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Would shorter work time reduce greenhouse gas emissions? An analysis of time use and consumption in Swedish households

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Abstract

This paper analyzes the impact of work hours on energy use and greenhouse gas emissions in Sweden. The results of this study indicate that a decrease in work time by 1 percent reduces energy use and GHG emissions by about 0.8 percent on average, a bit less for high income households and a bit more for low income households. This result is mainly due to the effect of lower income and consumption. The effect due to more available time for leisure activities is more than an order of magnitude smaller than the income effect. In a sketched scenario we also elaborate on the long-term impacts of a work time reduction. A 30 hour work week in 2040 would result in a significantly slower growth of energy demand compared to a scenario with a 40 hour work week. This indicates that reduced work time would make it easier to reach climate targets. There are two important uncertainties related to this finding. The first is to what extent a slower economic growth rate would affect technological development like energy efficiency improvements. The second is to what extent shorter work weeks result in work sharing and reduced unemployment.

Keywords

Time use, work time, consumption, energy use, greenhouse gas emissions, work time reduction

1 Introduction

The current discussion on how society should be transformed to mitigate climate change is primarily focused on technological changes such as switching of fuels and energy carriers, carbon capture and storage technologies, and more efficient uses of energy. In the environmental movement there is an idea that a reduction in work hours could be good for the environment (Hayden 1999; Axelsson 2005). They argue that the choice of path between a consumption oriented future and a future with more spare time will have consequences for society's environmental impact. This thought has also been incorporated in some future scenarios for energy and environment (Azar & Lindgren 1998; Azar & Lindgren 1998; Gullberg, Höjer et al. 2007; Åkerman, Isaksson et al. 2007). The idea has also been brought up by the UK Sustainable Development Commission since they point out "sharing the available work and improving the work-life balance" as one of the 12 steps for towards a sustainable economy ((Victor 2008; Jackson 2009). The basis for this idea is that the development of energy use and greenhouse gas (GHG) emissions is coupled to the volume of consumption which in turn depends on to what extent society's increasing productivity is realized in terms of increasing income or in reduced work time (Schor 2005; Sanne 2007). In a recent report from the UNEP it is stated that "…channelling productivity gains toward more leisure time instead of higher wages that can translate into ever rising consumption also increasingly makes sense from an ecological perspective." (UNEP 2008, p 81). This idea is especially forceful since shorter work hours have possible positive consequences such as lower self-reported time pressure (Larsson 2007; Lippe 2007). Several studies have shown that shorter work hours are used for activities such as child care, sleep, meals, social contacts, volunteer work (Albertsen, Kauppinen et al. 2007) and these types of activities have also been shown to be more important for subjective well being than material consumption acquired by increasing income (Layard 2005).

Very few previous studies have specifically addressed the link between work time, energy use and GHG emissions. Schor (2005) conducted an analysis, using data from 18 OECD-countries, linking national ecological footprint and average hours per employee and found a significant positive correlation which indicates that an increase in work hours also increases ecological footprint. Rosnick and Weisbrot (2006) also approached this issue on the macro-level by comparing work time and energy use in 48 countries. The central estimate in this paper was that a 1 percent increase in work hours per worker resulted in a 1.3 percent increase in energy use per capita (controlling for GDP/hour, worker/population and temperature).

In addition to the effect on income, a change in work time also affects the availability of leisure time, which also may affect the composition of consumption. Very little is known about how people are changing their time use when working time is changed, some calculations have been made by Gershuny (2003) and Sanne (2006). Very little is also known about energy use from different kinds of time use. Binswanger (2001; 2004) used Becker's (1965) approach of a household production function to show that a time-saving innovation in the production of a service ought to lead to an increased demand for that service. In any case where the time-saving innovation affects a service that is energy intensive (which is the case for mobility), it will also result in an increased demand for energy. In a similar way, Jalas (2002) illustrated time-use rebound effects by looking at examples of measures in the eco-efficiency literature. One such example is delivery services of food which have been claimed to save both time and energy (since several households can be served by the same delivery service). The time-use rebound effect then depends on what activity that increases when more time is available. Under the assumption that the rebounding activity has the average time energy intensity (J/hr) of all activities, scaling down activities with lower than average time energy intensity would increase the total energy demand.

This paper aims to contribute to the understanding of this issue by analyzing the impact of work hours on energy use and GHG emissions in Sweden. In contrast to Schor (2005) and Rosnick & Weisbrot (2006) we use a micro-analysis approach to how a change in work time affects the energy use of households via changing income and time use patterns. This methodology is described in Section 2 followed by results in Section 3. Section 4 contains a discussion including a sketched scenario based on the results. Finally conclusions are drawn in Section 5.

2 Method

A change in the number of work hours can have many different consequences. In this paper we explore the effect on expenditures through changing income and time use patterns. Micro-data including both time use and expenditures in the same data set is not available. Instead we have carried out an analysis in two steps: first we have investigated the income effect (Section 2.1) and then the time effect (Section 2.2).

2.1 Income effect

In this part of the analysis we estimate how the consumption of various goods and services are affected by a change in income (Section 2.1.1), and what this means in terms of energy use (Section 2.1.2). For each type of good/service we want to identify whether a change in income effects the consumption proportionally, less or more.

A general reduction in work hours in the future would limit the income gains which otherwise would be possible due to the productivity improvements in the economy. However, it is not certain that a change in work hours is proportional with the effect on income. A reduction of working hours can have different type of effects on productivity. A positive effect is that workers are more thoroughly rested and therefore more effective while a negative effect is that capital utilisation might go down (Anxo & Bigsten 1989). Here, we assume that a change in work hours results in a proportional change in income.

2.1.1 Expenditure regressions

This analysis is based on data from the Swedish Household Budget Survey for 2006 (Statistics Sweden). This data set contains expenditure data from around 2000 Swedish households on around 800 different goods and services. In this study however, we use an aggregation level of 104 goods and services since these can be matched with available energy intensities (Section 2.1.2). Since the focus in this study is on changing work time, households where one or more of the adults were unemployed or retired were excluded from the set, leaving 1500 households in the sample.

For each of the 104 goods and services we carry out linear regressions with the expenditure as the dependent variable and disposable income as the independent variable. In order to improve the fit of the model we also include a set of other independent variables. Several different combinations of variables were tested and the model with the highest average adjusted R^2 value that did not cause multicollinearity was chosen for the analysis. This model has been used for all the regressions:

Expenditure on good or service = f(*Income*, *Age*, *Cohabit*, *Child 0-6*, *Child 7-15*, *Child 16-19*, *Low educ.*, *High educ.*, *Large city*, *Small city*)

Income	Disposable income	[continuous variable]
Age	Adults' average age (20 years or older)	[continuous variable]
Cohabit	More than one adult in the household (20 years or older)	[dummy]
Child 0-6	At least one child in the age 0-6 (pre-school)	[dummy]
Child 7-15	At least one child in the age 7-15 (primary school)	[dummy]
Child 16-19	At least one child in the age 16-19 (secondary school)	[dummy]
Low educ.	Households in the quartile with the shortest education	[dummy]
High educ.	Households in the quartile with the longest education	[dummy]
Large city	Stockholm, Göteborg or Malmö (>250000 inhabitants)	[dummy]
Small city	Other city	[dummy]

The resulting regression coefficients for disposable income are interpreted as the marginal consumption, i.e. the increase or decrease in consumption of a good or service for a change in income. We assume that a change in income results in an equally large change in total expenditures. Hence the estimated coefficients are adjusted so that the sum equals disposable income[1]. This was done by multiplying the expenditures on all items by same factor.

For the purpose of this study, we are not interested in the values of the regression coefficients for the other independent variables. It is important to notice that these variables are included only to improve the explanatory value of the regression model.

2.1.2 Energy use and greenhouse gas emissions

Energy use and GHG emission data are taken from an input-output analysis from Statistics Sweden's Environmental Accounts[2] for 2005. In this methodology primary energy use and CO_2 equivalents (global warming potential, GWP, of carbon dioxide, methane and nitrous oxide) per unit of final consumption are calculated using monetary transactions between sectors together with multipliers of direct energy use and emissions in each sector. Thus the

[1] In the data set, 18 percent of the disposable income was not attributed to expenditures, suggests very large savings. However, other statistics show that savings only constituted 7 percent of the disposable income in 2006 (Statistics Sweden 2008). Hence, we conclude that the 18 percent difference to a large extent may depend on that some households have failed to report some expenditures. If expenditures were not adjusted to match disposable income this would cause an underestimation of the marginal energy intensity. In any case, it would have been unrealistic to assign a zero energy intensity to these apparent savings.

[2] Available from http://www.mir.scb.se.

method re-allocates energy use and emissions from production sectors where they occur to the final consumption of goods and services, including indirect contributions from an unlimited number of upstream sectors[3]. The energy use and GHG emissions for imported goods and services have been calculated as if they had been produced domestically[4] (Carlsson-Kanyama, Assefa et al. 2007). The underlying method for compilation and analysis of input-output matrices is well described in a publication by the United Nations (1999).

2.2 Time effect

In this second step of the analysis we estimate how the non-work time use is affected by a change in work hours (Section 2.2.1), and what this means in terms of energy use (Section 2.2.2). If one works fewer hours how is this time spent instead? In order to identify the energy use of changing time use patterns the energy intensity per hour is calculated for different off work activities.

2.2.1 Time use regressions

The time effect is analyzed using data from the Swedish Time Use Survey 2000/2001. Time use for almost 4000 individuals has been recorded for one weekday and for one day on a weekend.

The time use were described for every ten minutes and later coded in 134 primary activities (simultaneously performed secondary activities were not included in our data set).

In this study we have aggregated this into 12 time use categories. As in the analysis of the income effect we have excluded households where one or more of the adults were unemployed or retired. We have also excluded households where all adults did not participate in the study. For households with two adults, one partner's work time may also affect the time use patterns of the other partner (e.g. if one partner works more then the other does more of the domestic work). In order to capture such effects, we have aggregated the time use of the adults living within the same household. Slightly more than 1000 individuals are included in the analyses.

As a basis for the final analysis of how a change in work hours affects the total energy use we first describe the average non-work time use. The second step is to estimate what effect an increase or decrease in work hours has on the non-work time use categories. How does an extra work hour affect the amount of time used for domestic work, child care, sleep, travel etc? We estimate this marginal time use by means of linear regression analyses. In the first regression domestic work is the dependent variable and time for paid work is an independent variable (then child care is the dependent variable, etc)[5]. In order to keep the analyses of income and time separate we control for income in the time regressions.

Time use on various non-work categories = f(*Work time*, *Income*)

Work time	Minutes used for paid work/studies, including breaks	[continuous variable]
Income	Disposable household income	[continuous variable]

2.2.2 Energy use

In order to approximate the intensities of energy use and GHG emissions of different time use categories we construct an allocation matrix where expenditures, energy use and GHG emissions of 104 different items are allocated to 12 categories of time use[6]. Similar methods to establish time energy intensities have previously been

[3] Figures on primary energy use for electricity production depend on the definitions used. In this analysis we use conversion efficiencies of 0.37 for nuclear and thermal power. This estimate is based on the national energy supply statistics (Statistics Sweden 2005). For hydro and wind, primary energy is calculated as produced electricity plus internal energy use. This gives a total weighted average conversion efficiency of 0.52 from primary energy to electricity.

[4] Since the Swedish energy system, particularly the electricity sector, is relatively low in CO_2 emissions, this results in an underestimation of the emissions abroad (Carlsson-Kanyama et al, 2007). In this study, were we analyse relative and not absolute changes this has little or no impact on the results.

[5] For the three different travelling modes we lack access to basic data. Instead we have used mean values for 20 subsets based on work hours and income for our regression analyses.

[6] In the input output methodology (Section 2.1.2) energy use and GHG emissions in production sectors are allocated to the final consumption of the goods and services. Energy use and GHG emissions from a person's activities at work, e.g. business flights, are considered as production and are therefore not included in his or hers personal energy use and GHG emissions since this would lead to double counting.

used by Schipper et al, (1989), Jalas (Jalas 2002; 2005), Wadeskog et al (2003) and Hille et al (2007). The allocation is based on the following assumptions:

- A large number of expenditure items have been assumed to be independent of time use: housing, heating fuels, food, clothes, furniture, package holidays, day care, insurances and other services.
- Vehicles, transport fuels and travel tickets are allocated to the three different time categories of travel.
- Electricity consumption is first divided on end uses based on energy statistics (SEA 2008):
    - Electric heating is assumed to be independent on time use.
    - Lighting is allocated based on the time of activities at home and awake.
    - Electricity for household appliances is allocated to time for domestic work
    - Electricity for computers is allocated to time for hobbies/other leisure time
    - Electricity for radio and TV is allocated to time for TV/radio/reading.
- Household appliances and tools are allocated to time for domestic work.
- Telephone and telephone services are allocated to time for socializing.
- Major durables for outdoor recreation (e.g. boats), sport equipment and services are allocated to time for sports/outdoor activities.
- TVs, radios, books and papers are allocated to time for TV/radio/reading.
- Photographic equipment, computers, music instruments, games, toys and gardening equipment are allocated to time for hobbies/other leisure time.
- Appliances and products for personal care are allocated to time for personal care.
- Coffee, tea, cocoa, soft drinks and alcohol are assumed to be partly independent on time use (as the assumption for food) and partly allocated to time for socializing.

Still, one problem remains. With the fixed energy intensities (MJ/h) constructed as described above, it will appear as if more spare time always leads to a higher energy use. However, in reality the energy intensities of some activities are not necessarily fixed. With more time available, some equipment may be used more extensively (a longer tennis match with the same racquet or a longer night's sleep in the same bed).

Also, since the estimates of marginal time use with respect to work time (Section 2.2.1) are carried out including disposable income as an additional independent variable, the marginal time use with respect to work time should not include any income effect (the income effect is estimated separately in Section 2.1). This means that the time effect should not lead to an increase in total expenditures.

In order to ensure that the total expenditures are not changed as a result of the time effect, we divide the activities in two types:

Type 1. Activities where energy use increase in proportion to the time spent on them: Travel; Entertainment and culture; TV, radio and reading; Domestic work. We assume that two hours of for example car travel or lawn mowing results in twice as much energy use as one hour.

Type 2. Activities where energy use does not increase in proportion to the time spent on them: Child care; Sleep, eating, hygiene; Sports and outdoor activities; Socializing; Hobbies. We assume that more time spent on these activities does not per definition require more consumption and energy use.

The expenditures on activities of Type 2 are adjusted with a factor so that the sum of expenditures does not exceed income.

3 Results

3.1 Income effect

We make a first estimate of the relationship between income and energy use simply by plotting total energy use per consumption unit[7] against total expenditures per consumption unit for the households included in the analysis (Figure 1).

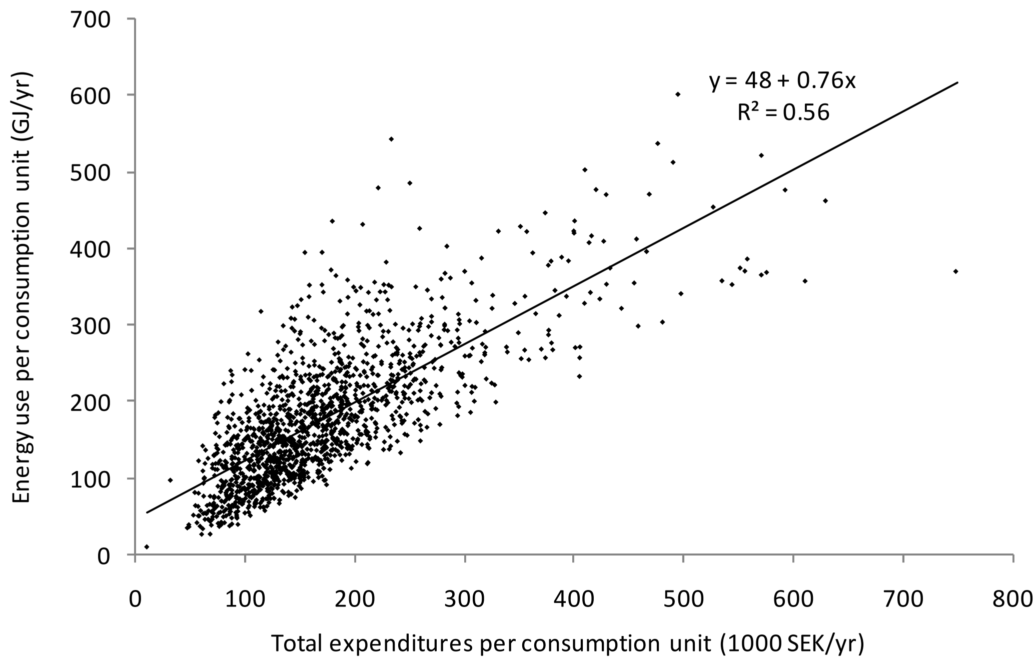

Figure 1. Energy use and total expenditures for Swedish households in 2006.
Households with one or more unemployed or retired were excluded from the set.

The equation of the linear trend line in Figure 1 gives that an increase in income (total expenditures, see footnote 1) of 1 SEK[8] would increase energy use by 0.76 MJ. The linear estimate gives a reasonably good fit but energy use grows a bit slower as a function of income for high income households. Dividing the data set into two halves based on income gives a marginal energy intensity of 0.95 MJ/SEK for the lower income group and 0.65 MJ/SEK for the upper income group.

However, there is also a large spread in these results. The energy use for households with similar total expenditures per consumption unit varies by approximately a factor of 3. This indicates that other factors than income should also be included in the analysis. The following results are based on multivariate regressions including a set of socio-economic factors (see method in Section 2.1.1). The results of these regressions along with average expenditure shares and intensities of energy use and CO_2-equivalents are presented in Table 1.

[7] Consumption unit (c.u.) is a simple measure of household size: single adult 1.16 c.u., two cohabiting adults 1.92 c.u., additional adult 0.96, child 0-3 years 0.56 c.u., child 4-10 years 0.66 c.u., child 11-17 0.76 c.u. The reason for using consumption units in the denominator is that we are only interested in how income affects energy use and not household size. In the multivariate regressions (Section 2.1.1) we handled household size in a different way by including the number of adults and children as independent variables.

[8] The average exchange rate in 2006 was 1 SEK = 0.108 Euro.

Table 1. Average and marginal expenditure shares together with energy intensities and CO_2-eq intensities for 104 goods and services.

	Expenditure shares		Energy intensity	CO_2-eq intensity
	Average	Marginal		
	SEK/1000 SEK	SEK/1000 SEK	MJ/SEK	gCO_2-eq/SEK
Bread, cereals	20.8	8.5***	0.77	49
Meat	24.5	15.7***	0.95	103
Fish, seafood	6.4	2.8*	0.96	54
Milk, cheese, eggs	19.8	8.6***	1.01	114
Oils, fats	2.8	0.9*	0.93	72
Fruit	10.0	4.5***	1.00	145
Vegetables	14.1	7.2***	0.99	132
Sugar, jam etc	11.8	5.0***	0.80	58
Salt, spices etc	5.5	3.3***	0.71	60
Coffee, tea, cocoa	2.9	1.0+	0.79	77
Mineral water, soft drinks, juices	7.1	4.7***	0.68	45
Spirits	1.4	-1.0	0.20	11
Wine	7.4	11.6***	0.33	18
Light beer	0.4	-0.3	0.57	31
Beer	1.8	0.3	0.35	18
Tobacco	6.0	-1.8	0.21	9
Clothing materials	0.1	-0.4	0.67	29
Garments	46.4	49.4***	0.45	21
Clothing accessories	2.2	3.4***	0.49	22
Cleaning, repair and hire of clothing	0.4	0.1	0.34	15
Footwear	10.5	14.1***	0.49	28
Repair of footwear	0.2	0.4	0.39	16
Housing excl. maintenance and energy	135.4	28.4*	0.36	17
Maintenance and repair of dwelling	20.6	8.7	0.69	28
Electricity	36.9	19.7***	8.69	58
Liquid fuels	2.6	0.0	4.85	335
Solid fuels (wood)	0.9	-0.6	22.83	47
District heating	2.3	3.4*	3.57	134
Summer house excl. energy	4.5	14.6***	0.22	13
Summer house energy	2.0	10.9***	8.69	58
Furniture and furnishings	26.0	27.2***	0.62	23
Carpets and other floor coverings	2.1	8.6**	0.55	21
Repair of furniture	0.0	0.0	0.39	16
Household textiles	6.5	7.6	0.57	21
Major household appliances	9.1	7.1*	0.52	19
Small electric household appliances	0.7	1.4+	0.53	19
Repair of household appliances	0.0	0.0	0.38	16
Glassware, tableware and household utensils	6.6	9.6*	0.67	27
Major tools and equipment	1.1	0.2	0.42	17
Small tools and accessories	6.4	1.1	0.53	20
Non-durable household goods	7.8	5.2**	0.76	27
Household services	0.3	0.0	0.32	16
Pharmaceutical products	7.2	7.3**	0.46	17
Other medical products	0.2	-0.3	0.47	17
Therapeutic equipment	3.7	25.5***	0.38	15
Medical services	1.5	0.2	0.26	8
Dental services	6.1	-2.2	0.24	8
Paramedical services	1.8	2.9*	0.29	10
Hospital services	0.0	0.0	0.24	8
Cars	77.7	197.0***	0.53	20
Motor cycles	6.1	8.8	0.56	22

Bicycles	1.9	2.0 *	0.56	22
Spare parts for vehicles	7.3	7.6	0.59	22
Fuels and lubricants for vehicles	55.8	38.3 ***	3.40	216
Maintenance and repair of vehicles	11.4	23.3 *	0.44	15
Vehicle tests	0.6	-0.9	0.25	11
Hire of vehicles	0.7	-0.2	0.56	26
Parking	0.8	0.6	0.19	8
Driving lessons and licenses	1.2	-3.0	0.17	5
Bridge tolls	0.1	0.0	1.15	78
Passenger transport by railway	3.5	-2.4	1.73	32
Passenger transport by road	6.7	-0.2	0.51	27
Passenger transport by air	1.2	5.2 *	1.93	123
Passenger transport by sea and waterways	1.1	1.5	3.14	231
Combined passenger transport	1.0	0.7	1.70	62
Other transport services	0.1	-0.3	0.69	41
Postal services	0.6	0.4	0.35	13
Telephone and telefax equipment	2.8	0.7	0.30	12
Telephone and telefax services	28.8	7.2 **	0.26	10
TV sets, radios, gramophones etc	10.6	24.2 ***	0.33	13
Photographic and cinematographic equipment	2.7	0.4	0.34	13
Information processing equipment	13.4	-1.5	0.43	18
Recording media	1.9	1.1	0.51	19
Repair of audio-visual, photogr., info. equipment	0.1	0.0	0.38	15
Major durables for outdoor recreation	10.6	55.2 ***	0.57	27
Musical instruments, durables for indoor recreation	1.4	0.5	0.49	19
Games, toys and hobbies	4.9	4.0 *	0.51	19
Equipment for sport, and outdoor recreation	7.8	16.3 *	0.55	22
Gardens, plants and flowers	6.9	15.3 ***	0.83	108
Pets and related products	4.9	1.5	0.86	90
Veterinary services	0.7	-0.3	0.35	40
Recreational and sporting services	10.5	12.4 *	0.38	17
Cultural services	17.4	8.2 ***	0.40	19
Games of chance	4.2	2.3	0.28	13
Books	4.5	2.5	0.54	19
Newspapers, periodicals	5.6	2.4	0.56	18
Miscellaneous printed matter	0.7	1.1 **	0.55	18
Drawing materials	1.4	1.1	0.75	24
Package holidays	41.7	77.2 ***	0.94	55
Education	1.1	1.7	0.28	9
Restaurants, cafés	41.2	56.1 ***	0.90	52
Accommodation services	3.7	5.4	1.01	59
Hairdressing, personal grooming	7.0	7.9 **	0.26	10
Electric appliances for personal care	0.4	0.2	0.55	20
Other appliances and products for personal care	15.1	9.9 ***	0.70	26
Jewelry, watches	3.3	1.7	0.44	17
Other personal effects	2.3	1.9	0.53	27
Daycare, kindergarten	11.5	9.2 ***	0.09	2
Insurance	31.9	25.1 ***	0.23	5
Financial services	0.4	0.6	0.13	5
Other services	1.0	-0.4	0.31	11
Union dues, unemployment benefit funds	17.0	5.3 **	0.50[1]	29[1]
Other payment of interest	0.0	0.2	0.50[1]	29[1]
Taxable fringe benefits	8.0	40.7 ***	0.50[1]	29[1]
Sum	1000	1000		

[1] Data not available; estimated from the average intensity of all non-energy goods and services

Significance levels: + = $p < 0.1$; * = $p < 0.05$; ** = $p < 0.01$; *** = $p < 0.001$

For several small expenditure items, the significance of the income regression coefficient is very low, but for the major expenditure items the significance is high. Items with p-values of < 0.001 constitute 79 percent of the marginal expenditures.

Using the results in Table 1, the energy intensity of the average consumption can be calculated to 1.06 MJ/SEK, and the energy intensity of the marginal consumption to 0.94 MJ/SEK. This gives a relation of 1:0.89, which shows that there is a rather strong coupling between income and energy use. The relation for GHG emissions is very similar, 44.7 gCO_2-eq/SEK for the average consumption and 39.0 gCO_2-eq/SEK for the marginal consumption, i.e. 1:0.87.

3.2 Time effect

Our calculations are based on cross-sectional regressions (see method in Section 2.2) and the results along with average time use and intensities of energy use and CO_2-eq are presented in Table 2.

Table 2. Average and marginal time use together with energy intensities and CO_2-eq intensities.

	Time use		Energy intensity	CO_2-eq intensity
	Average	Marginal		
	Minutes/hour	Minutes/hour	MJ/cap/h	kgCO_2-eq/cap/h
Work (energy-intensity: home heating etc. while at work)	15.1	-60.0	8.9	0.41
Domestic work	5.5	14.1***	34.3	0.72
Child care	1.2	4.4***	10.2	0.42
Sleep, eating, hygiene	24.6	14.4***	11.5	0.48
Sports, outdoor and participatory activities	1.4	3.4**	19.4	0.98
Entertainment, culture	0.2	1.3**	54.8	2.57
Socializing	2.4	5.2***	24.1	1.16
TV, radio, reading	5.0	9.0***	19.4	0.54
Hobbies	1.1	5.0***	43.0	1.95
Travel - bicycle/foot	0.8	1.7** [1]	10.3	0.46
Travel - bus/train	0.5	-0.8** [1]	44.9	2.01
Travel - car/motorcycle	2.1	2.4** [1]	134.1	7.61

Significance levels: + = p < 0.1; * = p < 0.05; ** = p < 0.01; *** = p < 0.001

[1] Significance level for total travel time. The shares of the different transport modes are based on other estimates (see footnote 5 in Section 2.2.2).

The column with marginal time use illustrates how one hour of less work is used on average. When one type of time use decreases other types of time use will increase. About fourteen minutes are used for domestic work and an equal amount is used for personal care (sleep, eating and hygiene). Nine minutes are used for TV, radio and reading. Five minutes each for socializing and hobbies. The four minutes for child care is an average number, being much higher for parents. From an energy point of view the two minutes used for travel by car or motorcycle are especially interesting. These results are well in line with what Gershuny found when doing similar cross-sectional calculations of marginal time use (Gershuny 2003).

The figures in the columns with energy intensities and time use for different activities are illustrated in figure 2 below. The area below the broken line represents energy use which we have identified as independent of time use (8.9 MJ/cap/h), for example energy for heating of one's home (see Section 2.2.2). Energy use for e.g. domestic work is made up by energy use which is independent of time use (8.9 MJ/cap/h) plus energy for cooking, washing, etc (total of 34.3 MJ/cap/h). Energy use coupled to the work itself (production) is not included here since this would lead to double counting (energy use from production activities is included indirectly in the energy intensities of consumption). A similar but less detailed figure is found for US households in Schipper et al. (1989).

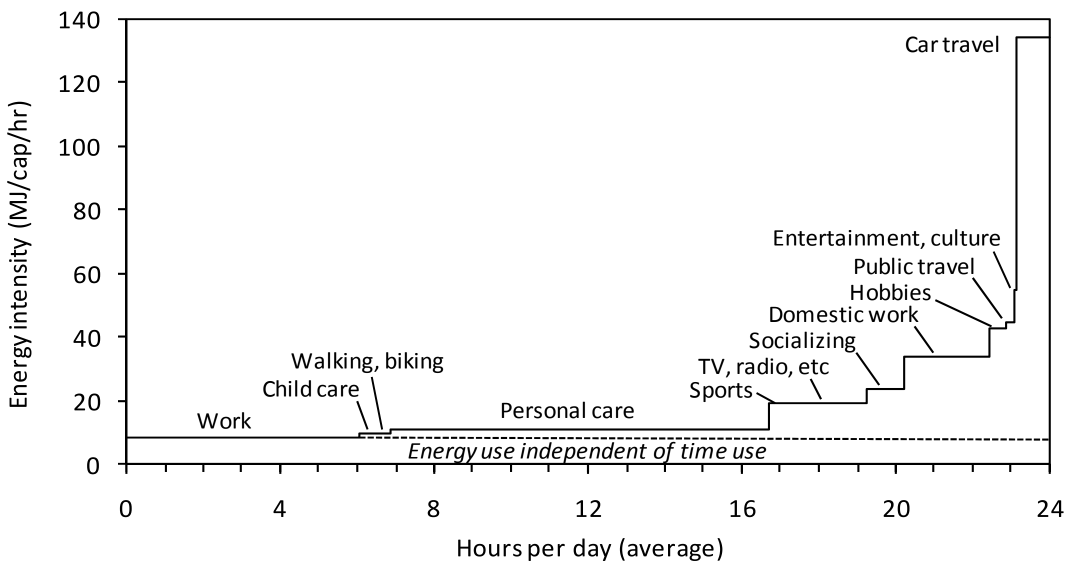

Figure 2. **The energy use of different activities during an average day**. Energy use below the broken line is considered to be independent on how time is spent (e.g. space heating).

What does this mean for the time effect on energy use? The fixed energy and CO_2 equivalent intensities from Table 2 imply that a reduction of work time by one percent would increase energy use by 0.24 percent and the GHG emissions by 0.20 percent. But this is unrealistic since this way of using the new spare time would mean that the total expenditures would exceed income. Using the method described in Section 2.2.2 we adjust the expenditures, and with it energy use and GHG emissions, on Type 2 activities (those where energy use does not increase in proportion to time use) so that the total expenditures do not exceed income.

The resulting time effect (the income effect is analysed separately in Section 3.1) is that a decrease in work time by one percent causes an increase in energy use by 0.06 % and an increase in CO_2 equivalents by 0.02 %.

3.3 Total effect of a change in work hours

The results from Section 3.1 and 3.2 are summarized in Table 3. It is assumed that an increase in work time by one percent is associated with a proportional increase in disposable income[9]. The total effect on energy use and GHG emissions is estimated as the sum of the income and time effects.

Table 3. Income and time effects. The effect on energy use and GHG emissions of an increase and decrease in work time / disposable income by 1 percent.

	Longer work hours by 1 %		Shorter work hours by 1 %	
	Energy use	CO_2 equivalents	Energy use	CO_2 equivalents
Income effect	+ 0.89 %	+ 0.87 %	- 0.89 %	- 0.87 %
Time effect	- 0.06 %	- 0.02 %	+ 0.06 %	+ 0.02 %
Total effect	+ 0.83 %	+ 0.85 %	- 0.83 %	- 0.85

[9] If marginal income taxes are higher than average income taxes, which is the case for high income households in Sweden, disposable income changes less than the change in work time, and hence the income effect is smaller. A part of this difference is however offset by increasing tax financed public consumption.

4 Discussion

4.1 Limitations

Which weaknesses are linked with our results? One apparent weakness with the approach is that we have carried out a cross-sectional study where we compare different households. If we would have been able to follow changes within households over time in a longitudinal study we would have reached results which were better adapted to our aims.

Another problem is that the effect of the number of workdays is not included since the analysis is limited by the data to a constant 5-day workweek. It is likely that a change in work hours in some cases mean a change in the number of workdays. A 6-day workweek would increase time spent on commuting, and a 4-day decrease it accordingly. The length of the weekend probably also affects how it is spent. For instance, 3-day weekends might result in longer weekend trips. The effect of the number of workdays needs to be analyzed in more detail.

Despite several shortcomings of our micro-level results, they are well in line with previous macro-level results which indicate a robustness regarding the overall picture: the number of work hours has a significant effect on energy use and GHG emissions.

4.2 Scenarios

Since the work time is relevant for energy use and GHG emissions it is interesting to dwell on the development over time. It is important to note that our results are based on the situation in the first years of the twenty-first century. It is far from obvious that they hold for making predictions regarding the coming decades. One must keep this in mind when making macro-level scenarios based on our micro-level results of today.

How will the work time develop in the future? On average workers in the 15 "old" EU-member states work 14 percent, equivalent to seven weeks, less than their US counterparts (Rosnick & Weisbrot 2006). The workweeks in many developing countries are often very long. Some economists argue that Europeans have to work longer in order to enhance competitiveness in the increasingly globalized economy. Politicians tend to argue for much work in order to ensure financing of the public sector, especially the increasing costs of the ageing population. Subsequently there are strong forces for longer work hours in the EU. Our results indicate that this would result in an increase in energy use which would make it harder to reach climate targets.

But on the other hand a reduction of work hours is also possible. The historic tendency is that Europeans, to a larger extent than Americans, collectively choose leisure time instead of income (Schor 1991). This might continue and it may accelerate if post material values will become more common along with a feeling of saturation regarding "stuff", and that work – life balance, time for relations and for realizing one's dreams will become relatively more prioritized.

Working time reductions are widely debated both publicly and academically (for an overview of academic perspectives see Golden & Figart 2000). The average amount of work hours per working age person have decreased with about 0.1 percent per year in Sweden during the period of 1980-2005 (SOU 2008:105). The increase in productivity (production per work hour) during the same time has been 2.0 percent (ibid). Wages after deducting inflation increased on average 2.6 percent per year during 1997 to 2006, between 1980 and 1996 it was lower (Medlingsinstitutet 2008).This shows that the vast majority of the productivity gains have been transformed into private and public consumption, and not into work time reductions.

30 years ago working time reductions always meant reduction of the standard work week but today more individualised forms of work time reductions have become more important, e.g. part-time work or temporary leaves of absence (Bosch 2000). One example is the Dutch law which gives all full-time employees the right to request shorter hours along with a subsequent cut in pay (Moss & Korintus 2008). Individual, voluntary downshifting of work and consumption can be appealing for some people but deviating from time norms at the workplace and consumption norms in one's reference group can be difficult. Swedish studies reveal that one in six are ready to take the step of cutting work and income individually, but one in two are in favor of a collective work time reduction instead of higher salaries (Sanne 1995).

We will here make two very simplified scenarios of work time and energy use (including GHG emissions would require assumptions regarding future changes in the mix of energy supply, and that is outside the scope of this study). In the first scenario (the baseline scenario) all of the expected productivity improvement is channeled into increased income and consumption. In the second scenario half of the productivity improvement is used to reduce the length of the work week resulting in a slower growth in consumption. We also assume that due to a slower exchange of products the second scenario suffers from a slightly slower improvement in technical energy efficiency. Another important aspect is whether work time reductions leads to lower unemployment, something which is often called work sharing. A research overview of the effects of work hour reductions on employment in different European countries found that “most studies conclude that working time reductions have positive employment effects of 25-70 percent of the arithmetically possible effect” while only a few studies find zero or negative effects (Bosch 2000, p 180). One Swedish study concluded that there are no positive long term employments effects of work hour reductions (KI 2002). We assume that 30 percent of the reduced hours are carried out by someone else.

The scenarios are for year 2040 starting at 2010. The two scenarios are described in Table 4 and illustrated in Figure 3.

Table 4. Scenario description.

		Baseline	Shorter work time	Comments
Inputs				
Productivity improvement	%/yr	2.0	2.0	*The historical rate in Sweden 1980-2005*
Length of standard work week	%/yr	0.0	-1.0	
Work sharing	%	-	30	*The extent to which a shorter work time leads to new employment*
Energy efficiency improvement	%/yr	0.9	0.8	*From IIASA A and B scenarios (Nakićenović, Grübler et al. 1998)*
Energy to consumption change ratio	-	0.89	0.89	*‘income effect’ (Section 3.1)*
Energy to work time change ratio	-	-	-0.06	*‘time effect’ (Section 3.2)*
Intermediate calculations				
Total work time	%/yr	0.0	-0.7	*Due to work week and work sharing*
Total private consumption	%/yr	2.0	1.3	*Productivity, work week and work sharing*
Outcome at the end of the scenario				
Standard work week	hours	40	30	
Total private consumption increase	%	78	45	
Energy use increase	%	30	12	*Energy use in Sweden and abroad related to Swedish consumption (see Section 2.1.2)*

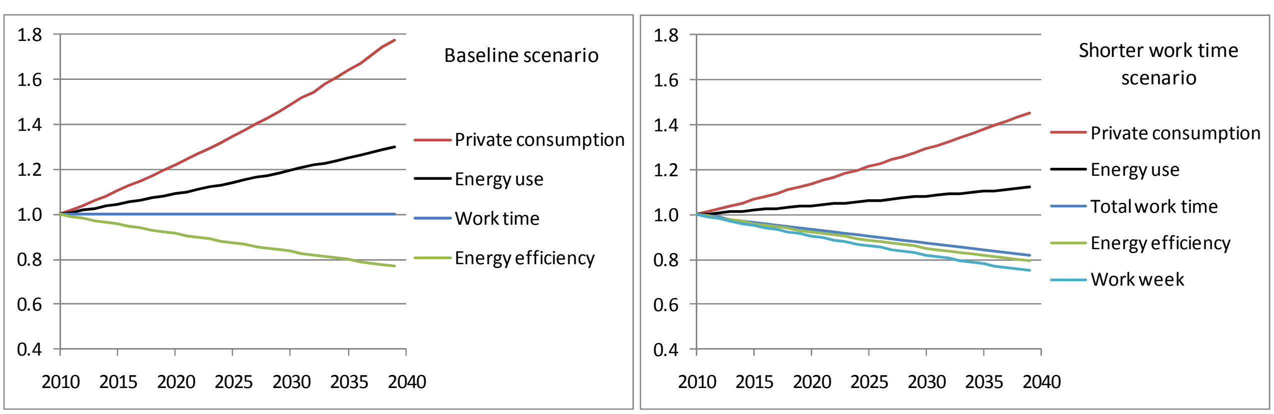

Figure 3. Two scenarios of work time and energy use. To the left a scenario with a constant standard work week of 40 hours and to the right a scenario where the work week is gradually reduced to 30 hours. Scenario descriptions are provided in Table 4.

In these rather simple scenarios a reduction of the work week from 40 to 30 hours would result in a significantly slower growth of energy demand compared to the scenario with a constant work week (12 percent instead of 30 percent). Note again that this is not energy use in Sweden, but energy use in Sweden and abroad which is coupled to Swedish consumption (see Section 2.1.2). Another possible benefit with this scenario is reduced unemployment due to the work sharing component. Total private consumption "only" increases by 45 percent in the 30 hour work week scenario as opposed to 78 percent in the 40 hour work week scenario. However, there are several uncertainties in these scenarios. For example if the "technological penalty" in terms of slower energy efficiency improvements would be higher than in our scenarios, then energy savings would be smaller. Another uncertainty is the work sharing parameter. If shorter work weeks would not reduce unemployment at all (which is argued for in KI 2000), then the growth in energy demand would be reduced further.

5 Conclusions

The results of this study indicate that an increase or decrease in work time causes a change in energy use and GHG emissions by almost the same amount. A decrease in work time by 1 percent reduced energy use and GHG emissions by about 0.8 percent on average, a bit less for high income households and a bit more for low income households. This estimate is lower than in the macro-analysis by Rosnick and Weisbrot (2006) where a 1 percent reduction in work time was found give a 1.3 percent reduction in energy use.

The increase in energy use with work hours is dominated by the effect of increasing income. The effect due to more available time for leisure activities is more than an order of magnitude smaller than the income effect.

In a sketched scenario we also elaborate on the long-term impacts of a work time reduction. A 30 hour work week in 2040 would result in a significantly slower growth of energy demand compared to a scenario with a 40 hour work week. This indicates that reduced work time would make it easier to reach climate targets. There are two important uncertainties related to this finding. The first is to what extent a slower economic growth rate would affect technological development like energy efficiency improvements. The second is to what extent shorter work weeks result in work sharing and reduced unemployment.

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