Growth, employment and sustainability: differences of environmental demands among patterns of development

Abstract

This paper analyses the problem of growth, employment and their relationship to environmental sustainability. In particular it considers whether environmental limits to growth make it more difficult to guarantee full and good quality employment across the world economy. Results are based on panel data for 147 countries over 28 years and considers a measure of human demand for ecological resources and services (ecological footprint). This analysis leads to two important results. Firstly, by aggregating countries into relatively groups with similar economic and environmental attributes, it highlights how different economic and labour dynamics affect the demand for natural resources. Secondly, the paper provides new evidences that the elasticity between economic growth and natural resources demand has gone down throughout the last decades (relative decoupling), although overall demand has gone up due to population increases and improvements in standard of living (rebound effect).

Keywords: environmental sustainability; employment; economic growth; ecological footprint; environmental Kuznets curve

JEL: O44, Q52, Q56, Q01

Introduction

Population growth and the raising of the demand for decent work is one of the central challenges of economic policies (ILO, 2001). Since the seminal work of John Maynard Keynes (1935), economic theory has shown that employment and wages are not set endogenously on the labour market. They are related to several key macroeconomics factors. In particular, economic growth is required to meet the employment pressures caused by population and labour productivity increases (Okun 1962; Knotek 2007; IMF 2010).

Many studies have, however, raised questions about limits to the economy and the problem of "ecological overshoot", where society consumes more resources than the planet can sustain or reproduce (for instance, Georgescu-Roegen 1971; Daly 1996; Jackson 2009; Ewing et al. 2010a; Moran et al. 2011). Central to this theoretical perspective is the relationship between economic growth, labour productivity, population change and environmental impacts. In most cases, population increases and increased economic activity lead to increased consumption of resources (Grossman and Krueger 1991; Yandle et al. 2002; Galeotti 2007). Similarly increases in labour productivity lead to more resource use per unit of labour. Resource consumption, however, can be tempered by other factors such as increases in resource productivity.

This paper analyses the problem of growth, employment and their relationship to environmental sustainability. In particular it considers whether environmental limits to growth make it more difficult to guarantee full and good quality employment for everyone who wants and needs it. This analysis leads to two important results. Firstly, by aggregating countries into relatively groups with similar economic and environmental attributes, it highlights how different economic and labour dynamics affect the demand for natural resources. Secondly, the paper provides new evidences that the elasticity between economic growth and natural resources demand has gone down throughout the last decades (relative decoupling), although overall demand has gone up due to population increases and improvements in standard of living (rebound effect).

1. *Background*

1.1. *The relation between growth, employment and environmental sustainability*

A central aim of many economic policies is the provision of welfare, work and decent conditions of employment (ILO 2001). Access to employment has objective value as a social good, be it in reducing poverty, increasing personal empowerment and self-esteem, reducing social problems like crime and social exclusion, or increasing consumption and government revenues through taxation income. Similarly, the quality and conditions of employment matter to social welfare, family life and health. The International Labour Organization (ILO) estimates that across the world there were over 200 million people officially unemployed in 2010, 1.53 billion workers were in vulnerable employment in 2009 and 630 million workers (20.7 per cent of all workers in the world) were living with their families at the extreme level of US$ 1.25 a day(ILO 2011). These statistics are almost certainly an underestimation but serve to illustrate the magnitude of the employment problem faced.

At the heart of this discussion, is the relationship that employment has with economic growth. While employment rates are affected by various political, demographic and labour market conditions, crucially they will only rise if economic growth rates outstrip population and labour productivity increases (Okun 1962; Knotek 2007; IMF 2010).

There is a strong relationship between the dynamics of economy, population and resource extraction, waste and emissions (UNDP 2007; Ewing et al. 2010a). Many studies have demonstrated that there are limits to the rate at which the planet can absorb waste and replace resources (Millennium Ecosystem Assessment 2005). When the rate of resource consumption (through-put) exceeds these limits, the economy starts consuming more resources than the world can sustain or reproduce. If humanity is able to consume at a rate faster than this at the moment, it is only because we are consuming the energy and resources saved-up from the billions of years before human activity (Daly 1996).

There is, therefore, a major dilemma: growth is required to provide welfare and create employment, while at the same time growth is reducing welfare by pushing economies over world environmental limits (Georgescu-Roegen 1971; Daly 1996; Ewing et al. 2010a; Jackson 2009). In fact, studies now suggest that the global economy has already substantially surpassed these limits, e.g. over fishing, deforestation and greenhouse gases (Ewing et al. 2010a). This dilemma has led many economists and policy makers to explore the possibility of decoupling employment and growth from resource use and environmental damage.

This idea of decoupling lies behind the debate over the existence of a Kuznets relationship between environmental damage and economic growth. First proposed by Grossman and Krueger (1991), the Environmental Kuznets Curve (EKC) hypothesis describes a quadratic relationship between GDP and environmental damage, similar to that found by Kuznets (1955) in his work on inequality at different stages of economic development. The broad argument is that, as a country's GDP increases, there is likely to be a dramatic increase in pollution and environmental degradation. Potential reasons for this include increased manufacturing production, energy use, changes to agriculture and the growth of cities. There comes a point, however, when the trade-off between financial well-being and environmental well-being ceases to be weighted towards finances. This would coincide with the growth of service sector activity in the economy.

There have been several studies analysing this theory (for instance, Dinda 2004; Bagliani et al. 2008; Galeotti et al. 2006; Kahuthu 2005; Raymond 2004; Yandle et al. 2002). The general conclusion is that these relationships are not as simple as the EKC theory suggests. There is some evidence that a quadratic relationship could exist for pollutants that have an immediate or short term impact on quality of life (Yandle et al. 2002; Raymond 2004). These include issues like air quality, chemical dumping and waste disposal. It is far from clear, however, that this relationship exists for longer term pollutants, such as carbon emissions or other greenhouse gasses that take many years to produce an effect (Raymond 2004; Galeotti et al. 2005). Evidence for these emissions suggests that they have usually tended to continue to rise with GDP. This could either imply that we have not yet reached the automatic turning point for such emissions or that there is no automatic EKC relationship.

1.2. Decoupling and rebound effect

Whether there is an automatic EKC relationship or not, decoupling environmental damage from growth would be an aspirational target for employment creation policies. This is the motivation behind "green" Keynesianism policies (Elliott et al. 2008; Steiner and Sukhdev 2009; Barbier 2010). The idea is to use investment and other policy instruments to focus growth onto activities that reduce environmental damage and provide jobs. The use of environmental taxes, for example, has been shown to make some difference in changing behaviour and off-setting job losses with new jobs (Bosquet 2000; OECD 2004; Patuelli et al. 2005; ILO 2010, UNEP 2011).

Such ideas have been challenged recently though as so far there has been no evidence of absolute decoupling of resource use from GDP growth on a global scale, even if some relative decoupling has taken place (Harris 2006; Jackson 2009). As resource productivity per unit of activity has increased, so too have rates of activity. This is what has been called the "rebound effect," i.e. efficiency savings negated by increased total consumption (Khazzoom 1980, Brookes 1990, Saunders 1992, Alcott 2005)

An alternative policy would be to try to decouple employment from growth itself. This would involve the creation of economies without growth, such as a steady state economy (Daly 1996) or ideas of sustainable de-growth (decroissance) (Rijnhout and Schauer 2009; Martínez-Alier et al. 2010;). Such theoretical models envision economies that maintain or reduce overall resource through-put caused by economic activity in order to keep economies within environmental limits. The aim is therefore to improve the quality of economic activity rather than the quantity (Victor 2008; Spangenberg et al. 2002). Such changes however would require a radical rethink of current economic policies, including changes to world trade, redistribution, the replacement of private consumption with more public goods, controls on population, as well as caps on resource use and protections for environmental service.

Employment levels in such economies would be maintained by redistributing the benefits from productivity gains to workers in the form of shorter working hours and more leisure time (Altvater 1999; Gorz 1999; Spangenberg et al. 2002; Forstater 2003; Victor 2008; Jackson 2009; Martinez-Alier 2009; Spangenberg 2010). Reducing working hours would improve welfare for workers and also open space for full employment by using more workers to do the same amount of work. This extra leisure time could involve other benefits such as greater parental leave, time off for studying, training and volunteering, civic duties or longer retirement (Jackson 2009). Others have further argued that the right to receive welfare and remuneration should be de-linked from work itself (Forstater 2003; Gorz 1999; Martinez-Alier 2009). This, they argue, would help reduce pressure for employment and providing welfare as a human right, something that current systems of economics often fail to do.

2. Material and Methods

2.1. Ecological Footprint and socioeconomic indicators

The empirical relationship that growth and employment have with environmental degradation is evaluated with the Ecological Footprint (EF) measure of natural resource use (Rees 1992; Wackernagel 1994; Rees and Wackernagel 1996). EF accounting is designed to represent human consumption of natural resources and generation of wastes by defining the ecosystem area required to sustain it. This measure, in turn, can be compared to the biosphere's productive capacity in a given year, referred to as biocapacity (BC), which can be use assess the total deficit or surplus of natural resources by a given population, state, city or even by the whole planet.

EF and BC calculation covers six land use types: crop land, grazing land, fishing ground, forest land, built-up land, and the uptake land to accommodate the carbon footprint. The demand for ecological products and services is divided by the respective yield to arrive at the footprint of each land use type. EF and BC are scaled with yield factors and equivalence factors to convert this physical land demand to world average biologically productive land, expressed in global hectares (gha) (Ewing et al. 2010b). This allows for comparisons between various land use types with differing productivities.

EF accounting has been widely used for international comparison (for instance, Niccolucci et al. 2012, Bagilani et al. 2010, Moran et al. 2008, White 2008). An important property of this indicator is that it allocates the demand for a given resource to the end consumer, avoiding, for instance, the underestimation of environmental impacts in a country that consume high levels of imported manufactured products. In turn, while simple and comprehensive, EF is not and cannot be considered a complete measure of environmental sustainability. Any attempt to reproduce the complex diversity of environmental damages in a single measure will undoubtedly incur a significant loss of information. For instance, the EF may provide limited information for toxic materials for which the biosphere has no regenerative capacity, land degradation or biological conservation (Kitzes et al. 2009, Fiala 2007). Moreover, EF is only useful when considering present or historical consumption,as it is unable to predict how human activities will lead to increasing or decreasing environmental demands in the future. Many studies have discussed the accuracy, strengths and weaknesses of EF and BC (for instance, Fergunson 1999; Kitzes et al. 2009; Wackernagel and Yount 2000). Overall, while an approximation of the human pressure on the biosphere, EF provides a clear and consistent consumption-based measure to analyse inequalities of environmental demands on global regenerative capacity among countries.

In the analysis that follows, time series data for EF and BC measurements, provided by the Global Footprint Network (GFN), are compared to times series data for economic and labour indicators, provided by the World Data Bank (WDB)[1] and the ILO LABORSTA[2]. Table 1 describes all variables considered in our analyses.

1 Available at http://data.worldbank.org/. Access on April, 2011.
2 Avalilable at http://laborsta.ilo.org/. Access on October, 2011.

Table 1: Variable description

Variable	*Description*
EF	Total ecological footprint (in gha)
EFpc	Per capita ecological footprint (in gha)
Cropland	Area required to grow all crop products, including livestock feeds, fish meals, oil crops and rubber (% of total EF)
Grazing	Area of grassland used in addition to crop feeds to support livestock (% of total EF)
Fishing	Annual primary production required to sustain a harvested aquatic specie (% of total EF)
Forest	Annual harvests of wood, fuel and timber to supply forest products (% of total EF)
Built land	Area of land covered by human infrastructure (% of total EF)
Carbon	The uptake land to accommodate the carbon footprint (% of total EF)
BC	Total biocapacity (gha)
BCpc	Per capita biocapacity (gha)
Pop	Population Total
GDP	Gross Domestic Product (constant 2000 US$)
GDPpc	Gross Domestic Product per capita (constant 2000 US$)
Export	Exports of goods and services (constant 2000 US$)
Import	Imports of goods and services (constant 2000 US$)
Balance	Difference between exports and imports of goods and services (% of GDP)
NRProd	Natural resource productivity, GDP per unit of energy use (constant 2005 PPP $ per kg of oil equivalent)
Lprod	Labour productivity, GDP per person employed (constant 1990 PPP $)
Unemployment	Unemployment, total (% of total labor force)
Employment	Employment to population ratio, 15+, total (%)
EmpAgric	Employment in agriculture (% of total employment)
EmpInd	Employment in industry (% of total employment)
EmpServ	Employment in services (% of total employment)
VulnEmp	Vulnerable employment, unpaid family workers and own-account workers (% of total employment)
WTime	Average number of hours of work per week spent by persons in the performance of activities which contribute to the production of goods and services (h)

2.2. *Cluster analysis and multiple regression model*

Results are based on two main statistical analyses. Firstly, EF per capita and GDP per capita statistics from 2007 were used as criteria in order to aggregate countries into relatively homogeneous groups - *clusters of economic and environmental development (cluster).* The analysis considered the hierarchical cluster technique, using the Ward's method to aggregate countries according to the Euclidean distances between their EF and GDP per capita. The aim of the Ward´s method is to obtain hierarchical groups in such a way that variance is minimum within groups and maximum between groups (Crivisqui 1999).

Second, we propose a log-linear fixed effects model to explain EF as a function of multivariate economic and labour indicators. The clusters obtained in the previous analysis are used to identify structural changes in the relationship between economic and environmental dynamics, this means, different impacts of economic growth on EF for different groups of countries. Our analysis is based on an unbalanced panel data containing 147 countries (*i*) and 28 periods (*t*, 1980 to 2007)[3]:

$$\ln(EFpc_{it}) = \alpha + \sum_{g=1}^{G} \beta_g \ln(GDPpc_{it}) \times Cluster_{gi} + \sum_{j=1}^{k} \delta_j X_{ji} + \phi_i + \pi_t + \varepsilon_{it} \qquad (1)$$

Where $Cluster_{gi}$ is a binary variable which assumes 1 when the country *i* belongs to cluster *g*. Coefficients β_g represents the elasticity between GDP pc and EF pc for cluster *g*. In other words, this model assumes different relations between economic growth and environment impact for different clusters of countries. For instance, economic growth in richer and more polluted countries may have higher impacts on environment, since their patterns of development may be more based on the consumption of manufactured goods and raw materials, especially oil. Explanatory variables X_j represent other economic and labours indicators and ε is the idiosyncratic error term. We also used fixed effects to control unobserved characteristic of the countries (ϕ_i) and time (π_t).

3. *Results*

3.1. *Clusters of economic and environmental development*

Countries were aggregated into six relatively homogeneous clusters of economic and environmental development according to their EF and GDP per capita. The aggregation was relatively successful, obtaining clusters of countries with low dissimilarities. The variability due

3 However, many observations were missed due to null information for dependent or independent variables.

to the differences between the average values of the clusters represented 91% percent of the total variability of the variables (R^2).

Average values for each cluster are presented in Table 2. Clusters 1 and 2 contain countries with the highest EF and GDP per capita. The first represents three extreme cases of natural resources consumptions (United Arab Emirates, Luxembourg and Qatar). Clusters 3 and 4 present intermediary and similar values of EF per capita, but GDP per capita is five times higher in Cluster 3 than in Cluster 4. Clusters 5 and 6 represent countries with the lowest GDP and EF per capita. The spatial distribution of the countries according to their clusters (colours) and total EF (circles) are presented in Figure 1.

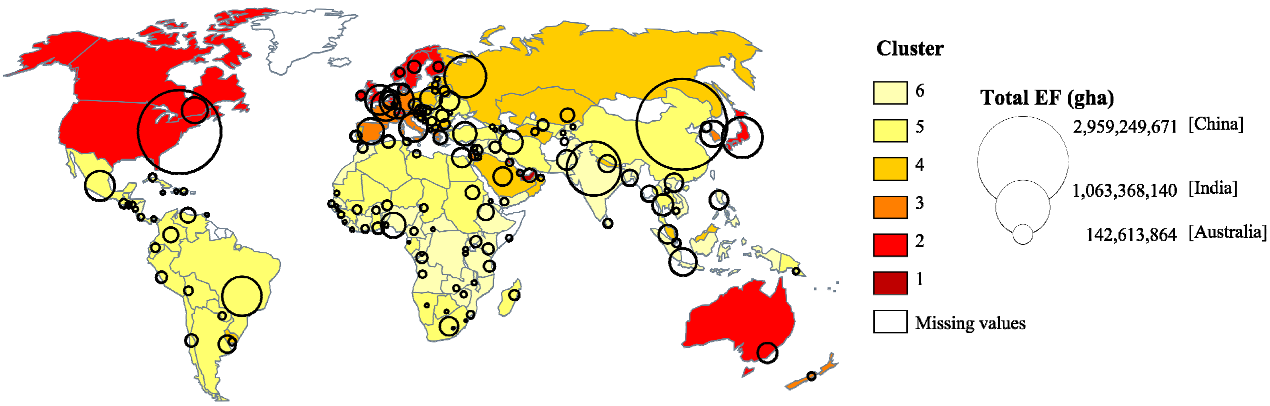
Table 2: Economic, environmental and labour indicators according to clusters of economic and environmental development - 2007

Indicator	*Clusters*						*Total*
	1	*2*	*3*	*4*	*5*	*6*	
Countries (N)							
Number	3	15	10	21	52	46	147
Population (%)	0.1	9.5	5.1	5.4	39.4	40.4	100.0
Ecological Footprint							
Per capita (gha)	11.8	6.8	5.0	4.4	2.3	1.0	2.5
Total (%)	0.5	26.1	10.3	9.6	36.7	16.8	100.0
Components of EF (column %)							
Cropland	12.2	14.5	22.5	19.4	25.5	40.8	24.2
Grazing	4.2	3.4	4.7	3.0	10.7	4.3	6.3
Fishing	3.1	3.7	5.4	5.0	5.3	6.1	5.0
Forest	4.4	12.2	10.3	11.2	9.6	16.2	11.6
Built land	0.8	1.3	2.9	1.6	3.7	5.7	3.1
Carbon	75.4	65.0	54.3	59.8	45.1	27.1	49.8
Biocapacity							
Per capita (gha)	0.1	20.7	5.1	11.0	44.8	18.3	100.0
Total (%)	1.3	3.9	1.8	3.7	2.1	0.8	1.8
GDP							
Per capita (1000 US$)	25.4	36.1	20.7	4.3	2.6	0.7	6.1
Total (%)	0.5	56.9	17.6	3.8	16.8	4.4	100.0
Balance of Trade (% of GDP)	3.7	-1.2	1.4	-3.1	3.0	-0.9	-0.1
Imports (% of GDP)	0.4	45.4	23.4	7.8	18.7	4.5	100.0
Exports (% of GDP)	0.4	43.1	24.3	7.4	20.5	4.3	100.0
Nat. Res. Product. (US$ / kg oil)	4.9	6.7	8.1	4.9	5.7	5.1	6.6
Labor Product. (1000 US$ / worker)	27.3	56.1	45.3	23.9	14.9	7.4	44.0
Unemployment (% of EAP)	1.3	4.6	7.0	6.7	5.5	7.8	5.8
Employment (% of WAP)	75.4	61.0	53.2	57.7	66.2	60.5	62.5
Work Time (h)	-	36.1	35.2	39.9	45.2	41.6	42.5
Employment (column %)							
Agriculture	2.2	2.3	4.4	11.0	33.5	39.1	25.5
Industry	44.5	22.6	27.4	28.9	25.9	19.4	24.9
Services	51.9	74.8	68.1	60.1	40.5	41.0	49.4
Vulnerable Employment (%)	4.3	10.1	13.2	12.0	32.7	57.6	29.6

Source: elaborated by the authors using data from GFN, WDB and ILO.

Clusters 1 and 2 represent the wealthiest countries of the world, which also use the highest levels of resources. They are mostly countries in North America, Northern Europe, Arab oil producer countries and Australia. Average EF per capita for cluster 2 is almost four times higher than global biocapacity and more than six times higher in cluster 1. This is primarily due to high dependence on carbon consumption. Together, they represent less than 10% of the global population but more than 25% of global GDP. Countries in cluster 2 account for almost 50% of total international trade and their labour markets are characterised by the highest levels of labour productivity, a predominance of service sector workers, low working time and the lowest shares of vulnerable employment.

Figure 1: World distribution of countries according to clusters of economic and environmental development (colours) and total EF in gha (circles)



Source: elaborated by the authors using data from GFN, WDB and ILO.
Cartographic source: Philcarto

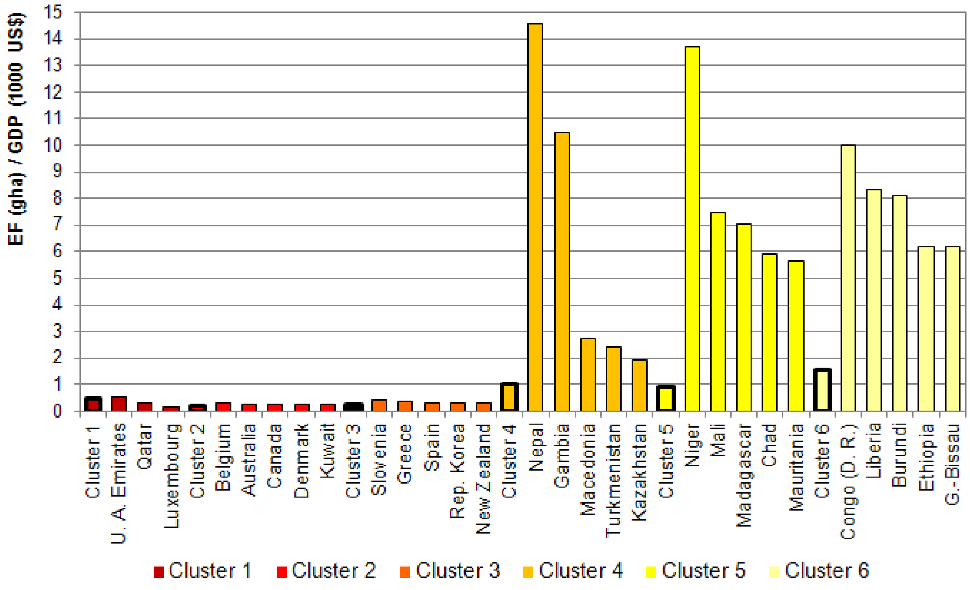
Cluster 3 mostly represents European countries and accounts for a significant share of global GDP (18%). EF per capita in this cluster is lower than in the cluster 2, but still almost three times higher than global biocapacity. The EF of these countries is predominantly due to both high carbon footprints, and also a significant crop-land footprint. These countries have the highest levels of natural resource productivity, and their labour markets are characterised by high productivity, a prevalence of service sector workers, low level of vulnerable employment and the lowest average working time.

Cluster 4 is mostly made up of Eastern European countries. They have an EF per capita similar to those countries in cluster 3, but their average GDP per capita is five times lower. Their high relative level of natural resource consumption is primarily due to a dependency on carbon component (60% of the total EF). This group is also characterised by the lowest level of natural resource productivity and higher share of industry sector workers (29%).

Clusters 5 and 6 represent mostly emerging and developing countries in Africa, the Middle East, South East Asia and South America. Together, these countries account for almost 80 percent of the world´s population, particularly due to the presence of China, India, Indonesia and Brazil. Their EF is characterised by a high share of crop-land (cluster 6) and grazing (cluster 5), which is related to a high prevalence of primary activities and, consequently, a large percentage of agricultural workers in the total labour force. The labour markets in these countries are also characterised by the lowest productivity, highest share of vulnerable employment and highest values for working time.

The ratios between EF and GDP provide additional information to analyse the relative patterns of demands for natural resources among the clusters of economic and environmental development (Figure 2). Although the most developed countries in clusters 1, 2 and 3 use much more resources than their fair global share, their relative consumption is substantially lower than those of the emerging and developing countries (clusters 4, 5 and 6). In other words, the poorest countries tend to consume more natural resource than expected for their low level of economic development, which would be associated with the lower levels of productivity, gross value added or differences in the structure of economic activity.

Figure 2: The ratio between EF (gha) and GDP (1000 US$) for the clusters of economic and environmental development and the countries with the highest ratios in each cluster



Elaborated by the authors using data from GFN and WDB.

Figure 2 highlights that there are considerable differences between countries in the same cluster, while overall, relative demand for natural resources tends to be higher in less developed countries. For instance, in cluster 2, Australia uses more natural resources per unit of GDP than the United Kingdom (0.28 and 0.17 gha per 1000 US$, respectively). Similarly, in cluster 5, African countries, such as Niger, Mali and Ghana use much more EF per unit of GDP than Brazil.

3.2. The relationship between resource use and economic development

A fixed effect model was fitted in order to explain the multidimensional relationship between the natural logarithmic of the EF per capita and selected explanatory factors (equation 1). Indicators with no direct causal relationship with EF per capita or those representing a high level of collinearity with other explanatory factors were not considered in this analysis. Since several countries had no information for the dependent variable and, many of the independent variables for the whole period of analysis, the final sample was reduced to 95 countries and 28 periods. Overall, results were based on a final sample of 1,616 observations and the adjustment presented reasonable goodness of fit measures, with coefficients of determination close to 0.98 and F statistics significant at 0.1%. Ordinary Least Squares (OLS) estimations of the coefficients (generically represented by θ) are presented in Table 3.

Table 3: Ordinary Least Square estimation for dependent variable ln(*EF per capita*)

Variable	$\hat{\theta}$	$S_{\hat{\theta}}$	T	p
Intercept	0.950	0.410	2.318	0.021
ln (*GDPpc*)	0.594	0.064	9.321	***
ln (*GDPpc*) × *Cluster 1*	0.247	0.086	2.885	0.004
ln (*GDPpc*) × *Cluster 2*	0.192	0.054	3.578	***
ln (*GDPpc*) × *Cluster 3*	0.392	0.057	6.853	***
ln (*GDPpc*) × *Cluster 4*	0.303	0.054	5.646	***
ln (*GDPpc*) × *Cluster 5*	0.071	0.048	1.492	0.136
Balance	-0.003	0.000	-7.047	***
ln (*NRProd*)	-0.342	0.025	-13.518	***
ln (*LProd*)	-0.055	0.044	-1.237	0.216
EmpAgric	0.001	0.001	2.027	0.043
EmpInd	0.003	0.001	2.517	0.012

Source: elaborated by the authors using data from GFN, WDB and ILO.
*** Significant at 0.1%

Results highlight that, holding constant economic and labour characteristics such as productivity and industry composition, there is a significant and positive relation between GDP per capita and EF per capita. Moreover, this relation is stronger in those countries with higher natural resources use (*Clusters* 1, 2, 3 and 4). For example, for each one percent increase in the GDP per capita of the poorest and leasts polluted countries (*Cluster* 6, reference of analysis), EF per capita tends to increase by 0.594 percent. This elasticity is 0.303 percentage points higher in the *Cluster* 4 and 0.392 higher in the *Cluster* 3.

Results also highlight the important role that natural resource productivity has in reducing EF. On the other hand, there is no significant evidence that increases in labour productivity tends to impacts on EF, after we hold constant economic growth and other labour characteristics. Moreover, a positive balance of trade tends to reduce natural resource demand, as export sectors can be characterised as part of others countries consumption.

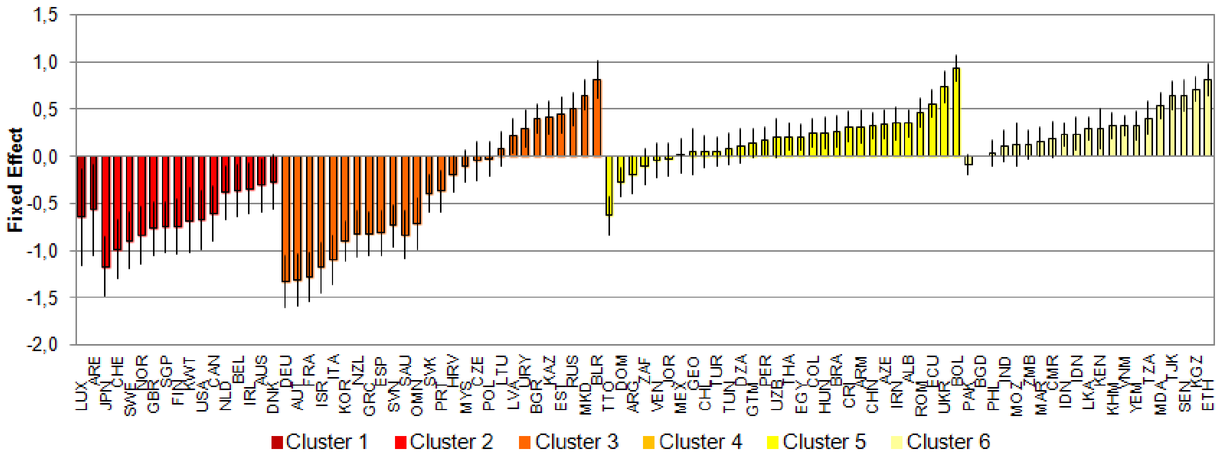
The data implies that countries with a higher share of workers insecondary and, to a lesser extent, primary activities tend to consume higher quantities of natural resources if everything else is held constant. The demand for natural resources tends to increase by 0.1% and 0.3%, respectively, for one percentage point increase in the share of primary and secondary sector workers. Countries with high levels of agricultural and extraction industries also tend to have high levels of vulnerable employment and poverty. They tend to be either producing for subsistence or exporting resources to wealthy countries. This suggests firstly that the ultimate consumer of those resources is not the poorer country, as products and resources exported to wealthy countries form part of the unsustainable consumption patterns of other countries. This means that they are neither providing decent employment nor sustainable economic activity. Similarly, industrial activities tend to consume larger amounts of natural resources, such as energy, carbon and raw material.

Finally, we analyse the impacts of country and time trend on the demand for natural resources. Figures 3 and 4 show the distribution of fixed effects ϕ and π respectively (equation 1) according to countries (Figure3) and years (Figure 4). Central markers in both plots represent predicted values; upper and lower lines represent a 95% predicted interval. Countries in Figure 3 were ranked according to clusters and fixed effects to facilitate interpretation. Fixed effects consider Bangladesh[4] (*Cluster* 6) as the reference of analysis for country heterogeneity and the year 2007 for time trend. Thus, the fixed effect is zero for this country and year.

Results in Figure 3 highlight that, holding constant economic and labour indicators, countries heterogeneities play important roles in defining different patterns of resource use. There are two main patterns of natural demand: low values for clusters 1, 2 and 3; and high values for clusters 4, 5 and 6. These two patterns roughly divide by wealth with clusters 1,2 and 3 representing the wealthiest countries and clusters 4, 5 and 6 representing the poorest nations. This result reinforces previous analyses that the poorest nations are using more natural resources per unit of GDP. Since GDP and natural resources productivity are controlled in these analyses, among other factors, this result would be related to differences in the level of technological development or gross value added among these countries.

4 Bangladesh was chosen due to its position roughly at the centre of the range of variation.

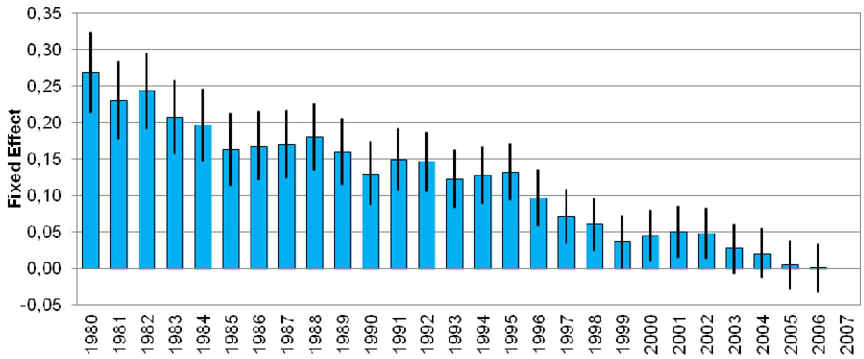
Figure 3 –Fixed effects for country heterogeneity[1]



[1] Vertical lines represent 95% prediction intervals
Elaborated by the authors using data from GFN, WDB and ILO.

In addition, fixed effects for time trend in Figure 4 suggest a substantial reduction in the demand for natural resources after we hold constant economic and labour indicators. For instance, EF per capita was about 30% higher in 1980 in comparison with 2007 if we considered the same level of development for the selected explanatory factors. In other words, world economies have witnessed a relative reduction in the demand for natural resources although overall demand has continued to rise. To what extent this reduction is sustainable in the long term is another question, since it depends on several other determinants, such as increases in population and GDP per capita.

Figure 4 – Fixed effect for time trend[1]



[1] Vertical lines represent 95% prediction intervals
Elaborated by the authors using data from GFN, WDB and ILO.

4. Discussion

This analysis illustrates the variation in patterns of development and their different impacts on the environment. Carbon emissions are by far the most significant of these factors, representing around 50 percent of global EF. Moreover, carbon footprint is relatively greater in wealthier countries, where it accounts for more than 65 percent of total EF. These results suggest two main conclusions. Firstly, the real limits to growth, especially in developed countries, are more due to waste disposal services than by resources availability (similar results are presented by Ewing et al. 2010a). In some of the poorest countries, which aggregate to around 40 percent of the world population, the demand for crop land, grazing, fishing forest and built land is more significant (63 percent of the total EF), but these five components account for just half of global EF. Secondly, in order to bring the economy down within global ecological limits, focus should be placed on reducing carbon footprint. Besides leading to a more sustainable economy, reductions in the carbon emission in more developed countries would also lead to a more just distribution of the EF overall (White 2008).

Results also suggest that the impact of economic growth on the environment differs greatly amongst groups of countries. The wealthiest countries, which also have the higher shares of industry and service sector workers, consume much more natural resources than their fair global share, although their relative pattern of natural resource consumption (per unit of GDP) is substantially lower than those of the poorest countries. This latter result can be explained by differences in the level of productivity, technology and gross value added for these countries . Economic growth, however, in these wealthiest countries is actually more environment demanding (higher elasticity between GDP and EF per capita), since it is usually followed by increasing per capita consumption of resources and fossil fuels.

In addition, the structure of the labour market plays an important role on resource use. Holding constant economic indicators, such as GDP per capita, the transition from an agricultural or industrial economy to a service economy tends to reduce EF. In turn, differences in labour market structure also determine the type, quantity and quality of work available. In general, there is a link between work in agriculture, vulnerable employment and low levels of GDP. All of the indicators of decent work used, such as working time and levels of vulnerable employment, imply that improved working conditions are strongly associated with economies with higher GDP per capita and, thus, EF. On the other hand, most countries with high industrial and service sector activity tend to have lower levels of poverty, higher GDP per capita and thus a higher EF per capita. The exceptions to this trend are those countries with high levels of inequality and urban poverty, found particularly in Latin America. These economies are characterised by high levels of low paid service sector jobs.

Country heterogeneities and time trends suggest significant structural changes in the relationships between EF and GDP per capita. Firstly, countries are actually consuming fewer natural resources for similar levels of development than before but GDP growth and improved efficiency of resource use has been undermined by increased consumption overall (the rebound effect). This implies that GDP growth per se is not leading to absolute decoupling of resource use or faster growth in resource productivity. This conclusion tends to support those authors that have doubts about sustainability driven by economic growth

Countries with different levels of development and consumption cause different impacts on the environment. These results imply, for instance, that the relationship between EF and GDP cannot be analysed by usual linear models without considering substantial differences between societies and their patterns of consumption. In other words, what is the economic activity that is taking place? The environmental impact of producing agriculture commodities is likely to be very different to manufacturing aeroplanes. Serious analysis of such differences should hold clues to how changes in consumption trends could be made while maintaining high standards of living. These statistics reinforce questions about GDP as a measure of welfare, as it conflates many types of activity, both positive and negative (Cobb and Daly 1989; Cobb et al. 1995). For example, negatives such as pollution count twice towards GDP, first when it is caused and then when it is cleared up. To quote the founder of GDP, Simon Kuznets, “Goals for more growth should specify more growth of what and for what” (Kuznets 1962)

5. Conclusions

This paper provided additional information to analyse the relationships between population and economic growth, employment and environmental damage. Results allow us to conclude, for instance, that natural resource productivity is the main driver of reductions in ecological footprint, but so far such productivity gains have been cancelled out by more rapidly increasing overall consumption. Analysis also allows us to conclude that environmental sustainability has to be viewed from a global perspective. Growth in GDP and growth in consumption, while caused at a local level, are highly dependent on behaviours in other countries. This implies that the economic benefit of moving production to countries with lower labour costs needs to be balanced with the environmental costs of that production. Incorporating environmental costs into prices could help, as would technology transfers from wealthy countries to help improve the productivity of workers and production in less developed economies.

EF statistics describe resource use in total, but the reality is that not all resources are currently at the same crisis point. The countries with the best indicators for decent work and

GDP per capita tend to have higher EFs per capita, and the majority contributor to EF for these countries is their carbon footprint. This underscores the need to find ways to reduce carbon footprints as an urgent priority. There is hope that these problems could be solvable in the short term with appropriate political commitment and resourcing (Stern 2006; IPCC 2007; UNEP 2011).

In order to reduce environmental impacts without reducing employment, more sophisticated strategies of employment creation are needed than simply growth. While not detailed enough to make explicit conclusions, it is clear that different kinds of economic activity have different levels of ecological and social impacts. This implies that policy makers need to consider more specifically what kind of jobs are being produced in an economy rather than simply leaving this to the market dynamics. As green Keynesian proposals suggest, there is a clear role for government in guiding and stimulating job creation in areas that have positive ecological and social impacts (e.g. in sustainable forestry, renewable energy generation, new construction skills to retrofit buildings). Exploration of some of the employment solutions suggested by steady state and degrowth economists may also provide some answers. There is no evidence, however, of countries having successfully attempted to implement green economic policies and, as several authors have pointed out, there has been little political appetite to experiment with them to date (van den Bergh 2001; Jackson 2009).

In the long term the question of how economies can provide good quality work while remaining within planetary resource limits implies more holistic solutions. With population predicted to reach 9 billion in 2050 (UN, 2004) the focus should be on how to build an economic framework to accommodate this population and stabilise resource use back into the Earth´s sustainable limits. To do this we need to reconsider many of our assumptions regarding economic success. If we hope to provide welfare for all without destroying our environment we need to think again about distribution of resources, measurements of well-being that include more than simple finances and the nature of work and remuneration. Finding a way to provide decent work and social well-being within environmental resource limits is one of the primary challenges of our time.

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