EXPLORING THE RELATIONSHIPS BETWEEN WORKING TIME, CONSUMPTION, AND THE ENVIRONMENT

by

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Abstract

This thesis explores the relationships between working time, consumption, and environmental impact by expanding on the work of Hayden and Shandra (2009) and Knight, Rosa, and Schor (2013). Panel data models were constructed to estimate the relationship between working hours and three measures of environmental impact: Ecological Footprint, carbon Ecological Footprint, and CO_2 emissions. The sample contains 2007-2012 data from OECD countries, and a number of control variables were included. Of particular interest was the influence of GDP/capita, full and part-time employment, and female participation in the labour force on the relationship between working hours and environmental impact. The results show a positive and statistically significant relationship between working hours and all three measures of environmental impact. These estimates, however, are smaller and less significant when GDP/capita is controlled for. This indicates that the positive relationship between working hours and environmental impact is predominantly driven by variation in GDP/capita. Work-time reduction could cause a decline in environmental impact; the desirability of such a policy is contingent on attitudes towards consumption.

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Chapter 1: Introduction

1.1 Statement of the Problem

The environmental impacts of modern civilization are significant. Recent decades have been filled with calls to radically and urgently change the way our economies and societies relate to the environment. Such calls often manifest in the demand for increased regulation of the environment or for more efficient technology. Carbon pricing, investment in renewable energy, and the protection of natural ecosystems are all examples of remedies to environmental problems that are driven by either government or technological change. These solutions are important, but they do not address the problem in its entirety. Insatiable consumption in advanced economies is a major contributor to the negative environmental impacts of the economy and should also be changed.

In recent years, a number of authors have proposed that work-time reduction (WTR) could be used to slow rampant consumption, and therefore reduce negative environmental impacts, in advanced economies. There are at least three key mechanisms by which a reduction in working time could theoretically have this impact on the economy. WTR could potentially make reduced GDP growth more viable, reduce consumption, and reduce the resource intensity of consumption.

The first mechanism is macroeconomic. It has been well established that GDP growth is positively associated with measures of environmental impact such as Ecological Footprint (EF) and CO_2 emissions (for example, Antal, 2014)**.** Because of this association, many environmentalists call for reductions in GDP growth. One iteration of this idea is labeled "degrowth". In such a regime, GDP growth is allowed to be low or negative, but low or negative growth is not targeted; the economy is set up to optimize indicators such as the poverty rate or environmental impact rather than GDP (for example, Victor, 2012). Although reduced GDP growth is desirable from an environmental perspective[1], economic problems arise. Most notably is the issue of unemployment.

[1] It is important to note that this is based on the assumption that externalities are not adequately included in the measurement of GDP.

Historically, GDP growth has been used as a means to promote full employment. GDP growth has a relatively stable, negative relationship with the unemployment rate (Antal, 2014; Okun, 1962). This means that one would expect a reduction in GDP growth, for environmental or other reasons, to be associated with an increase in the unemployment rate. Therefore, there is a tradeoff between environmental and socioeconomic problems due to the conflicting relationships GDP growth has with environmental impact and the unemployment rate (Antal, 2014).

WTR could potentially be used to minimize the socioeconomic impacts of reduced GDP growth. Working hours could be redistributed from those working a lot to those working very little or not at all. If this is done, then the employment rate in the economy should increase, all else equal. Therefore, WTR policy could be implemented in tandem with a reduction in GDP growth, minimizing the environmental impact of an economy without causing a subsequent increase in the unemployment rate.

The second and third mechanisms by which WTR might reduce environmental impact are microeconomic, affecting the way that individuals consume. Working time is a major determinant of income, particularly for wage workers. Similarly, income is a key determinant of consumption. If WTR causes a decline in income, then a decline in consumption should follow, which would in turn reduce the overall environmental impact of the economy. Knight, Rosa, and Schor refer to this as the scale effect (2013).

In contrast to the scale effect, Knight et al. also explore the possibility of what they refer to as a composition effect, which concerns the resource intensity of consumption, or environmental impact per dollar (2013). Labour economists typically model the decision to work as a trade-off between labour and leisure; a reduction in working time would, by this definition, be associated with an increase in leisure time[2]. The logic behind the composition effect suggests that many individuals have the preference to engage in activities like gardening, biking, eating at home, and so on, which are ostensibly more sustainable. However, the time scarcity imposed upon most lives by a busy work schedule precludes this. Therefore, WTR could liberate time, allowing people to satisfy their desire to engage in sustainable activities.

[2] The term “leisure time” can be slightly misleading. In this paradigm, leisure is anything that is not paid work. Therefore, the production of goods in the home would constitute leisure.

1.2 Purpose of the Study

The three aforementioned points establish that there is some logic behind the idea that WTR could reduce the environmental impact of an economy. Further, some studies have established a statistical and positive relationship between working hours and environmental impact (Schor, 2005; Hayden and Shandra, 2009; Knight et al, 2013). This paper aims to expand on previous studies and add to the discussion concerning the relationship between working time and the environment.

A set of statistical models will be constructed to estimate the relationship between working hours, environmental impact, and various other variables. The models will take the basic form of those tested by Knight et al (2013) but will differ in a few critical ways. This paper will use data from 2007-2012, the majority of which was not available at the time of Knight et al's study. The period of interest encapsulates the 2008 financial crash and its aftermath, which may have implications for the relationship between working hours and the environment due to unemployment during the recession. Additionally, particular attention will be paid to other variables that could influence the relationship.

Previously, authors exploring this topic have focused on average annual working hours. This indicator treats all sources of variation in working hours as equal. The prevalence of part-time work in the economy is one potential source of variability in working hours. An increase in the amount of part-time work would likely have a different impact on consumer behavior, and therefore the environment, than a government-legislated reduction in the standard work week. Because of this, part-time employment will be a focal point of this study. Additionally, female participation in the labour force and the length of maternity leave are also considered. These two variables could have an impact on consumer behavior, and particularly on the balance between household production and consumption in the market. A key objective of this paper is to determine how these variables influence the relationship between working hours and the environment.

Work-time reduction could be a way to minimize the environmental impact of advanced economies. This paper seeks to test the hypothesis that working hours and environmental impact are related and to further explore the mechanisms behind any observable relationship.

1.3 Definitions

Work-time reduction (WTR): following from Schor (2005), Hayden and Shandra (2009), and Knight et al (2013), WTR refers to a reduction in the average annual working hours per worker in the economy.

Part-time work: anyone working fewer than 30 hours per week on average is considered a part-time worker.

Chapter 2: Literature Review

Work-time reduction has been proposed as a potential method to reduce the environmental impact of the economy. This chapter will begin by illustrating how WTR policies offer a counterpoint to other solutions to environmental problems, in particular those based on technological progress. The theory that suggests that WTR can have a positive environmental impact will then be described, and these theoretical claims will be evaluated based on existing empirical research. Finally, other variables that may influence the relationship between WTR and environmental impacts will be discussed.

2.1 Economy and Environment

Miklos Antal outlines two well-known empirical relationships and the dilemmas they create. GDP has a strong negative correlation with the unemployment rate, which is part of the reason why GDP growth is at the focal point of economic policy-making. Additionally, global GDP growth is positively associated with CO_2 emissions (Antal, 2014). This relationship is the source of many environmental problems, and calls for serious reductions in CO_2 emissions abound (for example, Hansen et al, 2015; IPCC, 2014). Therefore, a key problem for the immediate future is reducing the environmental impact of the economy without creating rampant unemployment.

Based on the dichotomy established by Antal, achieving this goal can be done by breaking either the relationship between GDP growth and environmental impact or between GDP growth and unemployment. If the former is done, then growth could continue – keeping unemployment in check – without further damaging the environment. The latter would make reductions in growth, and therefore in environmental impact, more viable.

Arguments supporting the notion that growth and environmental impact will decouple are fairly common. This idea is codified in the Environmental Kuznets' Curve (EKC) hypothesis, which posits that growth and environmental impact have an inverted U-shaped relationship (eg. Panayotou, 1993). In the early stages of economic development, growth is associated with increases in emissions. However, once a certain level of wealth is reached, further growth will be associated with a decline in emissions (Panayotou, 1993).

There is a considerable amount of evidence concerning the EKC hypothesis, and a comprehensive analysis is beyond the scope of this paper. The following studies serve to illustrate some general points within the literature on the EKC. Han and Lee studied OECD countries from 1980-2009. They found that over that time period the effect of CO_2 emissions on growth in GDP declined significantly (Han and Lee, 2013). Chen and Chen's analysis of the most developed urban areas of China also yields support for an EKC (2015). Further, Sephton and Mann found strong evidence for an EKC in the UK (2016).

These studies support the notion that GDP growth can decouple from environmental impact, but it is important to qualify this evidence. It is notable that all of the studies mentioned only found evidence that they interpreted as consistent with decoupling in the wealthier parts of the world. This is problematic because resource-intensive production has moved from developed to developing economies without a simultaneous change in consumption (Dietzenbacher, Pei, and Yang, 2009). As a result, some of the emissions associated with consumption in advanced economies are displaced, creating the illusion of decoupling at a national scale but not on a global scale. For example, estimates for emissions associated with Chinese exports may be inflated by as much as 60% based on this process (Dietzenbacher et al, 2009).

How decoupling is defined in these studies is also relevant. Han and Lee (2013) Chen and Chen (2015), and Sephton and Mann (2016) all focus on the relationship between GDP per capita and CO_2 emissions per capita, which would constitute relative decoupling (Bassetti, Benos, & Karagiannis, 2013). Relative decoupling means that the impact of a unit of GDP is declining over time; GDP continues to have a negative, albeit smaller, environmental impact. In contrast, absolute decoupling occurs when growth no longer has any negative impact, or even has a positive impact, on the environment. Absolute decoupling is necessary to avoid the worst environmental impacts warned of by, for example, Hansen et al (2015). Some estimates suggest that, in order to constrain global temperature rise to 2 degrees Celsius, global emissions will have to decrease by

6% per year (Hansen et al, 2015, p. 20122). This clearly constitutes absolute as opposed to relative decoupling. Unfortunately, there is no evidence of the absolute decoupling of GDP growth from CO_2 emissions (Bassetti et al, 2013) or energy use (Luzzati & Orsini, 2009).

It is important to note that the lack of evidence for absolute decoupling does not contradict the results presented by, for example, Chen and Chen (2015). The problem for many critics of the EKC hypothesis is not the existence of decoupling but the speed with which it occurs relative to the urgency needed to adequately address climate change and other environmental problems. For example, Antal does not discredit the notion of decoupling in general, but he is extremely sceptical of "quick absolute decoupling" (2014, p. 279). This view is echoed by the UNEP, which cites the sheer scale of resource use and energy consumption as an indication that absolute decoupling will not occur in the near future (2011).

Technological progress, increases in efficiency, and other potential causes of the decoupling of GDP growth from environmental impact are all important aspects of the solution to modern environmental problems. However, following from Antal and the UNEP, the likelihood that absolute decoupling will occur in a timely manner (for example, to meet the targets set in Paris in 2015) is small. Because of this, additional and complementary solutions should be sought.

2.2 Work-Time Reduction

A number of authors have suggested work-time reduction or work-sharing as an alternative method to resolving the dilemma presented by Antal (2014). Peter Victor, for example, uses annual hours worked as a key variable in his simulation models of the Canadian economy (2006, 2012). Though working time plays a critical role in Victor's modelling, it is not the focus of his analyses. Victor's research and his simulation model of the Canadian economy, LowGrowth, are focussed on making the argument that wellbeing and prosperity can increase in the absence of economic growth (Victor and Rosenbluth, 2006). To do this, he simulates the Canadian economy under scenarios of "business as usual" growth, low growth, and "degrowth", where GDP growth is not a primary economic goal and is often negative (Victor and Rosenbluth, 2006). Among other variables, he tracks CO_2 emissions, employment (as a percent of the labour force), the poverty rate (percent of the population below the low income cut-off, or LICO), and annual labour hours (Victor and Rosenbluth, 2006).

The results of Victor's simulation model make an interesting case for WTR as a policy to aid in reducing the environmental impact of an economy. In the degrowth scenario, CO_2 emissions decline quite significantly (2012). Taken alone, this is a fairly predictable result, as it is one of the key goals of a degrowth regime. The impact on the poverty and employment rates are more surprising. Overall, employment increased and the poverty rate decreased in the degrowth scenario (Victor, 2012). One of the critical elements of the simulation model that made this possible was a reduction in average annual working hours (Victor, 2012). Working hours are redistributed from those who work the most to those who work less or not at all. This redistribution decreases the unemployment rate, even though an employed person works fewer hours on average. Victor shows that, at least in a purely theoretical framework, it is possible to reduce growth and environmental impact without concurrent increases in unemployment and poverty (Victor, 2012).

The use of a reduction in working time in Victor's models suggest that similar policies can be used to make decreases in growth more economically viable. This indirectly benefits the environment due to the pressures caused by economic growth. Other avenues through which work-time reductions may reduce pressure on the environment are also conceivable.

One way is by minimizing growth in consumption. The benefits of increased labour productivity are typically distributed through increases in incomes. However, a reduction in working hours is an alternative way to distribute these benefits (Bosch and Lendhorff, 2001; Hayden and Shandra, 2009). If productivity gains result in decreased work-time rather than increased incomes, then future growth in consumption could be prevented (Hayden and Shandra, 2009; Schor, 2005). Work-time reduction may halt growth in consumption, and it could also alter the resource intensity of consumption. Schor speculates that, if incomes are stabilized through work-time reduction, then "the average consumption intensity of a unit of time will decline. It seems likely that, on average, as the economy shifts to a situation of 'time surplus,' there will be a decline in demand for speed and convenience, both of which are [environmentally] damaging" (2005, p. 47). Rather than spending time consuming and producing, extra leisure time might be spend with friends and family, in a garden, or on any number of other low-impact activities (Pullinger, 2014).

In addition to the various ways in which work-time reduction can conceivably reduce the environmental pressure of the economy, there seems to be some demonstrable preference for work-time reduction in advanced economies. The Canadian department of Employment and Social Development reports that 58% of Canadians feel overloaded by duties in their home and work lives (2016). Otterbach compares the preferred and actual work times in various countries. He finds that there tends to be an excess demand for paid work in poorer countries and an excess demand for leisure time in most developed nations (Otterbach, 2010). An investigation of the Australian labour market conducted by Reynolds and Aletraris also found that the preference for working fewer hours was a major source of work hour mismatches (2006). This evidence suggests that the desire for reduced working hours is prevalent in advanced economies but is precluded by inflexible work arrangements.

The demand for working less seems to be present. Further, if the arguments introduced above are true, there is an environmental incentive for working less. Three main avenues through which work-time reduction can theoretically improve the sustainability of the economy have been outlined as follows:

1. Work-time reduction could keep employment high in a low growth environment, thus making low growth more viable (Victor, 2012; Zwickl et al, 2016).
2. Work-time reduction could halt growth in consumption (Hayden and Schandra, 2009; Schor, 2005).
3. Work-time reduction could decrease energy intensive consumption (Schor, 2005; Pullinger, 2014).

This creates a theoretical case for work-time reduction as a policy to encourage a more sustainable economy. However, these claims about work-time reduction should be empirically evaluated before being accepted.

2.3 Work-Time Reduction and Employment

The employment effects of work-time reduction are of vital importance to the arguments presented above. If work-time reduction is not associated with increases in employment, as Victor's model assumes, then the degrowth scenario (2012) would certainly not include reduced unemployment, poverty, and emissions. Work-time reduction policy has never been used with explicit environmental goals in mind, but there are many instances when working time has declined in the past for other reasons.

Average working hours have been declining in most advanced economies since the 1870s (Whaples, 2001). There is a variety of reasons for this trend. One notable cause is the entry of women into the workforce, and the associated growth in part-time work (Zwickl et al, 2016). Another is unions. In fact, the OECD found a strong relationship between various measures of collective bargaining power (such as union density and coverage) and work-time reduction (1998). This suggests that unions are key players in lobbying and negotiating for work-time reduction policies.

In the long term, paid working hours have been declining fairly steadily and without adverse economic consequences. Work-time reduction has also been used to dampen unemployment effects in the short term. For example, during the Great Depression, the average work week in the USA declined from 48 hours to 35 hours, and some argue that this helped reduce the negative effects of the depression (Whaples, 2001). Further, some European countries have begun to introduce or consider working time reduction policies since the 1990s (Bosch and Lendhorff, 2001) and especially since the 2008 crash (Balleer, Gehrke, Lechthaler, and Merkl, 2016). Notably, France reduced the average work week from 40 hours to 35 in 2000 (Bosch and Lendhorff, 2001). These recent experiments with work-time reduction in Europe have provided ample opportunity to analyse the short-term employment effects of the policy in more detail.

Jennifer Hunt used a series of regression analyses to estimate effects of reduced standard work-weeks on employment in Germany from 1984-1994 (1999). She used panel data to explore the relationship between the reduced standard work-week, which emerged largely as a result of union pressure, and a number of variables, including wages and the change in actual time worked (Hunt, 1999). Hunt found that a reduction in the standard work-week by one hour was associated with about a 2% increase in the hourly wage rate (1999, p. 144). This means that any income lost to working fewer hours is compensated by the wage increase, which was one of the key demands of German labour unions (Hunt, 1999). Hunt's results concerning the effect of work-time reduction on employment, however, were mostly statistically insignificant. For males in particular, however, the results did seem to indicate that employment had declined (1999).

The results of Hunt call into question the effects of work-time reduction purported by those like Victor (2012) or Zwickl et al (2016). Balleer et al also find evidence questioning the connection between work-time reduction and employment (2016). Their study also focussed on the German labour market but distinguishes between two forms of work-time reduction. Firms in Germany are allowed to institute work-time reductions if they meet particular criteria. These criteria are such that more firms are eligible during recessions, which means the policies will have an automatic stabilizing effect on unemployment by encouraging reductions in working hours rather than layoffs (Balleer et al, 2016). Alternatively, changes to the eligibility criteria or other aspects of Germany's work-time reduction policies can be introduced at the whim of legislators, which Balleer et al refer to as discretionary policy (2016). Balleer et al find that the automatic stabilizing effects of the policies did indeed have an effect on unemployment; the authors estimate that the policies prevented a 1.29% increase in unemployment during the great recession (Balleer et al, 2016, p. 120). Conversely, they find that discretionary work-time reduction policies had no effect (Balleer et al, 2016).

The results of Balleer et al have mixed implications for the ability of work-time reduction to encourage employment in the absence of growth. They found that the automatic stabilization effects of work-time reduction policies in Germany does in fact minimize unemployment during recessions. This could be interpreted as being consistent with Victor's (2012) position, but this is not quite true. Work-time reduction policy effectively discourages layoffs during recessions (Balleer et al, 2016). There is not, however, clear evidence that the policy redistributed working hours to the unemployed, which would cause a decrease in unemployment.

Though underwhelming, the results of Hunt (1999) and Balleer et al (2016) do not necessarily disprove the claim that work-time reduction is associated with reduced unemployment in a low-growth economy. Based on the evidence presented, work-time reduction can best be used to minimize the negative impacts of low growth, but it does not appear to generate any positive employment effects.

Of critical importance in Hunt's study is the role that unions played in determining the effects of the policy on wages. Unions demanded full wage compensation for the reduced working hours in Germany, and their demands were generally accommodated (Hunt, 1999). In the 1998 economic outlook, OECD researchers investigate the relationship between various measures for collective bargaining power (such as union density and coverage) on work time. They found that countries with higher levels of collective bargaining power also had lower average work times (OECD, 1998). Unions are such decisive entities in terms of the effects of work-time reductions because they often negotiate the conditions upon which work time can be reduced. Bosch and Lendhorff review various evaluations of work-time reduction policies, and find that complementary policies (which tend to be part of a collective agreement) are often the key determinant of the employment outcome (2001).

Bosch and Lendhorff argue that a number of measures can be taken to ensure that positive employment effects will result from work-time reduction. Hours reductions, wage compensation, and working arrangements (e.g. shift systems, operating hours) should be negotiated as part of one package to coordinate outcomes (Bosch and Lendhorff, 2001). This can be done in order to ensure that the unit costs of labour do not increase in response to the policy, which is one of the key criticisms levelled against work-time reductions. Retraining should also be a part of these collective agreements, as it is a way to ensure that there is an adequate supply of highly skilled labour (Bosch and Lendhorff, 2001). Finally, the way in which social security contributions are collected has significant bearing on the costs to firms of reduced working hours. If the contributions are collected per worker, as they are in the US, then costs will go up as a result of reduced working hours. Alternatively, if contributions are collected per hour worked, then reductions in working hours will not increase costs (Bosch and Lendhorff, 2001). Collection of social security contributions is not subject to renegotiation in collective agreements; this illustrates that the institutional structure of various labour markets influences the outcomes of work-time reduction policies.

Analyses of the effects of work-time reduction policies in the short term show that they does not have demonstrable positive employment effects, but they can minimize the unemployment resulting from low economic growth (Hunt, 1999; Balleer et al, 2016). There is no evidence to suggest that any negative employment effects are maintained in the long term (Whaples, 2001). Further, a set of complementary policies may be enough to alter this trend and encourage positive employment effects (Bosch and Lendhorff, 2001). In general, the empirical evidence supports the claim that work-time reduction can dampen the negative effects of low or negative economic growth by minimizing unemployment, though there is little evidence to suggest WTR can reduce unemployment in its own right. This is consistent with the notion that work-time reduction makes low growth more viable. The effect of work-time reduction on incomes is less clear.

2.4 Work-Time Reduction, Income, and Consumption

As discussed by Hunt (1999) and Bosch and Lendhorff (2001), unions have a significant impact on the income effects of work-time reduction policies. Hunt's results suggest that full wage compensation is possible (1999), and Bosch and Lendhorff advocate for full wage compensation as part of a complete collective agreement to encourage positive employment effects (2001). It is clear why wage increases are desirable from the perspective of the worker. Because of this demand and the role of the unions in determining working time (OECD, 1998), it is reasonable to expect that most work-time reductions will be associated with compensatory real wage increases. This results in a constant level of income with increased leisure time[3]. Some authors (for example, Pullinger, 2014) suggest that this additional leisure time will be used for activities that are not resource-intensive. However, it is also conceivable that the extra

[3] For those able to take advantage of the policy.

leisure time can be used for more consumption or resource-intensive activities (eg. Kallis, Kalush, Flynn, Rossiter, and Ashford, 2013).

A considerable amount of research has been conducted on the effects of work-time reduction on labour markets. In contrast, little empirical research has been done to evaluate the alleged positive relationship between working time and environmental impact.

Schor (2005) carried out an exploratory study of this relationship, finding a positive statistical relationship between working hours and ecological footprint (it is notable that working hours were the only independent variable in Schor's model). Hayden and Shandra conducted a more extensive statistical analysis of the relationship between working time and ecological footprint for OECD countries (2009). A stochastic version of the I=PAT (impact = population * affluence * technology) equation was used to estimate the effect of working time on environmental impact. The affluence term was represented by GDP/capita. In order to determine the impact of working on affluence, Hayden and Shandra disaggregate GDP/capita into labour productivity (GDP/hour), employment (as a percentage of the labour force), and average annual working hours (2009). Their work suggests that an increase in working time is generally associated with increased ecological footprint (Hayden and Schandra, 2009).

Interestingly, Hayden and Shandra argue that "work-time reduction need not involve reductions in income below current levels; however, it does require channelling the steady rise in hourly labour productivity towards more free time rather than growing production and consumption" (2009, p. 592). It is important to acknowledge this assumption and the fact that, if continued increases in labour productivity are directed toward (high resource-intensity) consumption rather than (low resource-intensity) free time, then work-time reduction will not have the purported environmental benefits.

Knight, Rosa, and Schor conducted the most extensive analysis on the relationship between WTR and environmental impact to date (2013). Following from Hayden and Shandra, their statistical model used the STIRPAT framework. They used panel data from OECD countries from 1970-2007 to evaluate the effect of working time on three measures of environmental impact: Ecological Footprint, the carbon component of Ecological Footprint, and overall CO_2 emissions from production, based on UNFCCC inventories (2013). Unlike Hayden and Shandra, Knight et al distinguish between two avenues through which working time reduction might reduce environmental impact. The first is the scale effect, which refers to any declines in growth and consumption that might result from a decline in working time (2013). Changes in income and income growth that result from work-time reduction are important because they drive the scale effect. The scale effect is measured as the statistical relationship between working time and environmental impact without controlling for income (i.e. GDP/capita is not included as an independent variable). The second effect measured by Knight et al. is referred to as the composition effect, which is the tendency for individuals who are working fewer hours to engage in less resource-intensive activities (2013). This effect is measured by regressing environmental impact on working hours and including GDP/capita as a control variable for income. Any relationship found in this model can be interpreted as the effect of working time on environmental impact, holding GDP/capita (income) constant (Knight et al, 2013).

Knight et al found considerable evidence for the scale effect and only marginal evidence for the composition effect (2013). Overall, their results show that there is an empirical relationship between working hours and environmental impact. More specifically, the results of Knight et al indicate that the primary mechanism through which work-time effects the environment is through consumption and GDP growth (2013). In general, statistical analysis of the data observed by Knight et al indicate that higher working times are associated with higher levels of growth and therefore higher levels of environmental impact. In contrast, when GDP is held constant, the effect of working time on environmental impact is insignificant (2013). This suggests that, at least in aggregate, the tendency to use extra leisure time for low resource-intensity activities is negligible.

Though Knight et al. (2013) find minimal evidence of the compositional effect, other authors have found empirical support for its existence. Druckman, Buck, Hayward, and Jackson explored the levels of carbon emissions associated with the various leisure and non-leisure activities of UK citizens (2012). They find that, in general, leisure activities produce fewer emissions than non-leisure activities (Druckman et al, 2012). This alone suggests that an increase in leisure time might be associated with a decline in

CO_2 emissions and other environmental impacts. Further, some forms of leisure such as reading or socializing have particularly low resource intensities (Druckman et al, 2012). Devetter and Rousseau also explore the relationship between working hours and the energy intensity of consumption, using data on French household expenditures (2011). Their findings support those of Druckman et al (2012), indicating that longer hours are associated with more energy-intensive and conspicuous consumption (Devetter and Rousseau, 2011).

Overall, the empirical evidence is consistent with the claims of Victor (2012) and Zwickl et al (2016). While work-time reduction is not generally associated with positive employment effects, it does in fact minimize negative employment effects during recessions (Baleer et al, 2016). Working less also has an empirical association with reduced environmental impact (Knight et al, 2013; Hayden and Shandra, 2009). Empirical evidence is more ambivalent about the claim that the resource intensity of consumption will decline with working time (Knight et al, 2013; Devetter and Rousseau, 2011). Further, the compensatory wage increases observed by Hunt (1999) and advocated by Bosch and Lendhorff (2001) have an ambiguous impact on the scale effect detailed by Knight et al (2013). It is conceivable that a constant income with increased leisure time could result in more consumption and resource-intensive activities (Kallis et al, 2013), or other rebound effects.

2.5 Measuring Working Time and Other Variables of Interest

Both Hayden and Shandra (2009) and Knight et al (2013) used the average annual working hours in the economy as the measurement for hours worked. Using this variable provides some indication of the macro-level relationship between working time and environmental impact. However, there are a number of reasons why the average annual working hours in one country might differ from those in another.

The most significant determinants are the length of the standard work-week and the relative proportion of part-time and full-time work in the economy. A reduction in the standard work-week from, for example, 40 to 35 hours have the same effect on average annual hours as an increase in the percentage of workers who are employed part-time.

While there may be no distinction between these two changes in the labour market in terms of average annual hours, it is likely that they would have a different impact on people's lives. This is particularly significant considering that part of the argument for WTR minimizing negative environmental impact is contingent upon individual behaviours.

It has been noted that unions play a key role in determining the outcome of a reduction in working time. Particularly, they can negotiate package deals that can ensure that wage compensation, among other benefits, accompanies a reduction in working time. If there is wage compensation, then any positive environmental effects of the WTR should be due to the compositional effect, because the effect on income is negligible or nonexistent. Alternatively, if there is not wage compensation as a result of WTR, then the scale effect might be at the root of any environmental impact. One reason that this is significant is because part-time workers are less likely to be covered by a union than full-time workers (Hernandez, 1995).

Considering this, the source of variation in working hours should have some bearing on the relationship between working hours and the environment. A reduction in the standard work week for full-time workers, if accompanied by the policies suggested by Bosch and Lendhorff (2001), could constitute the liberation of free time. This is consistent with, for example, Pullinger's notion that working less could translate into engaging in more sustainable, albeit time-consuming, activities (2014). As a result, a compositional effect could be expected. In contrast, an increase in the prevalence of part-time work could constitute a constraint on income for some workers, particularly those involuntarily working part-time. If this is so, then a positive relationship between working hours and environmental impact is likely driven by the compositional effect.

Characteristics of employment other than the part-time and full-time work may also have bearing on the relationship between environmental impact and working hours. As described above, the working hours and environmental impact are supposedly linked through consumption behaviour and the balance between household production and market-based consumption.

Two factors that may have an impact on this balance are the rate of female participation in the labour force and the length of maternity leave offered to new parents.

One might expect the former to be associated with an increase in consumption, simply because more women in the workforce means that there are more people in the workforce. A lack of maternity leave, alternatively, might be associated with higher levels of consumption due to time scarcity. These two variables could influence the relationship between working time and the environment in many conceivable ways. Including them in this analysis should provide further insight into the complex connections between working time, consumption, and the environment.

There are a number of possible sources of variation in average annual hours. Additionally, there are multitudinous social, political, and economic variables that could affect the relationship between working hours, consumption, and the environment. The goal of this study is to explore how different sources of variation in average annual working hours and other variables influence the relationship between working hours and environmental impact.

CHAPTER 3: METHODS

At the most basic level, the purpose of this study is to test hypotheses about the relationship between working hours and different measures of environmental impact. Considering this, and the fact that there is accessible data for average annual working hours and various measures of environmental impact, regression analysis is a logical analytical tool to apply to the problem. The purpose of regression analysis to estimate the statistical relationship between observed variables. Regression analysis has been applied to this problem (Schor, 2005; Hayden and Shandra, 2009; Knight et al, 2013), and this study differs from the aforementioned in a number of ways.

The time period of interest differs from previous studies. Knight et al. used data from 1970-2007 (2013). In contrast, this study will use data from 2007-2012, most of which was unavailable at the time of Knight et al's study. The period of interest for this study is primarily characterized by the 2008 financial crash and the subsequent recession. As such, focusing on this period might indicate whether or not the relationship between working hours and different measures of environmental impact holds in tumultuous economic times.

Extra regressors will be used to consider the effect of part-time employment, maternity leave, and female labour force participation on environmental impact. Finally, the statistical models used by Knight et al (2013) were adjusted slightly for technical reasons. Based on these differences, the goal of this study is to address the following questions:

1. Does the relationship between working hours and ecological footprint found by previous studies hold in the time period from 2007-2012?
    a. In particular, is there evidence for a relationship when controlling for GDP/capita (the composition effect)?
2. How does the prevalence of part-time work, female labour-force participation, and the length of maternity leave offered influence the relationship between working hours and ecological footprint?

3.1 STIRPAT Model

The models used by Knight et al (2013) were constructed using the STIRPAT (Stochastic Impacts Regressed on Population, Affluence, and Time) framework. STIRPAT is an expanded version of Ehlrich and Holdren's I=PAT identity, in which impacts are by definition equated to population, affluence, and technology (1971). Dietz and Rosa (1994) converted this identity into a multiplicative function, the general form of which is

$$I = aP_i^b A_i^c T_i^d exp^{ei} \tag{1}$$

Where *a* is a scaling factor, *e* is an error term, *i* indicates the state or "entity" (in this case country), *exp* is the exponential function, and *b, c, d,* and *e* weigh the effects of each term on impacts. This equation makes it possible to write environmental impacts as some function of working hours. To do this, for each state, the affluence term, A, is equated to GDP/capita. GDP/capita is then disaggregated into the employment rate (employed persons as a percentage of population), labour productivity (GDP per hour of work), and average annual hours of work per worker (Hayden and Shandra, 2009; Knight et al, 2013). In order to use linear regression analysis, the logarithm of each variable can be taken, which yields the linear equation (2).

$$Ln(I_i) = a + bLn(P_i) + cLn(A_i) + dLn(T_i) + e_i \tag{2}$$

Where e_i is the error term. In this functional form, regression coefficients can be interpreted as elasticities. For example, a 1% change in the P term is expected to result in a *b*% change in impacts.

3.2 Sample Selection and Panel Data

Advocates of WTR policy argue that it is only feasible and desirable in advanced economies, where stopping or reducing GDP growth would not necessarily have profound negative consequences (Victor, 2012; Knight et al, 2013). This paper shares this position, and will therefore use data for OECD countries. In these countries, a decline in consumption or income would not necessarily be associated with a decline in wellbeing (Victor, 2012); wellbeing in less-developed countries may be more sensitive to levels of income and consumption. Further, there is evidence of a demand for lower working hours in OECD countries, but there is no evidence of such a demand in developing nations (Otterbach, 2010). A sample consisting of a relatively small number of countries creates some statistical issues, as the sample size may not be large enough to make legitimate inferences. Using data for this subset of countries over time (in which case the data is referred to as longitudinal, or panel data) eliminates some of these issues. Equation (2) can be rewritten to accommodate panel data as follows:

$$Ln(I_{it}) = \alpha_i + bLn(P_{it}) + cLn(A_{it}) + dLn(T_{it}) + e_{it} \tag{3}$$

Where the subscript t denotes the time period from which the data is drawn. Of critical importance is the lack of a t subscript on α_i, which is considered an unobserved entity (in this case, country) fixed effect.

An advantage to using panel data is the possibility of eliminating the effect of unobserved or unobservable factors that might influence the dependent variable. In this case, cultural attitudes towards work and leisure might be one example of a unobserved factor that has an effect on the relationship between working time and ecological footprint. Different methods for the analysis of panel data can eliminate or estimate the effect of these unobservables. However, it is notable that these methods assume that any unobserved effects are constant over time or within a given country. If an unobservable is variable over time or within a country, then the use of panel data methods may provide biased estimates.

3.3 Variables

The models constructed by Knight et al (2013) are the benchmark for this study. Many of the variables used in their study will also be used here. The variables used by Knight et al (2013) fit into the STIRPAT framework as follows.

The affluence (A) term will be represented by GDP/capita. Following from Hayden and Shandra (2009) and Knight et al (2013), GDP/capita will be disaggregated into employment (as a percentage of the population), labour productivity (GDP/hour worked), and average annual hours worked. Population (P) will be represented by the total population, and the percentage of the population living in urban areas will be controlled for. Technology (T) will be represented by the percentage of value added attributable to either the service or manufacturing sectors of the economy (Knight et al, 2013). In order to explore the effect of working hours on environmental impact holding income constant (composition effect), a single variable for GDP/capita was also included in some of Knight et al's models (2013).

Three dependent variables were used in Knight et al (2013), which will also be used in this analysis. Ecological Footprint (EF) is a consumption-based measure of the total environmental impact of an economy. Carbon Ecological Footprint (EFc) estimates the portion of the total Ecological Footprint required to absorb the carbon emissions used in consumption, and is more sensitive to changes in overall energy use than in the consumption of goods. Finally, CO_2 emissions is a production-based measure of environmental impact that only considers what is produced within a country's borders. This means that the emissions associated with something consumed in, for example, Canada, but produced in China, will not count towards Canada's CO_2 emissions. If the relationship between working hours and environmental impacts is primarily driven by changes in consumption behavior, then one would expect there to be a stronger relationship between hours and the Ecological Footprint measures. Broader macroeconomic effects (such as altering the relationship between GDP and unemployment) might cause a stronger statistical relationship between hours and CO_2 emissions.

All of the variables mentioned were included in Knight et al's (2013) analysis. A few additional regressors (independent variables) will also be considered. Of primary interest is how the prevalence of part-time work influences the relationship between working time and the Ecological Footprint. To explore this, employment as a percentage of the population will be further disaggregated into full-time and part-time employment as percentages of the population. A variable to control for the quality of the labour market will be also be used. The length of maternity leave (in weeks) provides some indication of the services provided to workers by their government and employers. Presumably, longer maternity leave could be an indication of a society that values labourers primarily as people, rather than productive entities. This may in turn affect the relationship between working time and the environment. Finally, female labour force participation will also be included. The relationship between working hours and environmental impact is ostensibly driven by changes in consumption behavior. Women entering the workforce is a driver of changes in consumption behavior, and it is possible that female labour force participation has some influence on the relationship between hours and the environment.

The majority of these data were retrieved from the OECD and World Bank Databases. Notable exceptions include the prevalence of part-time and full-time work in the USA, which was retrieved from the Federal Reserve Economic Database. Data on Ecological Footprint was retrieved and used with permission from the Global Footprint Network. Summary statistics for each variable is provided in table 1.

Table 1. Summary statistics for all variables. Ecological Footprint data used with permission from the © Global Footprint Network, www.footprintnetwork.org

Variable	Obs	Mean	Std. Dev.	Min	Max
eft	174	4.23e+08	8.47e+08	6017115	4.98e+09
efc	174	1.55e+08	3.70e+08	1406886	2.22e+09
co2emissions	174	394266.5	989205.7	1870.17	5794924
gdpcap	174	42482.03	21475.77	9399.657	110001.1
urbanpop	174	77.26252	10.63838	54.163	97.732
population	174	3.60e+07	5.99e+07	311566	3.14e+08
manufactur~g	174	15.42504	4.855017	5.253746	25.96111
services	174	70.71607	6.287932	53.94256	87.37386
productivity	174	47.02299	14.19613	22.7	83.4
hours	174	1711.855	175.1662	1372.7	2111
fulltime	174	37.36287	4.666292	26.41107	47.85471
parttime	174	7.254804	4.066493	1.043794	19.06877
matleave	174	51.73046	46.32125	0	166
femalepart~n	174	53.91839	9.517152	23.1	77.7

3.4 Models

A number of statistical models will be constructed. Because the models used by Knight et al (2013) are the benchmark for this study, the first two sets of models (each set containing one model testing EF, EFc, and CO_2 emissions respectively) will be identical to those of Knight et al, aside from the time period of interest and the inclusion of female labour force participation. This will provide ample information to compare the different time periods, as well as the three dependent variables. The first set of these models measures the scale effect; the gross relationship between working hours and environmental impact (without controlling for income). The second set includes GDP/capita as a control for income and will therefore measure what Knight et al (2013) refer to as the composition effect.

The third set of models includes the additional regressors. Prevalence of part-time work is included as a disaggregation of employment as a percentage of the population, and employment is not present in Knight et al's models testing the compositional effect. Therefore, only the scale effect will be estimated with consideration of the effect of part-time work.

The general models to be tested are:

$$Ln(I_{it}) = \alpha_i + \beta_1 Ln(population_{it}) + \beta_2 Ln(urbanization_{it}) + \beta_3 Ln(manufacturing_{it}) + \beta_4 Ln(services_{it}) + \beta_5 Ln(hours_{it}) + \beta_6 Ln(productivity_{it}) + \beta_7 Ln(employment_{it}) + \beta_8 Ln(female\ participation_{it}) + e_{it} \tag{4}$$

$$Ln(I_{it}) = \alpha_i + \beta_1 Ln(population_{it}) + \beta_2 Ln(urbanization_{it}) + \beta_3 Ln(manufacturing_{it}) + \beta_4 Ln(services_{it}) + \beta_5 Ln(hours_{it}) + \beta_6 Ln(GDP/captia_{it}) + \beta_7 Ln(female\ participation_{it}) + e_{it} \tag{5}$$

$$Ln(I_{it}) = \alpha_i + \beta_1 Ln(population_{it}) + \beta_2 Ln(urbanization_{it}) + \beta_3 Ln(manufacturing_{it}) + \beta_4 Ln(services_{it}) + \beta_5 Ln(hours_{it}) + \beta_6 Ln(full\text{-}time_{it}) + \beta_7 Ln(part\text{-}time_{it}) + \beta_8 Ln(productivity_{it})\ \beta_9 Ln(mat\ leave_{it}) + \beta_{10} Ln(female\ participation_{it}) + e_{it} \tag{6}$$

where I_{it} could represent EF_{it}, EFc_{it}, or CO_{2it} emissions.

3.5 Estimation Methods and Model Misspecification

There are a variety of estimation methods for panel data, each of which contingent upon a particular set of assumptions. A variety of assumptions to verify the validity of the model and choose the best specification will be tested. The steps in this process will be shown in detail for model (4), with EF as the dependent variable; the process is similar, albeit with slightly different outcomes, for models testing the other two dependent variables.

The first step in determining what model specification is suitable is often visualizing the data. The log of hours is plotted against the log of EF in figure one, and a few immediate inferences can be made from these data. First, there are no noticeable outliers present. This is sufficient to state that the assumption of finite fourth moments (i.e. no outliers) is satisfied. Additionally, the data in this figure appears to be grouped into clumps, or clusters. Clustered data is typical of panel datasets; each cluster represents a specific country. If left unchecked, clustered data could result in inaccurate estimates of the standard error, which is key to determining statistical significance. To deal with this problem, standard errors will be clustered by country.

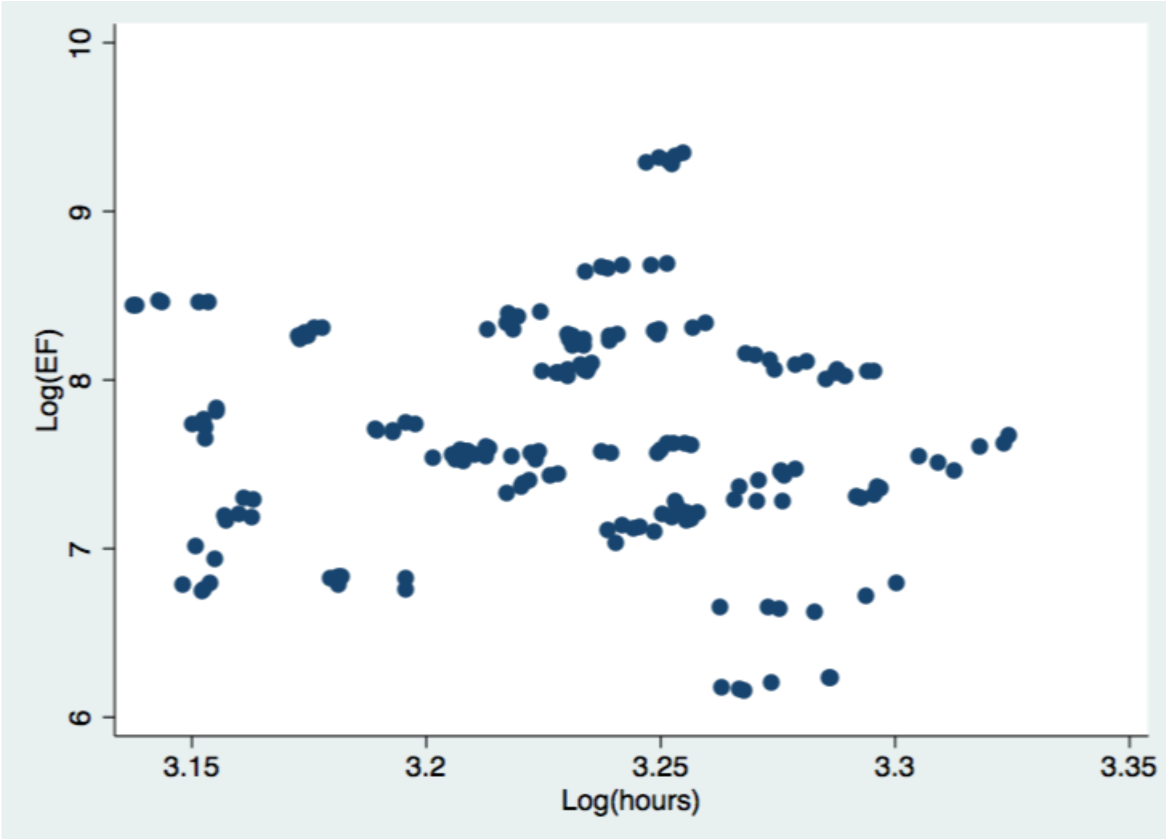

Figure 1. Log(hours) plotted against log(EF). This plot shows that there are not obvious outliers amongst the logged data, and that data is grouped into country clusters. Ecological Footprint data used with permission from the © Global Footprint Network, www.footprintnetwork.org.

Clustered data is a special case of heteroskedasticity, more general versions of which may also cause problems. Heteroskedasticity is the relationship between the variance of errors and regressors. If the variance changes in response to changes in regressors[4], then errors are said to be heteroskedastic. There is a testing procedure for heteroskedasticity in panel datasets, but the relatively small sample size for this dataset precludes meaningful results (Woolridge, 2010). Fortunately, clustered standard errors are also robust to heteroskedasticity (Stock and Watson, 2011). The assumption of homoscedasticity is not satisfied formally, but the potential for heteroskedasticity has been controlled for.

Clustered standard errors are typically used to deal with another econometric problem with panel data: autocorrelation. This occurs when a variable is correlated within a particular entity (in this context, country). For example, if the values for EF are correlated across time for Canada, then this would constitute autocorrelation. The

[4] i.e. Heteroskedasticity is when var(ei) = f(X); homoscedasticity is when var(ei) = δ for all values of all regressors (X).

Woolridge test for autocorrelation (Woolridge, 2010; Drukker, 2003) was used. This test produces an F statistic, which is used to evaluate the null hypothesis of no autocorrelation[5]. For model (4), $F_{1, 28} = 6.35$. This yields a p-value of 0.017, so the null hypothesis of no autocorrelation is rejected at the 5% significance level.

Strong evidence for autocorrelation was found for models with EF or CO_2 emissions as the dependent variable. Clustered standard errors can deal with a certain degree of autocorrelation, but other methods are better suited to the high degree of autocorrelation found in these models. Following from Knight et al (2013), the first difference (FD) estimator will be used for models with a high degree of autocorrelation.

Multicollinearity, which is a close relationship between two more independent variables, can diminish the explanatory power of the variables. In the case of perfect multicollinearity, the software used for these analyses would eliminate one of the correlated variables. Therefore, it is only necessary to test for near perfect multicollinearity. To do this, the variance inflation factor (VIF) for each independent variable was calculated[6]. VIFs for each variable in all models indicate that there was not near perfect multicollinearity; there are no close relationships between independent variables that could skew the results.

The assumptions underlying most panel data methods have been verified. One of the key advantages of panel data is the ability to eliminate or estimate entity (country) fixed effects, referred to as α_i. The choice of which method of estimation is based upon the properties of α_i. First, the assumption that α_i is a random variable will be tested. This can be done formally with the Hausman test, but technical details made the test unreliable in this context.

Testing the assumption that α_i is a random variable is a way to choose between random effects (RE) and fixed effects (FE) estimation. The random effects method assumes that the error term can be modeled as a random sample from a given population, or that any unobservable sources of error are not correlated across countries or time. This assumption can clearly not be made for this dataset. OECD countries were specifically

5 The F-Statistic tests Ho: $cov(u_{is}, u_{jt}) = 0$ for all s=/=t against Ha: $cov(u_{is}, u_{jt})$ =/= 0 for some s=/=t. In STATA, the command is xtserial

6 In general, a VIF > 10 is indicative of near perfect multicolinearity (Stock and Watson, 2011). For model (4), the highest VIF was <4. The command is estat VIF in STATA.

selected due to their higher level of development. Sources of error, like culture or institutional structure, may well be correlated across OECD countries. Because one cannot reasonably assumes that sources of error are uncorrelated across countries[7], the RE estimation method will not be used.

In contrast to RE, FE methods eliminate unobserved effects arithmetically, rather than attempting to estimate them. This is therefore based on the assumption that there are country fixed effects. The null hypothesis that there are no country fixed effects was tested using the Bruesch-Pagan test (1980)[8]. For all models, strong evidence ($p<0.01$) was found for the presence of country fixed effects, which indicates that panel data methods are preferable over linear estimation methods.

Based on the results of these misspecification tests, there will be two different model specifications. Models testing EF and CO_2 emissions were found to have a severe degree of autocorrelation, and the first difference estimator was used to address this problem. The general form of the first difference regression is as follows:

$$Y_{it} - Y_{i,t-1} = (\alpha_i - \alpha_i) + \beta(X_{it} - X_{i,t-1}) + (u_{it} - u_{i,t-1})$$

$$= \Delta Y_{it} = \beta \Delta X_{it} + \Delta u_{it} \qquad (7)$$

Where Y_{it} is the dependent variable for country i in time t, $Y_{i,t-1}$ is the dependent variable for country i in time t-1, X is the independent variable, and u_{it} is the error term. Under the assumption that α_i is fixed over time, taking the first difference eliminates α_i from the equation. The difference is taken manually, and the ordinary least squares (OLS) method is then applied to the differenced data. One benefit of this is that is allows for a heteroskedasticity test for the differenced data. The Breusch-Pagan test for heteroskedasticity[9] was used for this, and strong evidence for heteroskedasticity was found for each differenced model. As such, heteroskedasticity robust standard errors were computed for these models.

Models with EFc as the dependent variable did not show a high degree of

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[7] In fact, this exact selection is used as an example in Dougherty (2011, p 419) of a sample for which RE would not be a logical decision.

[8] Tests Ho: $\alpha_i = 0$ for all i. In STATA, the code is xttest0

[9] The code for this test in STATA is estat hettest

autocorrelation. In this case, the standard fixed effects estimator is more suitable than the first difference estimator. The general form for the fixed effects regression is similar to that of the first difference estimator, but with FE the mean – rather than data from the previous year – is subtracted from each data point:

$$Y_{it} - Y_{mean} = (\alpha_i - \alpha_i) + \beta(X_{it} - X_{mean}) + (u_{it} - u_{mean})$$

$$= Y_{fe} = \beta(X_{fe}) + u_{fe} \quad (8)$$

OLS is then applied to equation (8).

CHAPTER 4: RESULTS

The general trends for working hours and each dependent variable are depicted in figures 2-4. These figures illustrate some obvious correlation between average annual working hours and each measure of environmental impact during the time period of interest.

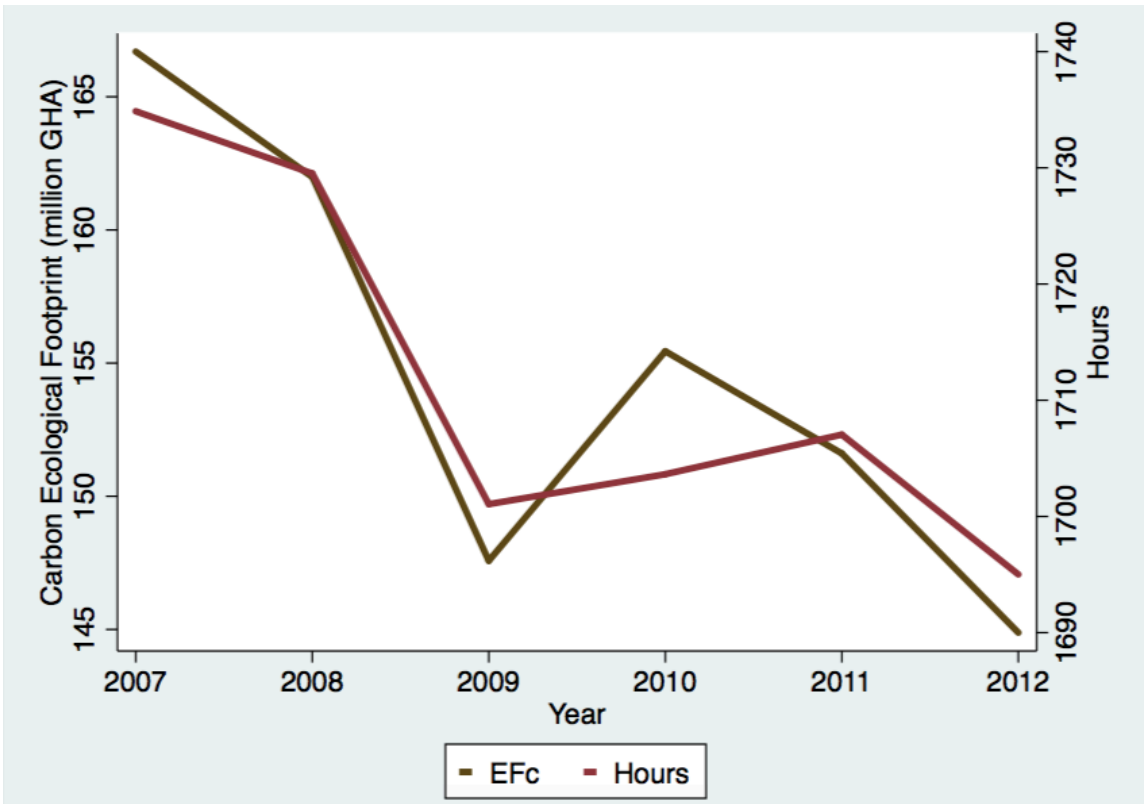

Figure 2. OECD average carbon Ecological Footprint and annual working hours from 2007-2012. Ecological Footprint data used with permission from the © Global Footprint Network, www.footprintnetwork.org

In order to more formally evaluate these relationships, nine regression models were tested, the outputs for which are reported in table 1. Models 2, 5, and 8 used the EFc as the dependent variable; models 1, 4, and 7 used total Ecological Footprint; models 3, 6, and 9 used total CO_2 emissions. Testing the same models for different variables allows for comparison of the relationship between working hours and each measure of environmental impact.

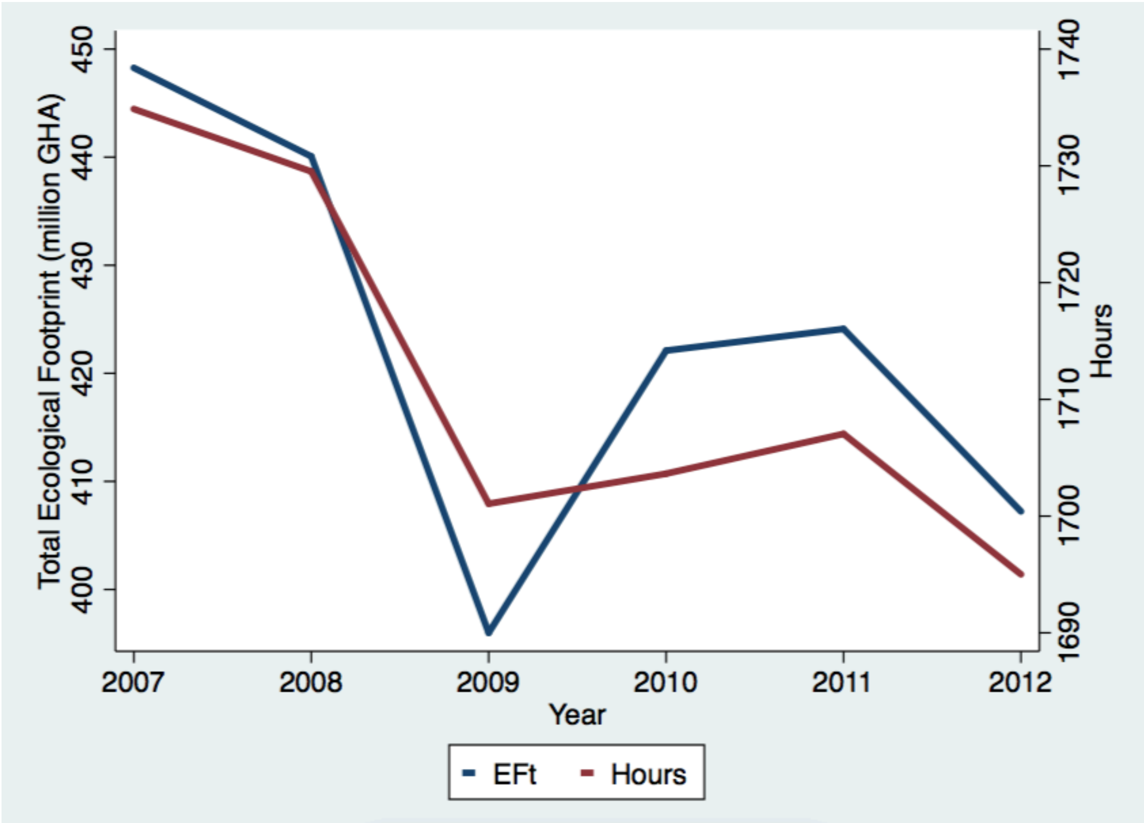

Figure 3. OECD average total Ecological Footprint and annual working hours from 2007-2012. Ecological Footprint data used with permission from the © Global Footprint Network, www.footprintnetwork.org

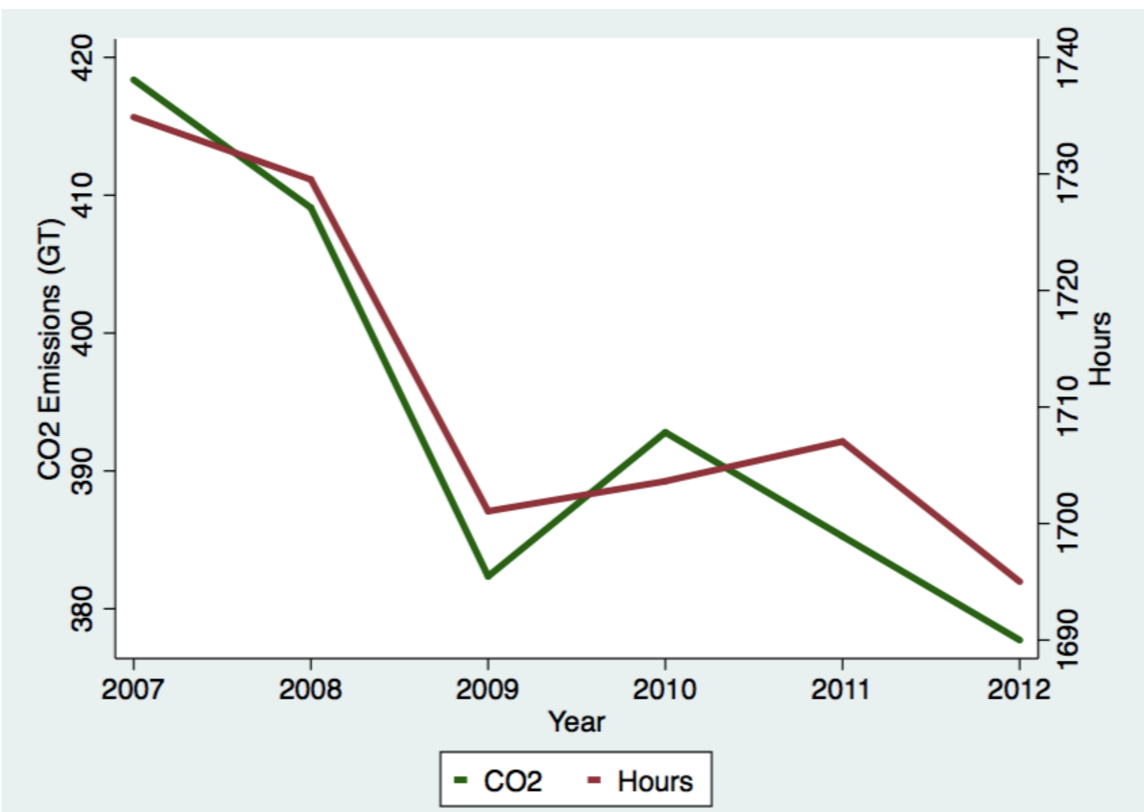

Figure 4. OECD average CO_2 emissions and annual working hours from 2007-2012.

The first six models contain the same independent variables as in Knight et al (2013), with the addition of the rate of female participation in the labour force. These models therefore act as a benchmark for comparison to Knight et al (2013), which focused on a different time period. Models 7-9 consider the impact of part-time work on ecological footprint by decomposing employment as a percent of the population to full-time and part-time employment as percentages of the population. These models also include the length of maternity leave, measured in weeks.

Models 1-3 and 7-9 all estimate the scale effect, or the direct relationship between working hours and environmental impact. Models 4-7 control for GDP/capita. They estimate the compositional effect, or the relationship between working hours and environmental impact holding income constant.

The regression output for each model is summarized in table 2. Each of these models takes the log-log form, which means that coefficients can be interpreted as elasticities. For example, the coefficient for working hours in model 1 is 1.86. This indicates that a 1% change in working hours would be expected to change total Ecological Footprint by 1.86%.

The statistical significance estimated coefficients is determined using standard errors, which are used to estimate standard deviation. Estimated coefficients are normalized by using clustered or robust standard errors. These normalized data – test statistics – can be compared to the standard normal distribution in order to test the null hypothesis that the estimated coefficient is zero. Each test statistic is associated with a given p-value, which indicates the probability of observing a sample that yields the estimated coefficient if the null hypothesis is true.

For example, the estimated coefficient for labour productivity in model 1 is 0.732, with a clustered standard error of 0.33. To normalize the data, the estimated coefficient is divided by the standard error[10], yielding a test statistic of 2.218. The distribution of the test statistic is asymptotically normal; this yields a p-value of 0.013 based on the normal distribution. If the true coefficient for labour productivity is zero, then the probability of getting a sample with an estimated coefficient of 0.732 is 1.3%. By convention, this

[10] More precisely, data is normalized using the formula $t_0 = (\beta_{est} - \beta_{null})/(SE(\beta_{est}))$ where t_0 is the test statistics, β_{est} is the estimated coefficient based on a given sample, $SE(\beta_{est})$ is the estimated standard error for β_{est}, and β_{null} is the coefficient stipulated in the null hypothesis. In this study, β_{null} is always zero.

estimated coefficient is said to be statistically significant at the 5% level (5>1.3), but not at the 1% level (1<1.3). The null hypothesis of no association between labour productivity and Ecological Footprint is falsified, indicating that there is some relationship between the two variables.

Table 2. Regression coefficients with clustered standard errors reported in parentheses (clustered by country). EF refers to Ecological Footprint, and EFC refers to the carbon component of Ecological Footprint. * indicates significance at the 10% level. ** indicates significance at the 5% level. *** indicates significance at the 1% level. All variables were logged, and those in models with EFC and CO_2 emissions were first-differenced.

	(1) EF	**(2) EFC**	**(3) CO_2**	**(4) EF**	**(5) EFC**	**(6) CO_2**	**(7) EF**	**(8) EFC**	**(9) CO_2**
opulation	1.073	0.978	0.705	1.165	0.13	0.559	1.12	0.856	0.715
	(0.866)	(0.483)*	(0.737)	(0.897)	(0.605)	(0.737)	(0.947)	(0.55)	(0.739)
rban population (%)	0.135	-0.412	0.571	0.565	-1.76	0.796	0.298	0.015	0.52
	(1.23)	(0.814)	(1.28)	(2.24)	(0.928)*	(1.31)	(2.34)	(0.81)	(1.302)
lanufacturing (% VA)	-0.175	0.19	0.011	-0.258	-0.17	0.032	-0.178	0.171	-0.0005
	(0.145)	(0.087)**	(0.11)	(0.10)**	(0.14)	(0.11)	(0.14)	(0.111)	(0.121)
ervices (% VA)	-0.221	-0.346	-0.16	-0.162	-1.55	-0.085	-0.271	-0.598	-0.221
	(0.40)	(0.32)	(0.59)	(0.485)	(0.729)**	(0.57)	(0.485)	(0.379)	(0.60)
mployment (% population)	0.876	1.75	0.295						
	(0.385)**	(0.179)***	(0.282)						
abour Productivity	0.46	-0.171	0.658				0.476	0.002	0.66
	(0.405)	(0.114)	(0.235)***				(0.347)	(0.15)	(0.24)***
/orking Hours	1.86	1.31	1.689	0.903	1.14	0.974	1.79	1.00	1.698
	(0.75)**	(0.384)***	(0.457)***	(0.704)*	(0.74)	(0.504)*	(0.666)***	(0.43)**	(0.47)***
ull-time employment							0.612	1.31	0.137
							(0.211)***	(0.157)***	(0.205)
art-time employment (% opulation)							0.014	-0.002	0.006
							(0.1)	(0.05)	(0.06)
laternity leave (weeks)							0.0027	-0.017	-0.003
							(0.009)	(0.01)*	(0.003)
DP/capita				1.01	0.794	0.607			
				(0.253)***	(0.307)**	(0.187)***			
emale Labour Force articipation	-0.89	-0.20	0.701	-0.789	0.16	0.691	-0.839	-0.137	0.735
	(0.349)**	(0.316)	(0.368)*	(0.366)**	(0.373)	(0.342)**	(0.349)**	(0.333)	(0.37)**
2	0.192	0.507	0.264	0.231	0.396	0.268	0.185	0.495	0.260

4.1 Total Ecological Footprint

Model 1 estimates the scale effect in the same way as Knight et al (2013), although it focuses on a different set of years and with the addition of female labour force participation. In this model working hours, employment as a percentage of the population, and female labour force participation were found to have a statistically significant relationship with EF, holding all other independent variables constant.

The estimated coefficient for working hours was 1.86, which suggests that a 1% increase in working hours should be associated with a 1.86% increase in EF (or vice versa). This result is consistent with the hypothesis that working hours and EF have a positive relationship. Similarly, the results for this model show a positive relationship between the employment rate and EF. A 1% increase in the employment rate is expected to be associated with a 0.876% increase in EF. Female labour force participation, in contrast to the other significant estimates, has a negative relationship with EF. An increase in the female labour force participation rate is expected to cause a decline in EF.

Model 4 estimates the composition effect, with the addition of female labour force participation. The contribution of the manufacturing sector to total value added, working hours, GDP per capita, and female labour force participation had statistically significant estimates for this model. The variables for both manufacturing and the female participation rate had negative coefficients, indicating that an increase in either variable should be associated with a decline in EF. As in model 1, the estimate for working hours was significant and positive, albeit smaller and less significant. Based on model 4, a 1% increase in working hours should result in a 0.9% increase in EF. This result is only significant at the 10% level, while the result for working hours in model 1 is significant at the 5% level. The change in value and significance of the coefficient for working hours is likely attributable to the inclusion of GDP/capita. Income, represented by GDP/capita, had a positive coefficient that was significant at the 1% level. A 1% increase in GDP/capita is expected to result in a 1.01% increase in EF, holding all other variables constant. It is possible that GDP/capita has a positive relationship with both EF and working hours, which would explain why inclusion of GDP/capita changes the estimated relationship between the latter two variables.

Employment as a percentage of the population was broken down into full-time and part-time employment as a percentage of the population for model 7. Further, the length of maternity leave in weeks was included. Similar to Model 1, the coefficients for working hours, full-time employment as a percentage of the population, and female labour force participation were statistically significant. The estimate for hours was 1.79 – slightly smaller than the estimate in model 1 – and was significant at the 1% level. Increases in full-time employment by 1% are expected to increase EF by about 0.6%. This is consistent with the estimate for the overall employment rate from model 1; part of the effect of employment on EF is based on changes in full-time employment.

Female labour force participation, as with models 1 and 4, was estimated to have a negative coefficient with EF. The similarity in results for models 1,4 and 7 provide statistical support for a negative relationship between the two variables. The other two variables of interest – maternity leave and part-time employment – did not yield statistically significant estimates.

4.2 Carbon Ecological Footprint

As stated above, model 2 tests the scale effect for carbon Ecological Footprint (EFc), model 5 controls for GDP per capita, and model 8 includes full- and part-time employment, as well as the length of maternity leave.

In model 2, the variables for manufacturing, population, working hours, and employment all had significant estimates, which were positive for the latter three, and negative for the percent of value added attributable to the manufacturing sector. Notably, the coefficients for working hours and employment differ in magnitude from the analogous model using total Ecological Footprint as the dependent variable. In contrast to model 1, the estimated coefficient for employment was much higher (1.75 compared to 0.876) in model 2. This suggests that changes in employment have a more significant impact on EFc than on total EF, or that the relationship between employment and total EF is driven by the relationship between employment and EFc. The converse is true for working hours. The estimated coefficient for working hours in model 2 is about half the size of the coefficient in model 1. This suggests that working hours does not exclusively influence total EF through the carbon component; working hours are also linked to non-carbon components of the total Ecological footprint.

There is no evidence in support of the composition effect for EFc. The estimated coefficient for working hours in model 5 is positive but not statistically significant. The variable for GDP/capita was estimated to have a positive and significant relationship with EFc, though the coefficient is both smaller and less significant than in the corresponding model with total EF. The results of model 5 also show a negative relationship between both urban population and services. This suggests that an increase in either the percent of the population in urban areas or the percent of value added from the service sector should result in a decline in EFc.

Model 8 produced significant estimates for working hours, full-time employment, and maternity leave. The estimated coefficient for working hours was 1, indicating that a 1% increase in working hours is expected to be associated with a 1% increase in EFc. The estimate for full-time employment was 1.31, which is higher than the coefficient for full-time employment estimated in model 7. This result is consistent with fact that employment as a percentage of the population has a stronger relationship with EFc than total EF, as shown in the comparison between models 1 and 2. Interestingly, the estimate for maternity leave was -0.017. This indicates that an increase in the length of maternity leave should be associated with a decline in EFc by 0.017%. This effect is small but statistically significant.

4.3 CO_2 Emissions

In contrast to the two Ecological Footprint measures, CO_2 emissions is a production based metric. If changes in working hours affect the environment primarily through consumption behavior, then one would expect working hours to have a smaller and less significant relationship with CO_2 emissions than Ecological Footprint. The results of models 3, 6, and 9 show that this is not the case.

For Model 3, labour productivity, working hours, and female labour force participation all had significant and positive relationships with CO_2 emissions. The estimated coefficient for working hours was 1.689, which is higher than the estimate in model 2 but lower than the estimate for model 1. In model 6, working hours, GDP/capita, and female labour force participation were found to have positive relationships with CO_2 emissions. The estimate for working hours was 0.974, which is the highest estimated coefficient for working hours in the presence of GDP/capita. Similarly, the estimate for GDP/capita was strongly significant, but it was the lowest coefficient for all models testing the compositional effect. This suggests that working hours has the greatest impact on CO_2 emissions when income is controlled for. Further, GDP/capita has a stronger relationship with the different forms of Ecological Footprint than CO_2 emissions.

In model 9 – as with model 3 – working hours, labour productivity, and female labour force participation were all significant and positive. The inclusion of maternity leave, full-time, and part-time employment had little effect on CO_2 emissions.

4.4 Summary

Overall, the estimated coefficients for working hours were highest in models testing total Ecological Footprint and lowest for those testing carbon Ecological Footprint, with the estimates for CO_2 emissions falling in between. Evidence was found for the scale effect for all dependent variables, and evidence for the compositional effect was found for models with total Ecological Footprint and CO_2 emissions. Variables for part-time and full-time employment reflected the impact of the total employment rate on the dependent variables but did not provide additional information. Female participation in the labour force was found to have a negative relationship with Ecological Footprint and a positive relationship with CO_2 emissions. This result is the most perplexing.

Chapter 5: Discussion

5.1 The Scale Effect

The scale effect is the relationship between working hours and environmental impact without considering the effect of variation in income. This can be interpreted as the gross effect of working hours on environmental impact, including all possible mechanisms. Changes in income and overall consumption, unemployment, consumer behavior, and other variables are all captured in this estimate.

Strong evidence for the scale effect was found for models with each dependent variable. The estimated impact of a 1% increase in working hours is a 1.79-1.86% increase in total Ecological Footprint. These results were significant at the 1-5% levels and are the highest estimated coefficients for working hours in models testing the scale effect. At the same significance levels, a 1% increase in working hours is expected to result in a 1-1.31% increase in the carbon component of Ecological Footprint. Significant at the 1% level, a 1% increase in working hours should result in a 1.69-1.7% increase in CO_2 emissions.

There are a number of mechanisms that could drive a relationship between working hours and environmental impact. Generally, these can be divided into consumption and non-consumption based mechanisms. A decline in overall consumption or a change in the resource intensity of consumption would constitute the former, while a shift in the relationship between GDP growth and the unemployment rate would constitute the latter. If consumption-based mechanisms are the primary drivers of this relationship, then one would expect consumption-based measures of environmental impact (such as Ecological Footprint) to be more responsive to variation in working hours than production-based measures (CO_2 emissions).

Total Ecological Footprint had the highest associated coefficients for working hours. Taken alone, this supports the notion that consumption based mechanisms are the primary drivers of the relationship between working hours and environmental impact. However, the results for carbon Ecological Footprint and CO_2 emissions complicate this hypothesis. If consumption-based mechanisms were the primary driver, one would expect the coefficients for working hours in models with total and carbon Ecological Footprint to be higher than those in models with CO_2 emissions. While estimated coefficients in models with CO_2 emissions were slightly lower than those for models with total Ecological Footprint, coefficients in models with carbon Ecological Footprint were the smallest.

It is likely that both consumption non-consumption based mechanisms involved in the relationship between working hours and each measure of environmental impact. The results provide strong evidence in favour of a generally positive relationship between working hours and the environment.

5.2 The Composition Effect

The composition effect is defined as the relationship between working hours and environmental impact holding income constant. One of the key ways in which a change in working hours might influence the environment is through changes in income. All else equal, a decline in working hours should be associated with a decline in income, which should then result in a change in consumption. Controlling for income makes it possible to isolate the effect of hours on environmental impact that is not driven by changes in income. The compositional effect can therefore be interpreted as representing changes in consumer behavior that are not the result of budgetary constraints. Deciding to ride a bike to work, engage in environmental politics, or to plant a food forest instead of importing fruits and vegetables could all be included in the compositional effect.

Evidence was found for a compositional effect for total Ecological Footprint and CO_2 emissions, but not for the carbon component of Ecological Footprint. Carbon Ecological Footprint is particularly sensitive to domestic consumption of energy, and this may be why no evidence for the composition effect was found for the variable. A decline in working hours will likely result in more time spent at home, and therefore more energy use in the household. Though possible, a concurrent decline in energy use at work is not certain, because many firms keep their operating hours constant while working hours change (Bosch and Lendhorf, 2001; Balleer et al, 2016). An increase in household energy use could offset the effects of reduced consumption following a decline in working hours, resulting in a lack of statistical evidence for the composition effect for carbon Ecological Footprint.

The coefficient for working hours was smaller and less significant when GDP/capita was controlled for in models with total Ecological Footprint and CO_2 emissions. Working hours has a diminished or eliminated effect on environmental impact in the presence of GDP/capita. Taken in concert with results of the models estimating the scale effect, these results suggest that a significant portion of the relationship between working hours and environmental impact is driven by changes in GDP/capita. Income may be the primary driver of this relationship, but this study provides some evidence for the presence of other mechanisms.

5.3 Comparison to Knight et al (2013)

The 2013 paper by Knight et al provides a benchmark for this study. With some minor differences discussed in chapters three and four, models 1-6 are almost identical to those tested by Knight et al (2013). As such, they allow for close comparison between the studies.

This study and Knight et al (2013) are similar in that each analysis provided strong evidence for the scale effect for all measures of environmental impact. In this paper, the coefficients were highest for total Ecological Footprint, followed by CO_2 emissions and carbon Ecological Footprint. In contrast, Knight estimated a similar coefficient for both measures of Ecological Footprint (1.37 and 1.30 for total and carbon EF, respectively), with a much smaller estimate for CO_2 emissions (0.5) for models testing the scale effect. This indicates that in the time period studied by Knight et al (2013), relative to the times included in this study, there is a stronger relationship between working hours and CO_2 emissions.

Contrasting estimates of the relationship between working hours and CO_2 emissions could be explained by differences in sample. These differences could be explained by randomness, particularly because the sample for this study was relatively small. There may also be some structural differences between the two time periods. The Kyoto protocol and other international efforts to reduce carbon emissions were in effect for only the last few years in Knight et al's dataset (2013). In contrast, these initiatives were in place for the entirety of the dataset used for this paper. This additional downward pressure on CO_2 emissions could account for the higher estimated relationship between hours and emissions in this study.

The results from this paper concerning the scale effect are consistent with Knight et al (2013), but there is some difference for results concerning the compositional effect. Knight et al found strong evidence (significant at 1%) for the compositional effect when total Ecological Footprint was the dependent variable (2013). In contrast, this paper found weaker evidence (significant at 10%) for the compositional effect for total Ecological Footprint and CO_2 emissions. Aside from differences in statistical significance, the estimated coefficients are generally higher in this paper than in Knight. For example, the coefficient for working hours in model (1) was 1.86, and the analogous coefficient from Knight et al was 1.37 (2013, p. 698).

The fact this study focused on a time period characterized by the 2008 crash and subsequent recession likely influenced the results. If working hours and environmental impact are primarily linked through income, then the recession would act as a strong downward force for both the dependent and independent variables. This coordination could partly explain why coefficients for working hours were generally higher for this study than in Knight et al (2013).

Overall, the results presented in this study are consistent with those from Knight et al (2013). Most of deviation from Knight et al's (2013) results can be attributed to random variation in the samples, though it is possible that there are structural differences between the time periods as well.

5.4 Full and Part-Time Employment

In Knight et al's models, a variable for employment as a percentage of the population was included as a control. Working hours may have some effect on the environmental impact of an economy, and so should the total number of people working in the economy.

For models 7-9 in this study, employment was broken down into part-time and full-time employment as a percentage of the population. The prevalence of part-time work could result in variation in working hours, just as changes in the length of the standard work week could. These two sources of variation would likely have different impacts on individual responses to the change in working hours. People working part-time are less likely to be unionized and have other benefits, which plays a role in how income responds to changes in working time (Hernandez, 1995).

The expectation was that more part-time workers would be associated with lower levels of environmental impact. Part-time workers have smaller incomes and fewer benefits than their full-time analogues and would therefore be expected to consume less. Those with part-time jobs certainly spend less time at their main job, but it is unclear if they have more free time over all. Students often work part-time during their full-time studies (Darolia, 2013), and some part-time workers juggle multiple jobs. Because of this, any relationship between part-time work and environmental impact is expected to be driven primarily by the relatively constrained incomes of part-time workers rather than by an excess of free time.

The estimated coefficients for the prevalence of part-time work were negative, as expected, but they were not statistically significant. In contrast, the coefficients for full-time workers were positive and significant in each model. This reflects the results for employment as a percentage of the population, but does not add any additional detail. Environmental impact is expected to increase with the proportion of people working. There is little evidence, however, that the prevalence of part-time work in the economy has a significant effect on environmental impact.

In earlier versions of these models, a variable for involuntary part-time workers as a percentage of the population was also included. Theoretically, this served to illuminate more details about the effect of part-time work on environmental impact. As discussed above, the budgetary constraints associated with part-time work were expected to be more significant than the amount of free time. This may be true, but it does not mean that some part-time workers do not enjoy more free time than their full-time compatriots. Including a measure for involuntary part-time would allow the model to focus on the part-time workers who would rather be working full-time (and making more money). In all specifications, the variable for involuntary part-time was found to be insignificant. Ultimately, it was removed from the models for this reason.

The results of this study do not indicate that the prevalence of part-time work has a significant relationship with environmental impact. It is possible that this lack of evidence is a product of the lens through which this study was conducted. Individual responses to working part-time are complex and likely vary across individuals, classes, and cultures. Further, whether or not someone entered the workforce with a part-time job, transitioned from full-time to part-time, or began working part-time for some other reason may influence their response. A microeconomic – or perhaps anthropological – exploration on the topic may allow for a better look at the intersection of part-time work and the environment.

5.5 Maternity Leave

The length of maternity leave only had a significant effect on the carbon component of Ecological Footprint. This effect was negative, indicating that an increase in the amount of paid maternity leave offered in a country should be associated with a decline in their carbon Ecological Footprint. An intuitive explanation could account for this result. Paid maternity leave means that new parents do not have to balance their work lives with taking care of their children. This means that new parents will experience less time scarcity if they have paid maternity leave, which may allow them to consume fewer goods than they would without the additional support. Further, it is more likely that new parents would hire a nanny or send their children to day care if they do not have maternity leave. This alone will result in increased consumption relative to the case where one parent stays at home to tend to the child.

The results for maternity leave, though statistically significant, are small. This could be indicative of complex relationships among working, consumption, and child-rearing.

5.6 Female Labour Force Participation

Female labour force participation should have some influence on consumer behavior, particularly on the balance between household production and market based consumption. A sample spanning a larger part of history (going back to the early 20th century) would provide a better picture of the dynamics of female labour force participation; any changes in this variable from 2007-2012 would certainly be overshadowed by more dramatic shifts in the past. Regardless, there is some variation in female labour force participation, though it is more pronounced between countries than across time.

On a theoretical level, it is not clear what the expected net effect of changes in female labour force participation on environmental impact would be. An obvious effect of an increase in female labour force participation is a rise in household incomes. Some authors have argued that women entering the labour force has driven economic inequality, due to the emergence of families with two incomes (Fox, Han, Ruhm, and Waldfogel, 2013). Such families would be able to consume more than a family supported by one income. Further, there could be more households overall, due to the economic independence that comes with labour force participation. These arguments suggest that female labour force participation should be positively associated with environmental impact.

The above arguments are summarized by the assertion that women entering the workforce results in a change in the balance of household production and market-based consumption in favour of the latter. It can be intuitive[11] to assume that purchasing goods and services from the globalized market has a larger environmental impact than producing them at home. Which option is more sustainable (in terms of environmental impact) is, however, contingent upon a number of variables. If one stays and produces at home, then that necessitates a certain amount of energy use. More energy may be used in the production of a unit of goods in the household than in a commercial facility depending on the skill of the workers, the quality of equipment and building, the scale of the project, and other factors.

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[11] Particularly coming from the milieu of Dalhousie's College of Sustainability.

Specialization could, in particular circumstances, reduce the environmental impact of an activity. Variation in energy use could drive a relationship between female labour force participation and environmental impact. Based on these arguments, female labour force participation could result in a decline in environmental impact by switching to forms of production that use energy more efficiently.

It is possible to make a fairly reasonable argument for a positive or negative relationship between female labour force participation and environmental impact. The actual effect of a change in female labour force participation on environmental impact will likely be the result of a variety of mechanisms acting simultaneously.

The analysis in this study found a negative and statistically significant relationship between female labour force participation and Ecological Footprint. In particular, the results suggest that a 1% increase in female labour force participation is expected to be associated with a 0.8-0.9% decline in Ecological Footprint. In contrast, a significant and positive relationship was found between female labour force participation and CO_2 emissions. The results indicate that a 1% increase in female labour force participation is expected to be associated with a 0.65-0.75% increase in CO_2 emissions.

It is important to recall the differences between CO_2 emissions and Ecological Footprint as measures of environmental impact when interpreting these results. CO_2 emissions is a production-based measure, simply the total amount of CO_2 emissions produced within an economy in a given year. Because of this, CO_2 emissions as a variable is more sensitive to changes in production than consumption. In contrast, Ecological Footprint is a consumption-based measurement. The goods and services consumed in an economy are calculated (total consumption = domestic production + net exports), and the land area required to accommodate those goods and services is then estimated (Global Footprint Network, 2016). Based on their construction, one would expect Ecological Footprint measures to be responsive to a change in consumer behavior, like the decision to eat vegetables grown in agroecological systems rather than monocultures. Similarly, CO_2 emissions should be more sensitive to a changes in producer behavior, like increasing domestic manufacturing on a large scale.

Female labour force participation could be a boon to economies overall. In general, more women in the workforce means more people in the workforce. More people in the workforce means there are more people making money, more disposable incomes, and more economic activity in general. If this is the case, it would explain the positive estimated relationship between female labour force participation and CO_2 emissions. But one would expect the increased economic activity resulting from women entering the workforce to be associated with more consumption. This explanation is consistent with the results for CO_2 emissions, but not with the results for Ecological Footprint. Further, if one expected an increase in female labour force participation to results in a decline in environmental impact by using less energy at home and in the production of goods, then one would expect there to be a significant relationship with the carbon Ecological Footprint, which measures the Ecological Footprint associated in particular with energy use. The estimated coefficients are consistent with this result, but they are not significant for carbon Ecological Footprint. This indicates that female labour force participation has an impact on some other part of the total Ecological Footprint, resulting in a statistically significant relationship with the latter but not former version of Ecological Footprint.

The estimated relationship between female labour force participation and CO_2 emissions is easier to explain – at least intuitively; any conjecture laid out here should be empirically validated before being accepted – than the relationship between female participation and Ecological Footprint. It is logical to attribute the former to changes in incomes, production, and consumption that result from a larger proportion of the population participating in the labour force. Explanations of the former relationship are both less obvious and less convincing. In general, these results indicate that female labour force participation has some effect on environmental impact, and particularly that it has some bearing on the complex relationship between impact and working hours. Unfortunately, a deeper investigation of this interaction is beyond the scope of this paper. Exploration of the connections between female labour force participation, working hours, and environmental impact could be a valuable area for further research on this topic.

5.7 Can Working Less Reduce Environmental Impact?

The research done by Schor (2005), Hayden and Shandra (2009), and Knight et al (2013) all show that there is a statistically significant, positive relationship between working hours and various measures of environmental impact. The regression models tested in this study support this notion. Further, the results of this study provide evidence for a relationship between working hours and some measures of environmental impact even when GDP/capita is held constant.

In general, the answer to the question "can working less reduce environmental impact" is yes. The exact mechanisms behind this, and their relative importance, are much less clear. In much of the literature on this topic, an ideal narrative of the relationship between working hours and environmental impact is put forth (Pullinger, 2014). This narrative suggests that people can work less, consume less, and increase their wellbeing (Pullinger, 2014; Hayden and Shandra, 2009). The research in this study does not necessarily refute that narrative, but it does raise questions about what exactly is meant by "wellbeing".

Some evidence for the composition effect was found, but the effect of working hours on environmental impact was diminished and less significant when GDP/capita was controlled for. This result indicates that variation in GDP/capita is a primary driver of the relationship between working hours and environmental impact. Working less is expected to result in a decline in environmental impact. The evidence presented in this study suggests that this decline is not predominantly driven by an increase in sustainable lifestyle choices as a result of liberated free time. Rather, a decline in working hours is closely associated with a decline in incomes. This constrains consumption, ultimately resulting in reduced environmental impact. The narrative about work-time reduction should be amended as follows: "work less, make less, and consume less (improved wellbeing optional)."

Reduced income does not necessarily preclude improved wellbeing, though it could create a significant barrier to it for many people. For some people, giving up income for additional leisure time may be a desirable trade. In fact, there is some evidence from the Australian labour market to support this notion (Reynolds and

Aletraris, 2006). However, one cannot assume that this is true for everyone. There are two main reasons why someone may not wish to trade income for free-time. Some people simply may not be able to afford a decline in their income. It is not clear how work-time reduction would affect people in different income brackets. But it is clear that those in the upper percentiles of the income distribution would be better equipped to deal with a decline in income than their counterparts in the lower percentiles. Those who would be able to afford a decline in income still may not want to do so for the sake of extra free time. This is a product of the culture of hyperconsumerism prevalent in advanced economies. Both poverty and local non-satiation could preclude an increase in wellbeing as a result of reduced working time.

The dream of work-time reduction can only be realized if some fundamental aspects of our social and economic structure are altered. Just as work-time reduction is not prescribed for less-developed economies, it should not be applied to the lower ranges of the income distribution in advanced economies. If work-time reduction is localized to people who can afford a decline in their incomes, then this could prevent an increase in poverty as a result of a decline in working times. The justification for keeping working time constant for those with lower incomes is logical, but it could exacerbate social (if not economic) inequality in the longer term. Those with initially lower incomes would continue to work the same hours for the same pay, while those with higher incomes make slightly less than they used to in exchange for much more free time. It is possible that overtime the overall incomes for each class converge, while a significant differential in their working time remains.

In addition to balancing the effects on different levels of the income distribution, the culture of consumerism would have to shift for work-time reduction to result in increased wellbeing. The evidence in this paper indicates that shifts in consumption are a vital mechanism behind the link between working time and environmental impact. A decline in working time should cause a fall in environmental impact, primarily by constraining incomes; work-time reduction can help the environment, but at a cost.

5.8 Limitations and Areas for Further Research

As discussed in chapter three, a wide variety of assumptions underlie the analyses in this study. Where possible, these assumptions were verified, but the relatively small sample size made this difficult or impossible in some cases. Failure to meet any of the technical assumptions could result in biased or inconsistent estimated coefficients.

Another technical limitation was the functional form of the STIRPAT model, inherited from Knight et al (2013). The STIRPAT model is the translation of a mathematical identity into a testable equation, which is theoretically dubious. Practically, this makes direct comparison of models testing the scale and compositional effect difficult. To add GDP/capita and test the compositional effect, both employment and productivity must be removed from the model (Knight et al, 2013). A different functional form that allows closer comparison of the two models would be a beneficial contribution to this area of research.

One goal of this study was to look at a particular source of variation in working hours: the prevalence of part-time employment. Focusing on macro-level indicators like average annual working hours per employee naturally obscures some complexity. Including part-time employment in some of the regression models was exploratory, and there are certainly many more factors at play in the interactions between working hours, consumption, and the environment.

Future research concerning this complexity would be useful. One problem that arose in this study was how people in different income brackets might respond differently to changes in their working hours. Using microeconomic – or even anthropological – data to explore this topic in more depth would be illuminating. Similar methods could also be used to further investigate the role of female labour force participation.

This study is an attempt to address some of the complexity in the relationship between working hours and the environment. Some aspects of the relationship remain unknown, and there are many areas for further research on this topic.

Chapter 6: Conclusions

This paper explored the relationship between working time and three measures of environmental impact. A number of statistical models were constructed based on the work done by Knight et al (2013) to test the relationship between these variables. The results of these models estimate a significant and positive relationship between working hours and all measures of environmental impact. Controlling for per capita income, or GDP/capita, causes these estimates to decline in magnitude and statistical significance. This indicates that changes in income are a primary driver of the relationship between working hours and environmental impact.

Work-time reduction is often purported as a way to reduce the impact we have on the environment while maintaining a given level of well-being. The results of this study do not refute that claim, but they do indicate its contingency. Based on the evidence presented here, work-time reduction is an indirect way to cause a decline in incomes, consumption, and therefore environmental impact. There is some evidence to suggest that time is liberated with reduced working hours, allowing people to engage in more sustainable and time-consuming activities. However significant this effect, it is much smaller than the effect of changes in income and gross consumption.

It is possible that work-time reduction could cause a decline in consumption and environmental impact without a subsequent change in wellbeing. This depends, however, upon cultural attitudes towards consumption. With a shift in cultural attitudes, work-time reduction could liberate people, improving their wellbeing by allowing them to spend their free time engaging in sustainable activities. Work-time reduction could be a valuable part of a larger strategy to reduce the environmental impact of economies. All evidence indicates, however, that the primary effect of working hours and the environment is through income. As such, the effect of changes in working hours on wellbeing, through income and other channels, should be a critical consideration in policy formulation.

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Appendix 1: STATA commands

```
log using "/Users/catherinekingfisher/Desktop/Honours Log.smcl"
import delimited "/Users/catherinekingfisher/Documents/Fifth Year/Honours/Data march 20.csv", encoding(ISO-8859-1)
egen countrynum = group(country)
xtset countrynum year, yearly
graph matrix log_eft log_efcarbon log_co2 log_gdpcap log_urb log_pop log_man log_serv log_ft log_pt log_prod log_hours log_femalepart lo...
xtreg log_eft log_pop log_urb log_serv log_man log_hours log_emp log_prod log_femalepart, fe
estimates store fixed
xtreg log_eft log_pop log_urb log_serv log_man log_hours log_emp log_prod log_femalepart, re
estimates store random
hausman fixed random
xttest0
xtserial log_eft log_pop log_urb log_serv log_man log_hours log_emp log_prod log_femalepart
reg log_eft log_pop log_urb log_serv log_man log_hours log_emp log_prod log_femalepart
reg log_eft log_pop log_urb log_serv log_man log_hours log_emp log_prod log_femalepart
xtreg log_eft log_pop log_urb log_serv log_man log_hours log_emp log_prod log_femalepart, fe vce(cluster countrynum)
xtreg log_eft log_pop log_urb log_serv log_man log_hours log_gdpcap log_femalepart, fe vce(cluster countrynum)
xtreg log_eft log_pop log_urb log_serv log_man log_hours log_gdpcap log_femalepart, fe
estimates store fixed
xtreg log_eft log_pop log_urb log_serv log_man log_hours log_gdpcap log_femalepart, re
estimates store random
hausman fixed random
xttest0
xtserial log_eft log_pop log_urb log_serv log_man log_hours log_gdpcap log_femalepart
reg log_eft log_pop log_urb log_serv log_man log_hours log_gdpcap log_femalepart
estat vif
xtreg log_eft log_pop log_urb log_serv log_man log_hours log_ft log_pt log_prod log_mat log_femalepart, fe
estimates store fixed
xtreg log_eft log_pop log_urb log_serv log_man log_hours log_ft log_pt log_prod log_mat log_femalepart, re
estimates store random
hausman fixed random
xttest0
xtserial log_eft log_pop log_urb log_serv log_man log_hours log_ft log_pt log_prod log_mat log_femalepart
xtreg log_efcarbon log_pop log_urb log_serv log_man log_hours log_emp log_prod log_femalepart, fe
estimates store fixed
xtreg log_efcarbon log_pop log_urb log_serv log_man log_hours log_emp log_prod log_femalepart, re
estimates store random
hausman fixed random
xttest0
xtserial log_efcarbon log_pop log_urb log_serv log_man log_hours log_emp log_prod log_femalepart
reg log_efcarbon log_pop log_urb log_serv log_man log_hours log_emp log_prod log_femalepart
estat vif
xtreg log_efcarbon log_pop log_urb log_serv log_man log_hours log_emp log_prod log_femalepart, fe vce(cluster countrynum)
xtreg log_efcarbon log_pop log_urb log_serv log_man log_hours log_gdpcap log_femalepart, fe
estimates store fixed
xtreg log_efcarbon log_pop log_urb log_serv log_man log_hours log_gdpcap log_femalepart, re
estimates store random
hausman fixed random
xtserial log_efcarbon log_pop log_urb log_serv log_man log_hours log_gdpcap log_femalepart
reg log_efcarbon log_pop log_urb log_serv log_man log_hours log_gdpcap log_femalepart
estat vif
xtreg log_efcarbon log_pop log_urb log_serv log_man log_hours log_gdpcap log_femalepart, fe
xtreg log_efcarbon log_pop log_urb log_serv log_man log_hours log_gdpcap log_femalepart, re
xttest0
xtreg log_efcarbon log_pop log_urb log_serv log_man log_hours log_gdpcap log_femalepart, fe vce(cluster countrynum)
xtreg log_efcarbon log_pop log_urb log_serv log_man log_hours log_ft log_pt log_prod log_mat log_femalepart, fe
estimates store fixed
xtreg log_efcarbon log_pop log_urb log_serv log_man log_hours log_ft log_pt log_prod log_mat log_femalepart, re
estimates store random
hausman fixed random
xtserial log_efcarbon log_pop log_urb log_serv log_man log_hours log_ft log_pt log_prod log_mat log_femalepart
```

```
reg log_efcarbon log_pop log_urb log_serv log_man log_hours log_ft log_pt log_prod log_mat log_femalepart
estat vif
xtreg log_efcarbon log_pop log_urb log_serv log_man log_hours log_ft log_pt log_prod log_mat log_femalepart, re
xttest0
xtreg log_efcarbon log_pop log_urb log_serv log_man log_hours log_ft log_pt log_prod log_mat log_femalepart, fe vce(cluster countrynum)
xtreg log_co2 log_pop log_urb log_serv log_man log_hours log_ft log_pt log_prod log_mat log_femalepart, fe
estimates store fixed
xtreg log_co2 log_pop log_urb log_serv log_man log_hours log_ft log_pt log_prod log_mat log_femalepart, re
estimates store random
hausman fixed random
xttest0
xtserial log_co2 log_pop log_urb log_serv log_man log_hours log_ft log_pt log_prod log_mat log_femalepar
reg log_co2 log_pop log_urb log_serv log_man log_hours log_ft log_pt log_prod log_mat log_femalepar
estat vif
xtreg log_co2 log_pop log_urb log_serv log_man log_hours log_gdpcap log_femalepart, fe
estimates store fixed
xtreg log_co2 log_pop log_urb log_serv log_man log_hours log_gdpcap log_femalepart, fe
xtreg log_co2 log_pop log_urb log_serv log_man log_hours log_gdpcap log_femalepart, re
estimates store random
hausman fixed random
xttest0
xtserial log_co2 log_pop log_urb log_serv log_man log_hours log_gdpcap log_femalepart
reg log_co2 log_pop log_urb log_serv log_man log_hours log_gdpcap log_femalepart
estat vif
xtreg log_co2 log_pop log_urb log_serv log_man log_hours log_emp log_prod log_femalepart, fe
estimates store fixed
xtreg log_co2 log_pop log_urb log_serv log_man log_hours log_emp log_prod log_femalepart, re
estimates store random
hausman fixed random
xttest0
xtserial log_co2 log_pop log_urb log_serv log_man log_hours log_emp log_prod log_femalepart
reg log_co2 log_pop log_urb log_serv log_man log_hours log_emp log_prod log_femalepart
estat vif
clear
import delimited "/Users/catherinekingfisher/Documents/Fifth Year/Honours/FD vars march 21.csv", encoding(ISO-8859-1)
egen countrynum = group(country)
xtset countrynum year, yearly
reg log_eft log_pop log_urb log_serv log_man log_hours log_emp log_prod log_femalepart
estat hettest
xtserial log_eft log_pop log_urb log_serv log_man log_hours log_emp log_prod log_femalepart
reg log_eft log_pop log_urb log_serv log_man log_hours log_emp log_prod log_femalepart, r
reg log_eft log_pop log_urb log_serv log_man log_hours log_gdpcap log_femalepart
estat hettest
xtserial log_eft log_pop log_urb log_serv log_man log_hours log_gdpcap log_femalepart
reg log_eft log_pop log_urb log_serv log_man log_hours log_gdpcap log_femalepart, r
reg log_eft log_pop log_urb log_serv log_man log_hours log_ft log_pt log_prod log_mat  log_femalepart
estat hettest
xtserial log_eft log_pop log_urb log_serv log_man log_hours log_ft log_pt log_prod log_mat  log_femalepart
reg log_eft log_pop log_urb log_serv log_man log_hours log_ft log_pt log_prod log_mat  log_femalepart, r
reg log_eft log_pop log_urb log_serv log_man log_hours log_ft log_pt log_prod log_mat  log_femalepart, vce(cluster countrynum)
reg log_co2 log_pop log_urb log_serv log_man log_hours log_emp log_prod log_femalepart
estat hettest
xtserial log_co2 log_pop log_urb log_serv log_man log_hours log_emp log_prod log_femalepart
reg log_co2 log_pop log_urb log_serv log_man log_hours log_emp log_prod log_femalepart, r
reg log_co2 log_pop log_urb log_serv log_man log_hours log_gdpcap log_femalepart
estat hettest
xtserial log_co2 log_pop log_urb log_serv log_man log_hours log_gdpcap log_femalepart
reg log_co2 log_pop log_urb log_serv log_man log_hours log_gdpcap log_femalepart, r
reg log_co2 log_pop log_urb log_serv log_man log_hours log_ft log_pt log_prod log_mat log_femalepart
estat hettest
xtserial log_co2 log_pop log_urb log_serv log_man log_hours log_ft log_pt log_prod log_mat log_femalepart
reg log_co2 log_pop log_urb log_serv log_man log_hours log_ft log_pt log_prod log_mat log_femalepart, r
```