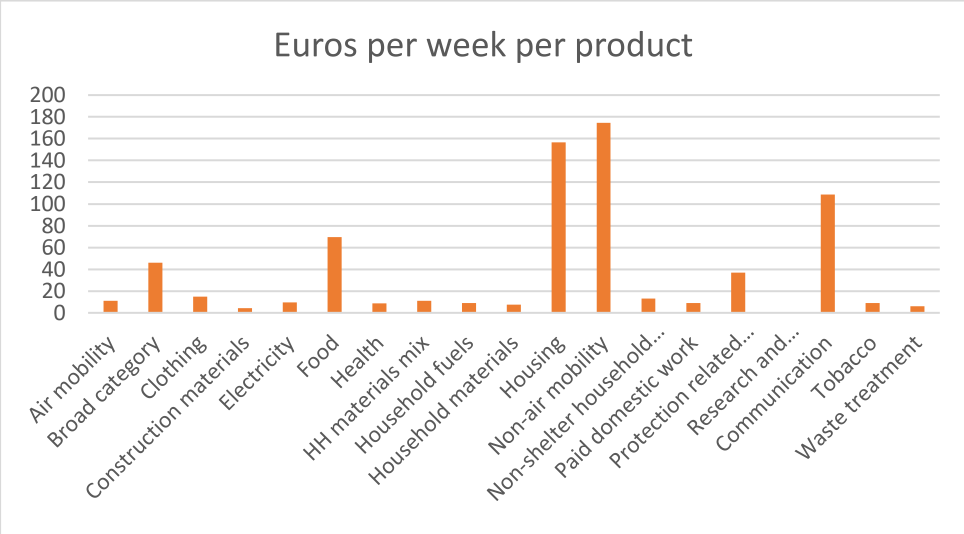

Figure E3: Absolute spending per week for an individual on different products in euros

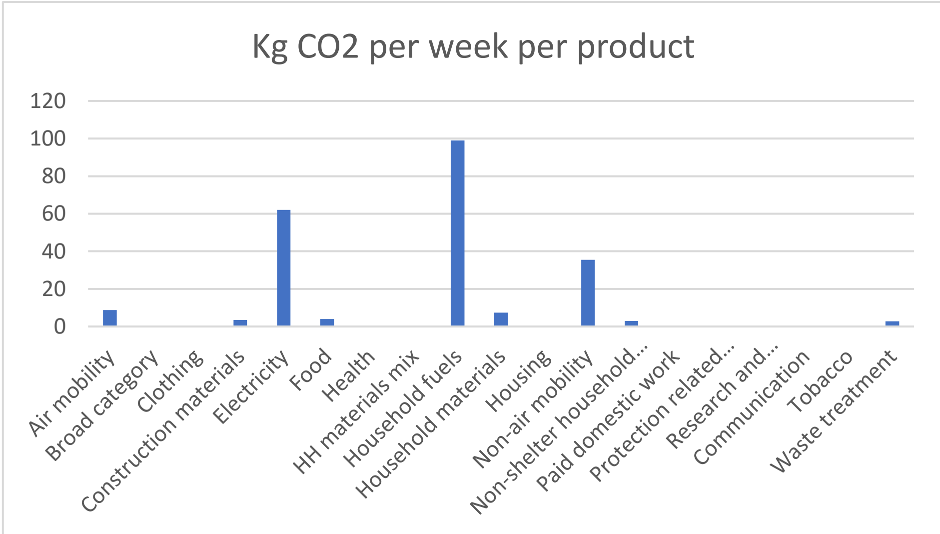

Figure E4: Absolute emissions per week for an individual of different products in kg CO_2