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Energy consumption and working hours: a longitudinal study of developed and developing nations, 1990–2008

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This study advances sociological research on the environmental impacts of working hours. Proponents of economic degrowth propose that a reduction in working time slows economic growth, which yields both social and environmental benefits. Building on such arguments, the authors conduct longitudinal analyses of the effects of average annual working hours on total energy consumption for samples of both developed and developing nations, and assess the extent to which the effect of working hours on energy consumption changes through time. The results suggest that the effect of working hours on energy consumption has increased through time, and this trend is observed for the samples of both developed and developing nations. The authors conclude by discussing the theoretical and policy implications of the findings.

Keywords: working hours; energy consumption; environmental sociology; degrowth

Introduction

Recent estimates suggest that humanity consumes close to 1.5 times as much renewable resources as the earth can produce in a year (Global Footprint Network 2013). This number would be much higher, around '4.6 Earths', if the populations of all countries were to assume the average consumption levels of those living in the United States (Global Footprint Network 2009). Further, it is argued that crossing certain global ecological thresholds will result in an earth that is not able to support human life as it does now (Rockström et al. 2009). Some of the planetary boundaries have already been crossed, such as those related to global climate change, biodiversity loss, and the nitrogen cycle (Rockström et al. 2009). Furthermore, global freshwater is another threshold that is likely to be crossed in the near future (Rockström and Karlberg 2010). The Intergovernmental Panel on Climate Change (2013) concludes that greenhouse gases are accumulating faster in the atmosphere due to deforestation and the ocean approaching its limits as a carbon sink. Since global environmental problems are caused by human activities, sociological research is warranted to help identify ways in which human societies can begin to mitigate and potentially reverse pathways of global unsustainability.

Although there has been a historical reduction in working hours since the nineteenth century, at least in the Global North, since 1980 there is evidence that the trend in developed countries has switched directions (Schor 2005; Knight, Rosa, and Schor 2013). Juliet Schor (2005, 43) indicates,

> The combination of rising hours in the United States plus a subset of Western European countries means that for the last decade, for a large fraction, (perhaps the majority) of the population, annual hours of work have been *increasing* rather than *decreasing*.

Beyond this, average working time in many developing countries remains higher than most developed countries (Lee, McCann, and Messenger 2007). With these trends in mind, economic degrowth proponents propose that reducing working hours, or more specifically a working time reduction (WTR), is a way for human societies to reduce environmental impacts (Hayden 1999; Jackson 2009a; Schor 2010). Recent research suggests that an increase in working hours (and income along with it) does not result in proportional increases in levels of happiness or life satisfaction after a certain income level has been reached (Kasser and Brown 2003; Jackson 2009b). Prior scholarship also suggests that economic development in general has large and often increasing impacts on the environment, including growth in resource consumption and anthropogenic greenhouse gas emissions (e.g., Jorgenson and Clark 2011, 2012). Following the assertions of the economic degrowth perspective concerning WTR, recent cross-national studies highlight the impacts that working hours have on various environmental outcomes (e.g., Schor 2005; Rosnick and Weisbrot 2007; Hayden and Shandra 2009; Knight, Rosa, and Schor 2013).

In this study, we advance macro-comparative research on working hours and the environment in two ways. First, we assess the extent to which the effect of working hours on national-level energy consumption changes through time. Second, this study investigates the energy consumption and working hours relationship for both developed and developing countries, allowing for greater generalizability or the identification of differences between nations in distinctive macro-economic contexts.

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Literature review

Environment and development

For decades, the environment–economy relationship has been at the center of theoretical debates in environmental sociology and its sister disciplines. It is important to note that our initial purpose is to highlight the broad debate regarding economic growth and environmental sustainability, in order to set the stage for a discussion on one part of the economic degrowth argument: working time reduction. Thus, we highlight only the propositions that are relevant for the present study.

Within environmental economics, some scholars suggest that economic growth and environmental sustainability are compatible with one another. They support the continuation of neoliberal economic policies that favor little-to-no government regulation (e.g., Grossman and Krueger 1995). It is argued that a lack of government oversight and regulation results in an economic system based purely on competition, leading to the most efficient production possible, which is assumed to lessen environmental demands. Ecological modernization theory, within environmental sociology, is another perspective that views economic growth as compatible with improvements in environmental conditions (Dinda 2004; Huber 2009; Mol and Janicke 2009; Mol, Spaargaren, and Sonnenfeld 2009). For example, Arthur Mol and Gert Spaargaren (2000, 23) suggest,

> Consequently, mainstream ecological modernization theorists interpret capitalism neither as an essential precondition for, nor as the key obstruction to, stringent or radical environmental reform. They rather focus on redirecting and transforming 'free-market capitalism' in such a way that it less and less obstructs, and increasingly contributes to, the preservation of society's sustenance base in a fundamental/structural way.

It is important to note that ecological modernization proponents do not support the continuation of neoliberal economic policies. Instead, they propose that sustainable changes result from the expansion of an 'ecological rationality' throughout society, technological innovations, and institutional environmental reforms. Economic development contributes to and benefits from these transformations.

These perspectives propose a similar environment–economy relationship as that suggested by the Environmental Kuznets Curve (EKC) hypothesis.[1] According to the logic of the EKC hypothesis, nations with a low level of economic development also have relatively few environmental impacts, given that these populations are largely rural and these nations are not yet industrialized. As nations economically develop, with increasing levels of industrialization and urbanization, the environmental impacts expand. These nations have higher per capita incomes and conditions of well-being. Once they reach a point of post-industrialization, these nations are able to expand economic growth while decreasing the overall associated environmental degradation and demands. In other words, economic growth is decoupled from environmental impacts. This decoupling occurs partly due to greater efficiency associated with technological development, which reduces the natural inputs required for production and the pollution generated from industrial operations. It is also the result of individuals feeling that their immediate needs are secure, thus they express greater concern for the environment.

In contrast to the more optimistic perspectives concerning the environment and development relationship, treadmill of production theorists argue that environmental sustainability and economic growth are likely not compatible. They contend that the expansionary logic of capitalism – its need for ever-growing profits – pushes aside other social issues, such as concern for the environment. It results in ever-larger demands upon natural resources and the generation of pollution, both contributing to ecological degradation (Schnaiberg 1980; Schnaiberg, Pellow, and Weinberg 2002; Gould, Pellow, and Schnaiberg 2004; Jorgenson and Clark 2012). Kenneth Gould, David Pellow, and Allan Schnaiberg (2004, 305) state, 'We can state boldly that *increasing the return on investment has displaced every other social and environmental goal* in this period'. Treadmill scholars are skeptical regarding the ability of technology to reduce the environmental impacts of society, within the existing economic order. They highlight that technology has a specific role in capitalist development: increasing profit. While production may become more efficient, it does not necessarily mean that the environmental consequences (whether in the form of resources or pollution) have decreased. In questioning the ability of technology to contribute to an absolute decoupling of economic growth and environmental degradation, proponents of treadmill of production theory often point to the existence of the Jevons paradox, whereby greater efficiency coincides with increased overall environmental impacts, due to the expansionary tendencies of capitalism (Jevons 1865; Foster, Clark, and York 2010; York 2012).

Economic degrowth

Recently, some researchers have begun calling for a shift in policy toward economic degrowth. They argue that a slowing down, or complete halt, of economic growth is socially desirable and ecologically necessary. They do not suggest that degrowth must immediately take place worldwide. Rather, wealthier developed countries ought to lower their economic growth to fall within sustainable limits. At the same time, poorer developing countries must be allowed to expand economic growth until they achieve levels on-par with developed countries, though still within planetary ecological thresholds

(Hayden 1999; Alcott 2008; Jackson 2009b; Martinez-Alier 2009; Schor 2010; Knight, Rosa, and Schor 2013). The call for economic degrowth is often coupled with a proposed cultural reorientation away from materialism and overconsumption and toward a perspective of community service and self-improvement, among other things, as a means for enhancing the quality of life.

Rather than focusing on efficiency policies, as is the case with the more optimistic environment and development approaches, economic degrowth proponents address concerns associated with sufficiency. They argue that there is a point where increasing the amount of material goods is no longer needed to produce a high quality of life, nor is it necessarily desirable (Hayden 1999; Hayden and Shandra 2009; Jorgenson and Dietz 2015; Schor 2010). Along these lines, Tim Jackson (2009b) shows that, cross-nationally, life-satisfaction levels plateau after around $14,000 gross domestic product (GDP) per capita. This means that any GDP per capita growth beyond $14,000 may not be resulting in better lives for people but rather simply producing excess consumption and increased environmental degradation. With this in mind, it is possible that economic degrowth policies have the potential to produce higher qualities of life than the current status quo position of unrestrained economic growth. A key component of the degrowth argument is WTR, which is argued to have both social *and* environmental benefits.

WTR and the environment

WTR has been promoted by some scholars as a mechanism to reduce unemployment (e.g., Hayden 1999). Fewer hours worked could mean that shifts need to be picked up by other workers, thus increasing the number of jobs available while also increasing the amount of leisure time. WTR, in order to reduce unemployment, was done in France in 1997 when legislation was passed reducing the 40-hour work week to a 35-hour work week (Hayden 1999). It is plausible that WTR can overcome social ills such as unemployment rather than the common suggestion of expanding production to incorporate more workers. For instance, Anders Hayden (1999, 35) explains,

> There was much hoopla in France surrounding Toyota's autumn 1997 announcement that it would create 1,500 jobs by building a new auto plant.… Green Party critics added that the same job-creation effect would be experienced if two large firms, each with 12,500 employees, brought in a 35-hour work week or, alternatively, if 2,500 small firms with ten employees did the same.

Research also shows that WTR has the potential to reduce the environmental impacts of societies (Schor 2005; Rosnick and Weisbrot 2007; Hayden and Shandra 2009; Knight, Rosa, and Schor 2013). In a pioneering study, Schor (2005) analyzed the effect of working hours on the ecological footprints of 18 OECD nations. Her analysis was largely exploratory, but it provided a strong and convincing case for further research. David Rosnick and Mark Weisbrot (2007), in a comparative analysis, revealed that if the United States adopted European work hours, it would have a 20% reduction in energy usage, and, alternatively, Europe as a whole would consume 25% more energy if it were to adopt the energy usage of the United States. Drawing directly from Schor's (2005) pioneering work, Anders Hayden and John Shandra (2009) conducted a cross-sectional analysis of the effect of working hours on the ecological footprints of 45 countries. Their findings suggested that working hours have a measureable and detrimental effect on the environment, meaning an increase in the ecological footprints of nations. More recently, Kyle Knight, Eugene Rosa, and Juliet Schor (2013) completed a longitudinal analysis of 27 high-income nations for the 1970–2007 period. They assessed the effect of working hours on nation's ecological footprints, carbon footprints, and total anthropogenic carbon emissions. They found that for the period of study, working hours has a positive and significant effect on all three measures.

In prior research, the effect of working hours on the environment is analyzed in two different ways. First, it is examined as its contribution to GDP. Second, it is examined in its impact net of GDP. Following Hayden and Shandra (2009) and Knight, Rosa, and Schor (2013), we refer to these two characteristics as scale impacts and compositional impacts, respectively.

More specifically, the scale impact of working hours is understood as its contribution to GDP: as individuals work more they help produce a higher GDP. In addition to the contribution to GDP in production, working hours also foster a higher GDP through increased consumption. Higher hours of work usually lead to larger incomes, and higher incomes are then parlayed into greater levels of consumption. This phenomenon is characterized by Schor (1993) as the 'work and spend cycle'. More broadly, the scale impact is understood as the contribution of hours worked to overall economic growth. According to Knight, Rosa, and Schor (2013, 694), 'more work generates greater economic output, income, and consumption'.

The compositional impact of working hours is measured as net of GDP. This impact rests on the notion that people with longer working hours are more likely to choose ecologically intensive activities than those who work fewer hours. Time affluence plays a critical role. Those with lower amounts of free time will, theoretically, choose more ecologically intensive options and activities whereas those with greater amounts of free time are able to pursue less ecologically intensive options and activities (Knight, Rosa, and Schor 2013). In support of this, Tim Kasser and Kirk Brown (2003) analyzed a sample of 308 people in the United States and found that those who had greater time affluence, specifically those who worked fewer hours, showed more environmentally friendly behaviors than those who worked longer hours.

Objectives of the present study

Overall, prior research has investigated the effects of working hours on the environment, primarily in higher-income, developed nations. The majority of work in this tradition is cross-sectional (e.g., Schor 2005; Hayden and Shandra 2009), and the prior studies that are longitudinal do not consider if the effects of working hours on the environment change in magnitude through time (Knight, Rosa, and Schor 2013). We advance this emerging area of research in two ways.

First, in longitudinal models of energy consumption, we analyze and compare the effects of working hours in both developed and developing nations. This contribution could potentially increase the generalizability of findings found in prior research, or just as important, identify notable differences, if any, in the environment–working hours relationship for developed and developing nations. This is an important issue because previous research has shown that the economies of developed and developing countries are qualitatively different from one another. For example, Stephen Bunker (1985) highlights that many developing countries emerged as extractive economies, exporting raw materials to developed countries for consumption. Thus, developed countries often have production-centered economies and developing countries are more likely to have extractive-oriented economies. Further, the process of ecologically unequal exchange, where developed countries are able to export their environmental impacts to developing countries (e.g., Jorgenson and Clark 2009), could potentially be present in the current analysis, where the populations in developing countries do not get the initial economic benefits associated with increased working time but are saddled with the environmental burden of high levels of working time.

Second, we employ appropriate statistical interactions and model estimation techniques that allow us to assess the extent to which the effect of working hours on energy consumption changes through time. Much recent longitudinal research in environmental sociology and sustainability science more generally has identified changes through time in the magnitude of society–nature relationships (e.g., Jorgenson and Clark 2011, 2012, 2013; Jorgenson 2014; Knight and Schor 2014; Jorgenson and Dietz 2015). Investigating the extent to which the effect of working hours on energy consumption changes through time is more than an academic exercise. If the effect of working hours on energy consumption increases through time, knowing so could help in the formation and adoption of policies to reduce working hours, given the potential for enhanced sustainability in general and climate change mitigation in particular.

Data and methods

The sample

The overall dataset consists of annual observations of 52 countries for the 1990–2008 period. The 52 countries are listed in Table 1, which includes 23 developing countries and 29 developed countries. A country is considered developed if it falls within the top income quartile classification by the World Bank (2014). A country is considered developing if it falls outside of the top income quartile group. Such distinctions based on income quartile classification are common in past research. Of course, this is not a perfect operationalization for the term 'development' as there are varying definitions and ongoing debates about what development is and how it should be operationalized and measured. Data availability at the time of the study for the key independent variables precludes us from including observations before 1990 (the earliest year in which our working hours measures are available for developing countries) or after 2008 (latest year in which our working hours measures are available). To maximize the use of available data, we allow the sample sizes to vary across reported models. In the overall dataset, the number of observations in the models range from 917 to 944, while the number of observations for reported models restricted to only developed countries range from 534 to 544, and for models restricted to only developing countries the number of observations range from 383 to 400. Thorough sensitivity analyses indicate that none of the reported models include any overly influential cases.

Table 1. List of countries.

Argentina*	Germany	Portugal
Australia	Greece	Romania*
Austria	Hungary*	Singapore
Bangladesh*	Iceland	Slovak Republic*
Barbados*	Ireland	Slovenia*
Belgium	Israel	South Korea*
Brazil*	Italy	Spain
Bulgaria*	Jamaica*	Sri Lanka*
Canada	Japan	St. Lucia*
Chile	Latvia*	Sweden
Colombia*	Lithuania	Switzerland
Costa Rica*	Luxembourg	Thailand*
Cyprus	Malaysia*	Turkey*
Czech Republic	Mexico*	United Kingdom
Denmark	Netherlands	United States
Ecuador*	New Zealand	Uruguay
Estonia	Norway	Venezuela*
Finland	Peru*	
France	Poland	

* denotes developing country.

Model estimation technique

This study utilizes a time-series cross-sectional Prais–Winsten regression model with panel-corrected standard errors (PCSE), allowing for disturbances that are heteroskedastic and contemporaneously correlated across panels.[2] We employ PCSE because the feasible generalized least-squares estimator that is often used to analyze panel data produces standard errors that can lead to extreme overconfidence with datasets that do not have very many more time periods than panels. We correct for AR(1) disturbances (first-order autocorrelation) within panels, and since we have no theoretical basis for assuming the process is panel specific, we treat the AR(1) process as common to all panels (Beck and Katz 1995). We include country-specific and year-specific intercepts to control for both country-specific and year-specific effects, the equivalent of a two-way fixed effects model. We note that this modeling technique controls for between-country variation in favor of estimating within-country effects, a relatively conservative approach commonly used in panel analyses in environmental sociology. All variables except for the country-specific and year-specific intercepts are transformed into logarithmic form. Thus, the regression models estimate elasticity coefficients where the coefficient for the independent variable is the estimated net percentage change in the dependent variable associated with a 1% increase in the independent variable.

Dependent variable

The dependent variable for this study is total energy consumption. These data, which are measured in kilotons (kt) of oil equivalent, are obtained from the World Bank (2014). According to the World Bank (2014), 'Energy use refers to use of primary energy before transformation to other end-use fuels, which is equal to indigenous production plus imports and stock changes, minus exports and fuels supplied to ships and aircraft engaged in international transport'. Primary energy includes non-renewable sources, such as oil, coal, natural gas, and uranium, as well as renewable sources, such as wind, solar, and hydro-power (EIA 2015). As one might expect, energy consumption is very highly correlated with carbon dioxide emissions as well as the ecological footprint of nations.

Independent variables

Consistent with previous research (e.g., Hayden and Shandra 2009; Knight, Rosa, and Schor 2013), to analyze the effect of working time on energy consumption we employ the measure annual number of hours worked per worker. As we discussed in greater detail in the 'Literature review' section, the impact of working hours on the environment has been understood in terms of both the scale and compositional impacts. For the scale impact, we disaggregate GDP into three subcomponents to understand working time's contribution to the size of the economy (Ark and McGuckin 1999; Hayden and Shandra 2009; Knight, Rosa, and Schor 2013). In addition to working hours, we control for the other two components of GDP: labor productivity (measured as GDP per hour of work) and employed population percentage (measured as employed population divided by total population). The compositional impact of working hours, in contrast, is measured as net of GDP. Thus, in the analyses that focus on compositional impacts we also control for GDP per capita (measured in 1990 US$ and adjusted for purchasing power parity). For models testing the scale impact of working time on energy use, we include labor productivity and employed population percentage along with working time as a proxy for GDP. In models testing the compositional impact, we use GDP per capita as a control variable to measure the impact of working hours outside of its contribution to GDP. All of these data are obtained from The Conference Board's (2014) *Total Economy Database*.

In order to assess potentially changing effects through time, we include interactions between annual working hours per worker and dummy variables for each year (1990–2008), with 1990 as the reference year (Allison 2009).

In line with past sociological research on total energy consumption and similar outcomes, we also control for urban population as percent of total population, industry value added measured as a percentage of total GDP, services value added as a percentage of total GDP, and total population size. We obtain all of these data from the World Bank (2014).

Table 2 provides the descriptive statistics for all variables included in the analyses (except for the interactions between working hours and the year dummy variables), while Table 3 reports their bivariate correlations.

Table 2. Descriptive statistics.

Variable	*N*	Mean	Std. dev.	Min	Max
Energy consumption	1017	10.3111	1.56251	4.02392	14.66438
Working hours	1039	7.52668	0.12442	7.23634	7.892452
GDP per capita	1010	9.36874	1.13579	5.59704	11.38187
GDP per hour worked	1017	2.59971	0.69608	−0.1744	3.649359
Employed population %	1017	3.75963	0.15498	3.31091	4.275971
Urban population %	1017	4.1929	0.35263	2.71306	4.60517
Industry value added	997	3.40081	0.22625	2.7153	4.103648
Services value added	978	4.12681	0.16539	3.2702	4.437135
Total population	1017	8.45753	1.63964	3.93183	11.90219

Note: All variables are logged (ln).

Table 3. Bivariate correlation matrix.

Variable	1	2	3	4	5	6	7	8
1. Energy consumption								
2. Working hours	−0.116							
3. GDP per capita	0.253	−0.579						
4. GDP per hour worked	0.279	−0.638	0.936					
5. Employed population %	0.114	−0.352	0.594	0.459				
6. Urban population %	0.255	−0.42	0.619	0.642	0.304			
7. Industry value added	0.181	0.283	−0.262	−0.236	−0.075	−0.005		
8. Services value added	0.049	−0.406	0.634	0.614	0.268	0.357	−0.782	
9. Total population	0.876	0.129	−0.177	−0.146	−0.143	−0.061	0.212	−0.161

Note: All variables are logged (ln).

Results

Model 1, listed in Table 4, includes all countries in the dataset. Model 2 includes only developed countries and Model 3 includes only developing countries. All three models analyze the scale impact of working hours on energy consumption. In Model 1, we find that the effect of working hours on energy consumption is positive and significant. More specifically, from 1990 to 2008, on average, a 1% increase in working hours results in a .318% increase in total energy consumption. GDP per hour and total population both exhibit positive effects on energy consumption, while the effects of employed population percentage and services value added are negative.

In Model 2 (developed countries only), the effect of working hours on energy consumption is positive and significant. More specifically, from 1990 to 2008, a 1% increase in working hours results in a .404% increase in energy consumption. GDP per hour, total population, and urban population percentage, all have positive effects on energy consumption, while the effects of employed population percentage and services value added are negative. In Model 3 (developing countries only), the effect of working hours on energy consumption is nonsignificant, which differs from the results of Models 1 and 2. However, the effects of the control variables are generally consistent with the findings for the preceding two models.

Table 5 presents the results for Models 4 (all countries), 5 (developed countries), and 6 (developing countries), which examine the compositional impact of working hours on energy consumption. The results suggest that the effect of working hours on energy consumption net of GDP per capita is nonsignificant in all three models. The control variables in the three models are all similar. The effects of GDP per capita, urban population as percent of total population, and total population on energy consumption are all positive, while the effect of services value added is negative.

Table 6 contains results for Models 7 (all countries), 8 (developed countries), and 9 (developing countries). These models assess the scale impact of working hours on energy consumption, and also include the interactions between working hours and the year dummy variables. In these models, the coefficient for work hours is the unit change in the dependent variable in 1990 for each unit increase in work hours for the same year. The overall effect of work hours for the other time points (i.e., 1991, . . ., 2008) equals the sum of the coefficient for work hours and the appropriate interaction term if the latter is statistically significant (Allison 2009).

In Model 7, the effect of working hours on energy consumption increases through time. In 1990, the estimated effect of working hours was actually negative, with a coefficient of −.262. However, the estimated effect changes to a coefficient of .492 by the year 2008. More substantively, whereas in 1990 a 1% increase in working time results in a .262% *decrease* in energy consumption, in 2008 a 1% increase in working time results in a .492% *increase* in energy consumption.

Table 4. Energy use (kt of oil equivalent): scale impact. Prais–Winsten regression with PCSE and AR(1) correction: 1990–2008.

	Model 1: all countries	Model 2: developed	Model 3: developing
Work hours	.318 (.078)***	.404 (.131)**	.133 (.113)
GDP per hour	.259 (.030)***	.488 (.076)***	.207 (.026)***
Employed population %	−1.136 (.202)***	−.720 (.298)*	−1.459 (.142)***
Urban population %	.280 (.203)	.790 (.338)*	−.031 (.157)
Industry value added	−.077 (.052)	−.162 (.099)	−.238 (.068)***
Services value added	−.310 (.061)***	−.703 (.146)***	−.374 (.080)***
Total population	1.662 (.191)***	1.245 (.255)***	1.993 (.128)***
Number of observations	944	544	400
R^2 value	.998	.998	.998

Notes: All models also contain unreported period-specific and unit-specific intercepts. Panel corrected standard errors are reported in parentheses.
*$p \leq .05$, ** $p \leq .01$, *** $p \leq .001$.

Table 5. Energy use (kt of oil equivalent): compositional impact. Prais–Winsten regression with PCSE and AR(1) correction: 1990–2008.

	Model 4: all countries	Model 5: developed	Model 6: developing
Work hours	.099 (.098)	.179 (.140)	.029 (.112)
GDP per capita	.385 (.056)***	.451 (.083)***	.335 (.041)***
Urban population %	.804 (.133)***	1.015 (.263)***	.651 (.106)***
Industry value added	−.007 (.063)	−.148 (.107)	−.138 (.073)
Services value added	−.209 (.050)***	−.627 (.164)***	−.259 (.068)***
Total population	.709 (.057)***	.572 (.093)***	.787 (.041)***
Number of observations	917	534	383
*R*2 value	.998	.998	.998

Notes: All models also contain unreported period-specific and unit-specific intercepts. Panel corrected standard errors are reported in parentheses.
*** $p \leq .001$.

Table 6. Energy use (kt of oil equivalent): scale impact. Prais–Winsten regression with PCSE and AR(1) correction: 1990–2008.

	Model 7: all countries	Model 8: developed	Model 9: developing
Work hours	−.262 (.095)**	.088 (.144)	−.656 (.142)***
GDP per hour	.204 (.032)***	.420 (.082)***	.173 (.024)***
Employed population %	−.898 (.184)***	−.597 (.261)*	−1.381 (.142)***
Urban population %	.247 (.195)	.765 (.321)*	−.126 (.165)
Industry value added	−.153 (.056)**	−.187 (.098)	−.288 (.079)***
Services value added	−.443 (.073)***	−.782 (.154)***	−.419 (.090)***
Total population	1.373 (.172)***	1.101 (.218)***	1.814 (.133)***
Work × 1991	.042 (.016)**	−.051 (.040)	.307 (.038)***
Work × 1992	.209 (.025)***	.127 (.057)*	.416 (.048)***
Work × 1993	.296 (.032)***	.292 (.063)***	.472 (.058)***
Work × 1994	.356 (.031)***	.506 (.062)***	.425 (.068)***
Work × 1995	.314 (.031)***	.289 (.067)***	.402 (.076)***
Work × 1996	.366 (.034)***	.325 (.074)***	.582 (.092)***
Work × 1997	.532 (.036)***	.518 (.082)***	.836 (.098)***
Work × 1998	.427 (.036)***	.367 (.090)***	.668 (.085)***
Work × 1999	.447 (.036)***	.288 (.092)**	.849 (.077)***
Work × 2000	.538 (.041)***	.341 (.098)***	.921 (.069)***
Work × 2001	.550 (.044)***	.366 (.105)***	.909 (.069)***
Work × 2002	.603 (.046)***	.389 (.111)***	.974 (.076)***
Work × 2003	.622 (.048)***	.439 (.118)***	.991 (.078)***
Work × 2004	.682 (.050)***	.520 (.126)***	.983 (.080)***
Work × 2005	.658 (.052)***	.278 (.133)*	.985 (.074)***
Work × 2006	.671 (.054)***	.293 (.136)*	.956 (.073)***
Work × 2007	.748 (.057)***	.339 (.145)*	1.023 (.070)***
Work × 2008	.754 (.059)***	.420 (.158)**	1.016 (.071)***
Number of observations	944	544	400
R^2 value	.998	.998	.998

Notes: All models also contain unreported period-specific and unit-specific intercepts. Panel corrected standard errors are reported in parentheses.
*$p \leq .05$, ** $p \leq .01$, *** $p \leq .001$.

In Model 8, the effect of working hours in 1990 is nonsignificant and thus not significantly different than zero. Like Model 7, the effect of working hours on energy consumption increases throughout the period of study. This model is moderately different than the previous one, however, as the increase in the effect of working hours is not as steady when restricting the sample to just the developed countries. The estimated effect increases to .506 in 1994 but then falls to .289 in 1995 before beginning to increase again. This occurs again in 2004 where the estimated effect decreases from .520 to .278 in 2005. Then the effect steadily increases through time, where in the year 2008, a 1% increase in working hours results in a .420% increase in energy consumption, which is relatively similar to the effect in 2008 for the full sample in Model 7.

In Model 9, the effect of working hours on energy consumption in developing countries increases throughout the period of study, and like Model 7, this increase is relatively steady. The estimated coefficient for the effect of working hours for the year 1990 is negative (i.e., −.656). By 1997, the estimated effect becomes positive with a value of .193. By 2008, the coefficient for the effect of working hours increases to .360. In summary, while a 1% increase in working hours in 1990 resulted in a .656% *decrease* in energy consumption, in 2008 a 1% increase in working hours resulted in a .360% *increase* in energy consumption.

Table 7. Energy use (kt of oil equivalent): compositional impact. Prais–Winsten regression with PCSE and AR(1) correction: 1990–2008.

	Model 10: all countries	Model 11: developed	Model 12: developing
Work hours	−.574 (.115)***	−.568 (.190)**	−.648 (.163)***
GDP per capita	.304 (.058)***	.357 (.079)***	.274 (.044)***
Urban population %	.617 (.140)***	.928 (.256)***	.470 (.093)***
Industry value added	−.106 (.065)	−.165 (.101)	−.184 (.082)*
Services value added	−.379 (.058)***	−.759 (.154)***	−.326 (.074)***
Total population	.628 (.055)***	.518 (.073)***	.728 (.037)***
Work × 1991	.032 (.013)*	−.032 (.067)	.209 (.033)***
Work × 1992	.199 (.022)***	.202 (.091)*	.266 (.052)***
Work × 1993	.292 (.030)***	.438 (.097)***	.303 (.062)***
Work × 1994	.362 (.032)***	.718 (.094)***	.263 (.061)***
Work × 1995	.345 (.035)***	.554 (.092)***	.218 (.076)**
Work × 1996	.384 (.037)***	.591 (.095)***	.295 (.085)***
Work × 1997	.576 (.038)***	.813 (.097)***	.563 (.092)***
Work × 1998	.540 (.035)***	.691 (.096)***	.530 (.091)***
Work × 1999	.594 (.036)***	.692 (.093)***	.698 (.102)***
Work × 2000	.686 (.042)***	.761 (.097)***	.776 (.103)***
Work × 2001	.720 (.044)***	.815 (.096)***	.792 (.095)***
Work × 2002	.771 (.046)***	.850 (.094)***	.809 (.090)***
Work × 2003	.776 (.049)***	.894 (.096)***	.845 (.088)***
Work × 2004	.828 (.052)***	.976 (.095)***	.871 (.084)***
Work × 2005	.812 (.054)***	.732 (.097)***	.923 (.082)***
Work × 2006	.813 (.056)***	.738 (.095)***	.919 (.081)***
Work × 2007	.893 (.059)***	.792 (.098)***	1.010 (.074)***
Work × 2008	.906 (.064)***	.889 (.106)***	1.060 (.075)***
Number of observations	917	534	383
R^2 value	.998	.998	.998

Notes: All models also contain unreported period-specific and unit-specific intercepts. Panel corrected standard errors are reported in parentheses.
*$p \leq .05$, ** $p \leq .01$, *** $p \leq .001$.

Table 7 includes Models 10 (all countries), 11 (developed countries), and 12 (developing countries). These models analyze the compositional effect of working hours on energy consumption, and include the interactions between working hours and the year dummy variables.

In Model 10, the estimated effect of working hours on energy consumption in the year 1990 is negative with a coefficient of −.574. By 2008, the estimated coefficient for the effect of working hours is positive with a value of .332. In general, this changing effect increases steadily throughout the period of study. Model 11 yields results similar to Model 10. For the sample restricted to only developed countries, in 1990 the estimated coefficient for the effect of working hours on energy consumption was −.568, and by the year 2008 the coefficient increased to a value of .321. Model 12 also exhibits a similar trend. For the sample restricted to only developing countries, the coefficient for the estimated effect of working hours on energy consumption in the year 1990 is −.648 and gradually increases through time, where in the year 2008 the coefficient is positive and an estimated value of .421.

Discussion and conclusion

Degrowth proponents argue that a WTR is one way in which countries can begin to slow down their economic growth, enhance well-being, and in turn reduce their impact on the environment. Previous scholarship suggests diminishing returns in greater human well-being and life satisfaction from further economic growth (Jackson 2005, 2009a, 2009b; Brady, Kaya, Beckfield 2007). Additionally, research indicates that greater working hours leads to increased environmental pressures (Schor 2005; Rosnick and Weisbrot 2007; Hayden and Shandra 2009; Knight, Rosa, and Schor 2013). There is much interest in further analyzing the relationship between working hours and the environment, given concerns regarding sustainability.

The present longitudinal study analyzed the relationship between average annual working hours and energy consumption for 52 countries. The reported findings contribute to the literature on this topic in two ways.

First, we included data for both developing and developed nations, while prior work in this tradition tends to focus on developed countries (e.g., Knight, Rosa, and Schor 2013). The focus in prior research on developed nations is due primarily to the fact that the propositions of economic degrowth target these nations, rather than developing countries. According to key tenets of the economic degrowth perspective, developed countries should work toward stabilizing and ideally shrinking their economies to ecologically sustainable sizes, thus allowing developing countries to continue pursuing economic growth until they reach a socially and ecologically desirable level on par with developed countries. This general position does not mean that we should overlook the relationship between working time and the environment in developing nations within the Global South. Indeed, as the results of the present study show, the relationship between working hours and energy consumption is growing most rapidly for developing nations. This means that as these countries continue to develop economically, working time will arise as a problem for sustainability there as well. Furthermore, as studies focusing on ecologically unequal exchange show, developed countries are often able to export their environmental impact to developing nations, oftentimes through trade (Bunker 1985; Bunker and Ciccantell 2005; Jorgenson 2012). Therefore, although this study does not engage this specific question, it is plausible that the environmental burdens of working time in developing countries, a large amount of which is dedicated to production of goods and extraction of raw materials destined for developed countries, are not benefitting people within those countries. This study sets the stage by showing that working time is associated with increasing energy consumption in developing countries; further studies can build upon this by examining if there is an ecologically unequal relationship occurring as well. In any case, and more broadly, although a reduction in working time in developing countries is not a current focus of the economic degrowth framework, understanding how the relationship unfolds in both developed and developing countries improves our collective understanding of such complex society–nature relationships.

Second, in this study, we employed appropriate interactions and modeling techniques that allow for assessing the extent to which the effect of working hours on energy consumption changes over time. The previous research that we draw from is either cross-sectional (e.g., Schor 2005; Hayden and Shandra 2009) or longitudinal, but the latter do not explore the temporal stability of the working hours and environment relationship (e.g., Knight, Rosa, and Schor 2013). It is important to assess the potentially changing magnitude in the relationship because it further sheds light onto whether or not nations can enhance sustainability through greater efforts in WTR.

Consistent with previous research, we find that working time increases energy consumption. Our results further indicate that the relationship between working hours and energy consumption is intensifying (i.e., increasing) through time for both developed and developing countries. Furthermore, we find this relationship for both the scale and compositional impacts, which supports the position that a WTR would be a viable pathway for countries to lower their environmental impacts. It is important to note, however, that our argument is not that WTR is more or less important than other environmental issues or ways in which countries can reduce their environmental impacts. Rather, we see WTR as one of many ways in which countries can begin down the path of environmental sustainability, just as it is only one of many ways economic degrowth could begin.

The findings for the analyses increase our collective understanding of the relationship between working hours and the environment. But they also provide some surprises that warrant future research. In particular, the estimated effects of working hours on energy consumption were initially negative in the earlier years of the longitudinal analyses for both the developed and developing nations. While these effects changed to positive and increasingly so through time, the initial negative effects are inconsistent with the general assertions of the WTR literature that we engage. Rather than providing tentative and inadequate explanations for the initial negative effects, we suggest that future research would do well to deeply consider why the relationships may have been negative in the early years of the study. Such surprising findings, coupled with the increasing magnitude of the effects of working hours on energy consumption through time, highlight the importance in considering such temporal changes in the magnitude of society–nature relationships. As illustrated by this study as well as prior research on related topics (e.g., Jorgenson and Clark 2012), when longitudinal data are available, such analyses are possible.

As noted above, the focus of economic degrowth, including WTR as a mechanism, is mainly intended for developed countries that already enjoy a relatively high standard of living. We share this view. Since a WTR can be both ecologically and socially beneficial, developed countries should focus on such a change, especially since our results show that the effect of working hours on energy consumption in developed nations has increased in magnitude through time, and these nations account for a much larger share of global energy consumption and thus anthropogenic carbon emissions than developing nations.

There are many hurdles that exist to make this sort of policy socially attainable in developed nations. One such hurdle could be the existence of social programs that ensure the lower incomes from reduced working time do not harm people. For instance, a reduction in working time is more feasible for countries where a larger 'social safety net' exists (such as in many Northern and Western European countries). However, a WTR in a country with a small 'social safety net' (such as the United States) could be difficult to implement as workers could then struggle to attain life necessities, such as health care. Due to this, it is likely that a WTR in countries without a large 'social safety net' would only be socially desirable if other structural changes were coupled with it to ensure that well-being is not negatively affected by a loss of income. Although this loss of income sounds politically unfeasible, prior research suggests that workers prefer increased leisure time over their lost incomes (Hayden 1999).

The observed increasing effect of working hours on energy consumption for the sample of developing nations suggests that degrowth proponents would do well to consider ways in which these nations can offset the growing environmental impacts of working hours within their borders. These results may also suggest a type of path dependency, posited by treadmill of production scholars, associated with economic growth in general. It is important to assess the historical trends of this relationship, while also considering the importance of addressing structures of inequality. In developing countries, it is likely that a large 'social safety net' coupled with additional national policies to alleviate inequality and to enhance human well-being must be part of any efforts to reduce working time and energy consumption. How these nations grow and then transition to degrowth societies remains a paramount concern, just as the shift in developed countries is vitally important.

Disclosure statement

No potential conflict of interest was reported by the authors.

Notes

1. The EKC is based on the Kuznets curve hypothesis developed by the economist Simon Kuznets (1955), which postulated on inverted U-shaped curve regarding the relationship between income inequality and economic development.
2. It is important to note that when using longitudinal regression techniques we are better able to make causal arguments relative to cross-sectional models. Whereas cross-sectional analyses only allow researchers to view relationships at one time point, thus making assertions of causality difficult, longitudinal analyses allow researchers to assess how changes through time in independent variables lead to changes through time in the dependent variable. Beyond this, our theoretical formulation suggests that the relationship being analyzed here, working hours and energy consumption, is a causal one.

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