Quantitative Analysis of Mainstream Economic Indicators and Selected Alternative Measures

IN-STREAM – The Integration of Mainstream Economic Indicators with Sustainable Development Objectives

Deliverable 3.2

24 March 2011
Final version

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1. Introduction

Mainstream economic measures such as GDP are useful and have great influence on both public and private decision making. Yet, they are flawed – and were never intended to serve – as a measure of human welfare. In addition, they give little information as to whether economic activity is helping Europe make progress toward its environmental goals and its commitment to sustainable development.

As such, there is a crucial need in Europe for indicators and measurement systems that provide a useful assessment of progress toward the simultaneous objectives of economic success, human well-being, environmental protection and long-term sustainability. The goal of the IN-STREAM project is to bridge the gap between these different types of indicators and to disseminate the results to policy-makers, economists, journalists and the public at large.

Key project objectives include:

- Performing the required quantitative and qualitative assessments in order to link mainstream economic indicators with key well-being and sustainability indicators.
- Providing insight into the synergies and trade-offs implicit in Europe's pursuit of economic growth and environmental sustainability.
- Recommending new indicator approaches (and sets of indicators) based on their robustness, feasibility and suitability to EU policy objectives.
- In consultation with stakeholders, developing strategies for implementing these approaches.

By doing so, the IN-STREAM project provides useful information to the European Union's "beyond GDP" process, which started with the 2007 high-level ""beyond GDP"" conference and resulted in the EU Commission releasing its communication "'Beyond GDP: Measuring Progress in a Changing World" on 20 August 2009. The communication presents Europe's desired path to developing and implementing alternative measures of growth, human well-being and environmental sustainability. Under the Roadmap laid out in the communication, the EU Commission will release a new EU environmental pressures index in 2011 (revised from 2010).

Within this context, the objectives and findings of the IN-STREAM project can inform the Commission's selection of alternative metrics of growth, wellbeing and environmental sustainability.

1.1 Objectives

The purpose of Work Package 3 (WP3) is to twofold. First, the goal is to conduct a literature to identify the different approaches developed to date for measuring and assessing progress toward sustainable development (cf. Deliverable 3.1). And second, the identified sustainability measures will be linked to widely used metrics of economic performance to gain a better understanding of the linkages, especially synergies and trade-offs, between sustainability goals and mainstream economic performance benchmarks. WP3 therefore plays an important role in the IN-STREAM project: it is the critical link between the qualitative analysis of sustainability, economic, and welfare indicators conducted in Work Package 2 (WP2) and the modelling exercises of Work Packages 4 to 6 (WP 4-6), which jointly model economic, social, and environmental objectives in computable general equilibrium models. The relevant

WP 3 tasks that lead to the present deliverable are shown below and full information can be found in the project documentation (DoW, p.23-25).

IN-STREAM WP3 Objectives (underlined objectives are addressed in this report):

- Examine past research on <u>how changes in SD indicators relate to changes in GDP, employment, and competitiveness</u>.
- Assess accounting frameworks where economic and non-monetary SD data can be integrated and used together
- Investigate how the links between various SD indicators and general macro measures could be established, and recommend whether it would be worth attempting to establish such links.
- <u>Establish and validate quantitative linkages between SD indicators and mainstream macro and sectoral indicators</u>.
- <u>Undertake selected quantitative analyses of the decoupling/decomposition between sustainability indicators and economic development</u>.
- Conduct sensitivity analysis of quantitative linkages to underpin the robustness of results and conclusions.

Task 3.3: Establish the database required for the quantitative estimation of identified linkages for sectoral and general macro indicators (Lead: IIASA). This task will tap into published materials from past analyses as well as available international and national statistics and datasets to prepare the quantitative basis for further tasks in WP3 and to provide complementary data inputs into WP5 and WP6. This task will review, compare and conduct thorough quality checks of the possible data sources and select the most appropriate sources for use in Task 4. Based on the reviews in WP2, this task will also include an assessment of relevant accounting frameworks where economic and non-monetary SD data can be integrated and used together.

Task 3.4: Develop, test and estimate statistical models to establish and validate the quantitative linkages identified in Task 2 for SD indicators and general-macro indicators (Lead: IIASA). After establishing the conceptual linkages between SD and traditional economic indicators, WP3 will attempt to estimate quantitative relationships depending on the availability of data. Suitable statistical methods will be used for testing, quantification and sensitivity analysis. Results of this exercise at the level of variables, groups of variables and composite indices are expected to inform the definition and exploration of sustainability targets in WP4 and should also usefully complement the equilibrium analyses in WP5 and WP6.

Associated with the above task is this deliverable, which presents the quantitative statistical and sensitivity analyses of the tested and quantified relationships among SD indicators and mainstream indicators of economic performance.

1.2 Overview

Deliverable 3.2 is structured as follows. Beginning with a description of the data, their sources and coverage as well as the methods used to analyse them, we present the main findings of (a) the extensive correlation analysis (IIASA) of the IN-STREAM indicators and selected "beyond GDP" measures in Section 4 and (b) the more advanced statistical examination of the relationships among a selected subset of mainstream and alternative indicators (Ecologic Institute) in Section 5.

Due to the substantial volume of indicators, we present only the most relevant (cf. Objectives of WP3) and interesting findings in the context of ongoing debates regarding the linkages between conventional growth metrics and more comprehensive wellbeing and sustainability indicators. A summary of the findings and conclusions based thereon conclude the main part of the report. The Appendix contains a full set of graphs and other results obtained in the statistical analysis.

2. Data

The basis for our analysis in Section 4 is the list of IN-STREAM indicators shown in Table 2-1 and selected "beyond GDP" indicators shown in Table 2-2.[1]

For the advanced statistical analysis presented in Section 5 we obtained data from the EU structural indicators for the time period 2000-2008. Data prior to and following this period (up to the cut-off date of June 30, 2010 for inclusion) were found to be too incomplete to add much value to the analysis. We completed the database by adding selected alternative measures of wellbeing and sustainability, namely Adjusted Net Savings (ANS), indicators from the EU SDS, UNDP's Human Development Index (HDI) and others. Figure 2-1 displays the different data sources.

[1] The "beyond GDP" initiative of the European Commission aims to develop improved and/or alternative indicators of economic and social progress as well as environmental sustainability. The Communication "GDP and beyond: Measuring progress in a changing world." (COM/2009/0433 final) released by the Commission on 20 August 2009 outlines a Roadmap and specific actions to achieve this goal.

Table 2-1: List of IN-STREAM indicators.

SD Dimension	Domain	Indicator included in IN-STREAM quantitative analysis
Economic	**Production/ income**	***1. GDP*** (In its various forms: total, per capita, growth rates etc)
		2. Household income (In its various forms: total, per capita, growth rates etc)
	Work force	***3. Employment/Unemployment*** (Various indicators can be used to measure distortions in the labour markets)
		4. Labour productivity
	Wealth	***5. Value of fixed capital (see also 8.)***
	Government debt	***6. General government debt***
	Reforms and competitiveness	***7. Comparative price levels*** (and other indicators of economic convergence and international competitiveness like various versions of **7b Revealed Comparative Advantage**)
		8. Net investment in fixed capital
Environmental	**Efficiency**	***9. Energy Intensity of GDP (of the economy)***
	Pollution/waste (Non GHG)	***10. Direct external costs from pollution*** ***11. Disability Adjusted Life Years*** (To be coupled as more informative with growth rates from different NON GHG pollutants)
	Biodiversity	***12. Potentially Disappeared Fraction***
	Climate change	***13. GHG emissions*** (In their various forms: e.g.: level, growth rates etc.) ***14. GHG intensity of GDP***
	Natural capital	***15. Adjusted Net Savings***
	Transport	***16. Volume of freight transport relative to GDP***
	Environmental policy evaluation	***17. Cost to target***
Social	**Equity**	***18. Inequality index*** (primarily Gini coefficient applied to GDP and Income)
	Education	***19. Various: (Educational attainment/drop-out rate (****connections to immigration****); employment rate by highest level of education attained; early school leavers).***
	Research/innovation	***20. Gross Domestic Expenditure on R&D***
	Poverty	***21. At risk-of-poverty rate after social transfers***

Table 2-2: List of beyond GDP indicators in the correlation analysis

Name and year of data	Short Description
Sustainable Society Index (SSI) 2008	The SSI measures the actual level of sustainability of a country and the distance of each country to sustainability. The index is composed of indicators clustered into 5 categories: 1. personal development, 2. healthy environment, 3. well-balanced society, 4. sustainable use of resources, 5. sustainable world; Scale: from zero (no sustainability at all) to 10 (full sustainability)
Human Development Index (HDI) 2007	The HDI is a summary composite index that measures a country's average achievements in three basic aspects of human development: 1. a long and healthy life, 2. access to knowledge, and 3. a decent standard of living; expressed as a value between 0 and 1 (higher
Corruption Perceptions Index (CPI) 2009	The CPI method combines data from a range of corruption surveys into an index, measures the perceived levels of corruption; scale from 1 to 10, higher means less corruption
Ecological Footprint (EF) 2006	Compares human demand with the ecological capacity of the area to regenerate; measure: global hectares per capita.
Environmental Sustainability Index (ESI) 2005	The ESI was developed to evaluate environmental sustainability; the score quantifies the likelihood that a country will be able to preserve valuable environmental resources effectively over a period of several decades. The index is composed of indicators grouped into five components: 1. SYSTEM - Environmental Systems , 2. STRESS - Reducing Environmental Stresses, 3. VULNER - Reducing Human Vulnerability, 4. CAP - Social and Institutional Capacity, 5. GLOBAL - Global Stewardship
Average Happiness 2006	Average Happiness measures subjective well-being and ranks nations using the best comparable set of survey findings on happiness. Shows how much people enjoy their life-as-a-whole on scale 0 to 10.

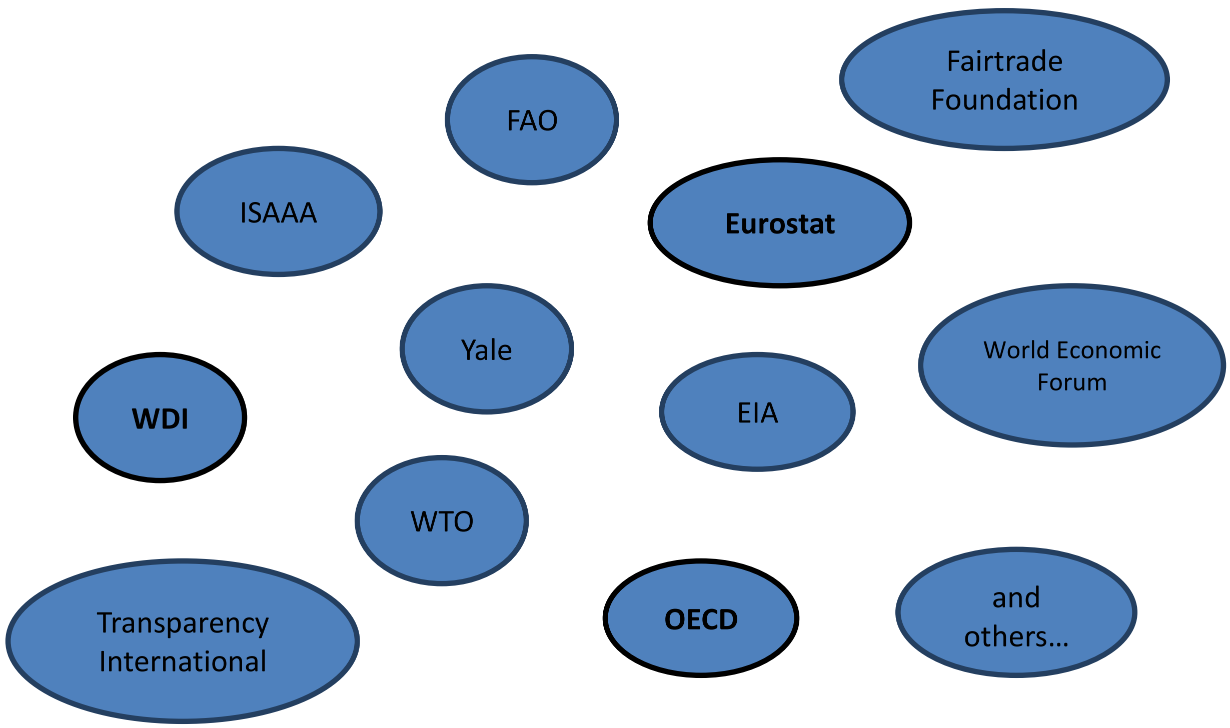

Figure 2-1: Overview of data sources used to build the database for the advanced statistical analysis.

Although available for some indicators, we excluded from the analysis aggregate data for country groupings such as the EU15, the EU27 or other regional and political aggregates because we felt that examining linkages and trends at aggregated EU levels – while interesting with respect to Europe's overall trajectory and total environmental impacts – was beyond the scope of the work and would inevitably lead to the disaggregation of the results by country or sector in order to understand the observed aggregate patterns. In total we examined 70 indicators from the economic, social and environmental spheres (cf. Table 2-3).[2]

Table 2-3: Thematic areas included in the database for the advanced statistical analysis.

Area	Indicators
Economy/Politics/Trade	22
Environment	29
Social	12
Others (e.g., Nanotechnology, GMOs, Research)	7

[2] A detailed list of the EU structural indicators, which are the core of the database for Section 5,5 is given in the Appendix.

The countries, regional and political groupings represented in the database are shown in Table 2-4 and Figure 2-2.

Table 2-4: Countries represented in the database for the advanced statistical analysis.

Countries				
(Argentina)	Czech Republic	(Indonesia)	(Mexico)	Slovenia
Australia	Denmark	Ireland	Netherlands	(South Africa)
Austria	Estonia	(Israel)	(New Zealand)	Spain
Belgium	Finland	Italy	Norway	Sweden
(Brazil)	France	(Japan)	Poland	Switzerland
Bulgaria	Germany	(South Korea)	Portugal	Turkey
(Canada)	Greece	Latvia	Romania	(Ukraine)
(Chile)	Hungary	Lithuania	Russia	United Kingdom
(China)	Iceland	Luxembourg	(Saudi Arabia)	(United States)
Cyprus	(India)	Malta	Slovakia	

Note: Countries in “( )” were used to obtain a more global assessment as they are representative for different regions, geo-political groups, levels of economic development, and eco- and social systems.

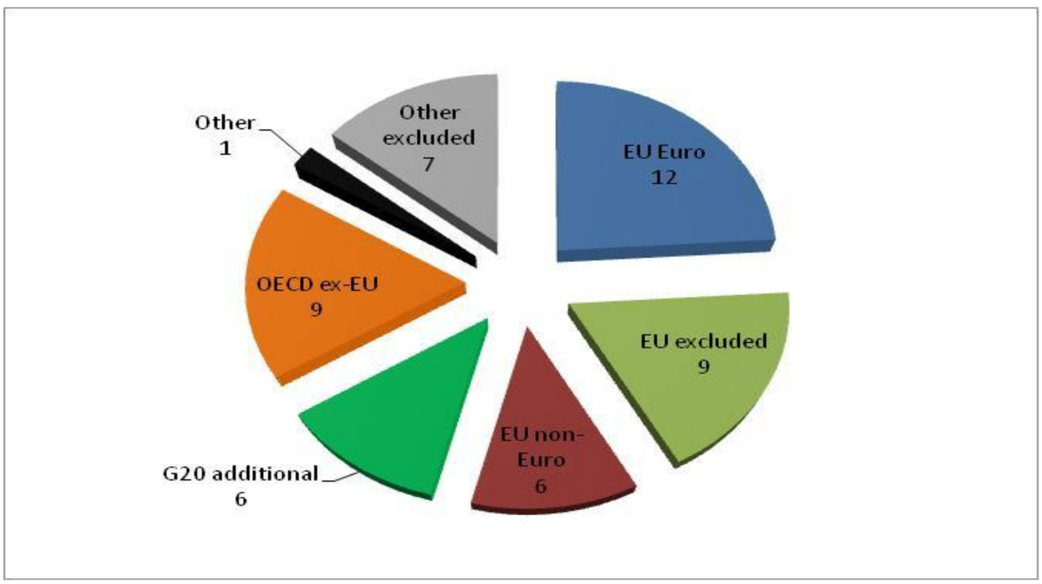

Figure 2-2: Country membership in different political, economic, and other groupings in the database for the advanced statistical analysis.

3. Methods

The analytical protocol for this deliverable was established at the IN-STREAM project meeting held from 1-2 October 2009 at IIASA's premises in Laxenburg, Austria. It defines a data exploration phase that includes correlation analysis (Section 4: Correlation Analysis) and is followed by a more focused statistical analysis, including dimension reduction and latent variable methods such as Principal Component Analysis (PCA) and Factor Analysis (FA), as well as a closer look at time series patterns and possibly the estimation of relationships among selected indicators using regression methods (Section 5: Advanced Statistical Analysis). In line with this analytical plan, Section 4 presents a variety of data patterns using scatter plots and bivariate correlation analysis.

We then examined time series patterns, PCA and also conducted a Cluster Analysis (CA) to identify similarities among the countries included in the database with respect to the selected indicators. Due to the large number of indicators, some of which are not generally part of macro-economic performance assessment, we selected indicators for this analysis that are widely known and reported on and for which the economic literature has formulated linkages to other metrics of human welfare and environmental sustainability.[3] By applying this approach we were able to underpin the purely empirical analysis with contextual information, which allows a more informed and nuanced interpretation of the data.

Taking the results of the correlation analysis into account, we also examined possibilities for regression modelling but decided not to pursue this path since it became apparent that a meaningful analysis would need to control for macro-economic, environmental, and political conditions that are outside the scope of this work package and would also require another round of data collection. We also think that to accomplish this part in a scientifically rigorous manner, there would be a need to first complete a literature review to identify hypotheses for empirical testing.

4 Correlation Analysis

This section provides a summary of the results of the first part of the statistical analysis conducted in Task 3.4. We start with some background information about this task in Work Package 3. The main part of this section presents the result of the comprehensive correlation analysis of the IN-STREAM indicators (Bosello et al. 2009). This is followed by some interesting associations between IN-STREAM, "beyond GDP" and other indices of sustainability emerging from the analysis. We finish with a few concluding remarks.

[3] Please refer to deliverable D3.1.

4.1 Background

The work in this task builds on two earlier Deliverables of the IN-STREAM project: the project's baseline indicators and an extensive literature review (Deliverable 3.1)[4] that also covered many indicators from the "beyond GDP" initiative. The basis for this analysis also includes the data base collected to represent the full set of baseline indicators (Deliverable 4.1)[5] that comprise 21 indicators included in the IN-STREAM quantitative analysis. In addition, we draw on data compiled to quantify selected indices from the "beyond GDP" initiative and other sustainability indices (see Hizsnyik and Toth, 2010 for details). The bulk of the original data for this analysis was taken from the official EuroStat online database. A diversity of other sources was used for the remaining indicators.

As mentioned in the introduction to this report, the mandate is to explore quantitative relationships among the IN-STREAM indicators on the one hand and between selected IN-STREAM indicators, "beyond GDP" and other indices on the other. We conducted an extensive correlation analysis (this section) as well as data mining and other techniques (see Section 5).

It is beyond the scope of this statistical analysis to go into the details of possible causal relationships among the selected indicators. Yet obvious or suspected causal linkages are mentioned in many cases to help further in-depth analyses in the quantitative work packages of the IN-STREAM project and beyond. These remarks refer to widely held beliefs or conventional wisdom.

4.2 IN-STREAM indicators

In all charts presented in this subsection, the vertical axis shows the correlation coefficients between -1 and +1. The horizontal axis depicts the correlation coefficients for the indicated pairs of variables across a range of countries included in the analysis. The countries represented in the analysis include the EU-27 and associated countries such as Switzerland, Croatia and Iceland. For the sake of simplicity we call these countries EU-27+. We do not identify individual countries, although this may be of interest to some. Our rationale behind this decision is that we first and foremost wanted to identify general relationships and second that we were concerned that perceived "outliers" in any of the bivariate relationships shown might be due to a variety of factors, including possible data problems that would be impossible to discern from a single bivariate correlation plot. The time horizon for the correlation analyses covers the period 1990 to 2008.[6]

4.2.1 Economic indicators

First we explore correlations between GDP per capita and other economic, environmental and social variables that are thought to be influenced by the level and pace of economic development. GDP per

[4] Hizsnyik, E. and F. Toth (2010) D 3.1: Internal summary report: Literature findings and recommendations for linking SD and mainstream macroeconomic indicators

[5] Bosello, F., A. Best, F. Ciampalini (2009) D 4.1: Internal report: Full set of baseline indicators

[6] The use of time series data for correlation analysis has benefits and risks. Time series data are not independent but exhibit various degrees of autocorrelation, which can bias correlations between countries.

capita data at current prices[7] are converted to an artificial currency unit, the so called ‘purchasing power standard’ (denoted in the figures as ppp) on the basis of the purchasing power parities of national currencies.

Figure 4-1 reflects some well-known correlations between GDP and income and labour productivity, but they are convenient for testing the data we collected and the method we applied. GDP per capita is strongly and positively correlated in most countries with labour productivity per capita on the production side and with household income per capita on the consumption side. Net national disposable income is also closely correlated with GDP per capita. The well-established negative correlation between GDP per capita and energy intensity is apparently valid in most countries included in the sample, indicating that as societies get more affluent, they use less energy to produce one unit of GDP.

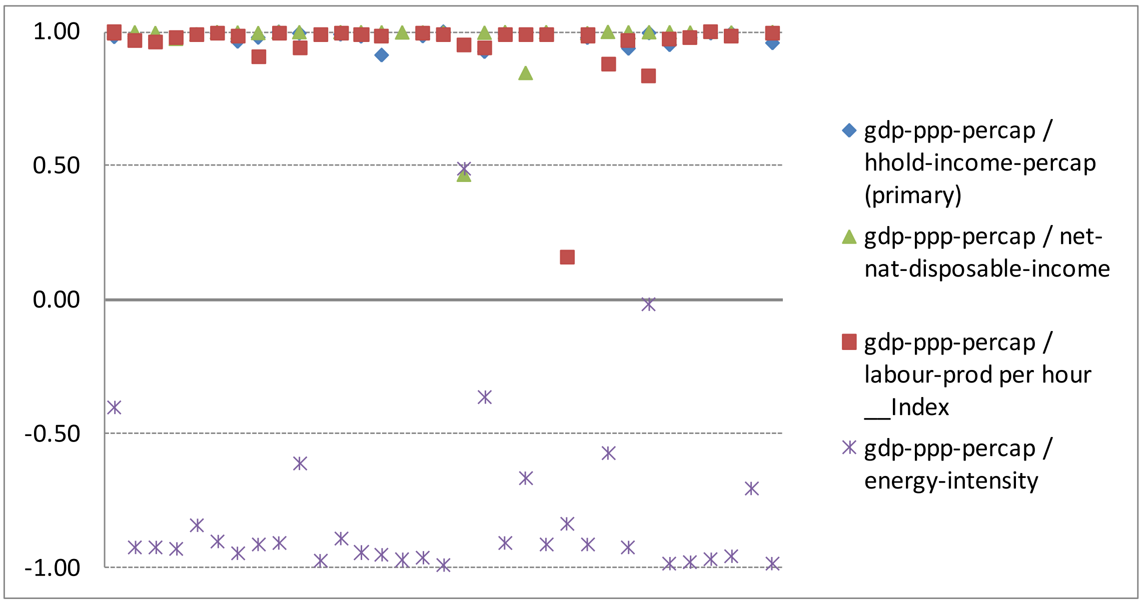

Figure 4-1: Correlation values for selected European countries: GDP vs. household income, net national disposable income, labour productivity, energy intensity

We also observe some interesting relationships between economic prosperity measured in terms of GDP per capita and different indicators of expected lifespan for the male and female population in the analysed countries. Figure 4-2 shows that the rich tend to live longer as there is a strong positive correlation between GDP per capita and life expectancy both for females and males. However, there is a much wider spread, and even many negative correlations between GDP per capita and healthy life years expected at birth, as shown in many countries. This means that higher incomes do not necessarily lead to healthier lives. The reasons are diverse, ranging from nutrition and lifestyle factors to differences in the availability and quality of the healthcare systems even at similar levels of GDP per capita.

[7] Note:, current prices do not remove inflationary trends from a time series, which may affect the observed relationships between GDP and the selected second variable.

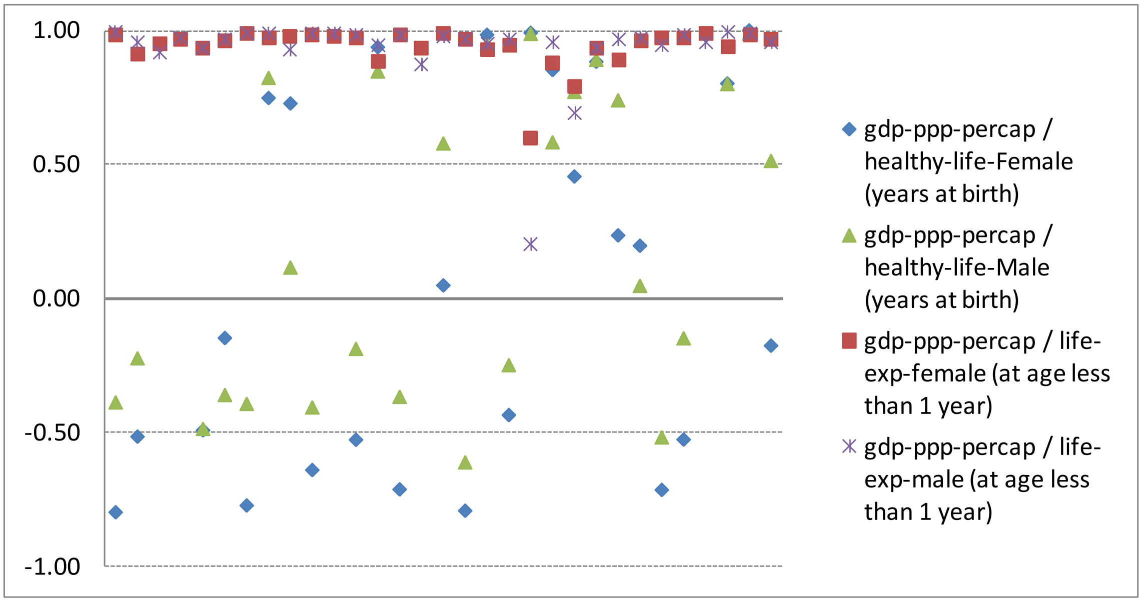

Figure 4-2: Correlation values for selected European countries: GDP vs. healthy life years, life expectancy

The positive association between GDP and educational achievement is confirmed by Figure 4-3. There is a strong positive correlation between GDP and the secondary education achievements of the total population. This correlation is somewhat weaker in the case of the young population. Nonetheless, these associations indicate that educational achievement and national wealth go hand in hand, and although it does not imply causality one way or the other, there is room to state that better education fosters further economic growth, even if there are a few countries in which this association is not very strong. The correlations between GDP and expenditures on research and development (R&D) present a mixed picture. With the exception of two outliers, per capita expenditures on R&D are strongly and positively correlated with per capita GDP in most EU27+ countries. However, when R&D expenditures are measured as percent of GDP, the strong association with GDP per capita can be observed in only about half of the countries in the sample while in several countries the relationship is reverse. This implies that increased R&D expenditures do not keep step with the growth of GDP per capita.

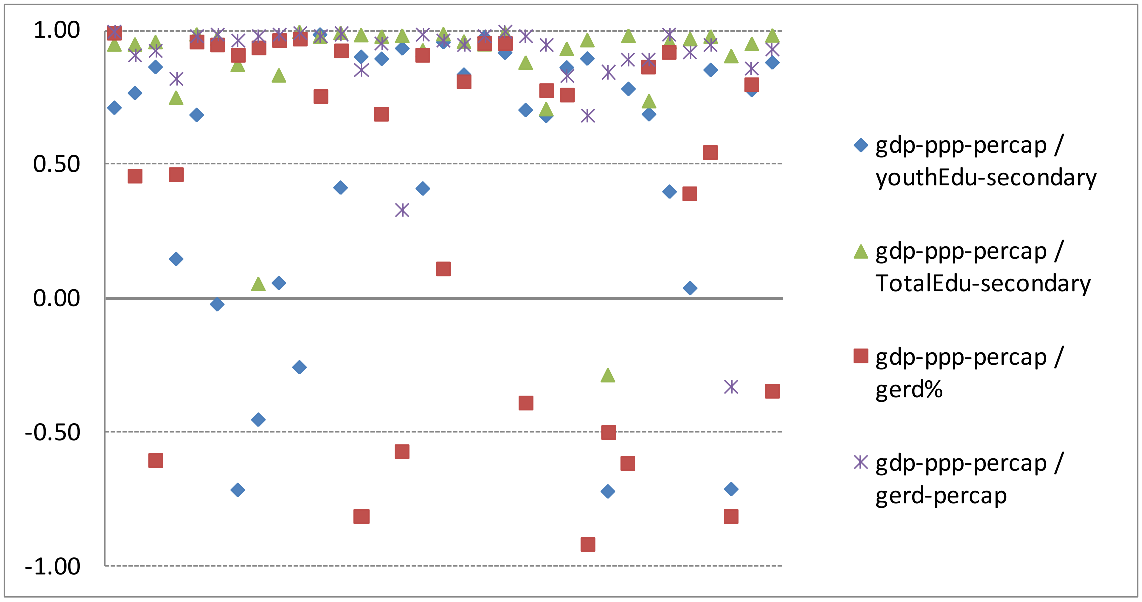

Figure 4-3: Correlation values for selected European countries: GDP vs. education, expenditure on R&D

While Figure 4-1 clearly demonstrated that labour productivity is an important factor determining GDP per capita over a longer period of time, the correlations between annual GDP growth rate and labour productivity growth rate are diverging across the countries included in the analysis (see Figure 4-4). In many, mainly more developed countries, the association is strong and positive, as labour productivity is the main driver of growth in these countries. In the rest of the countries the correlation between GDP growth and labour productivity growth is weaker, indicating the relative importance of other factors determining the economic performance of the country in a given year.

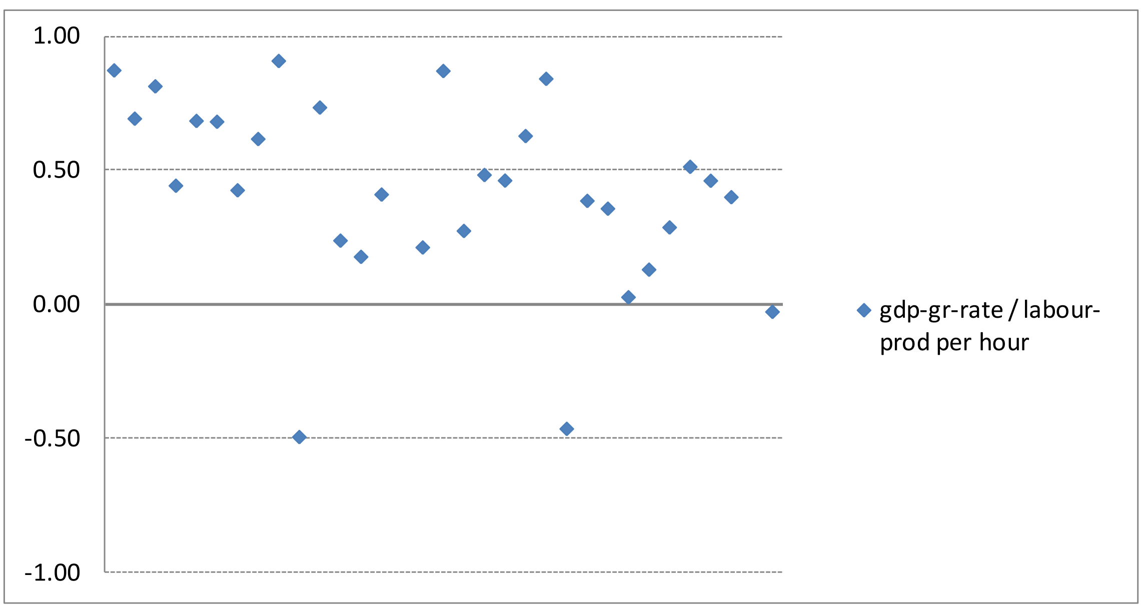

Figure 4-4: Correlation values for selected European countries: GDP growth rate vs. labour productivity growth rate

4.2.2 Social indicators

What kind of relationships can be observed among the social indicators included in the IN-STREAM indicator set? We start by linking economic and social measurements, and then consider some noteworthy linkages between selected social metrics.

As one would expect, the larger the fraction of the population engaged in gainful activity, the higher the available household revenue. This is shown in Figure 4-5 by the strong positive correlation between the per capita household income and the employment rate (defined as the share of those in the 15-59 age group who are employed), with the exception of a few countries in which this relationship does not hold for reasons that are beyond the scope of this report.

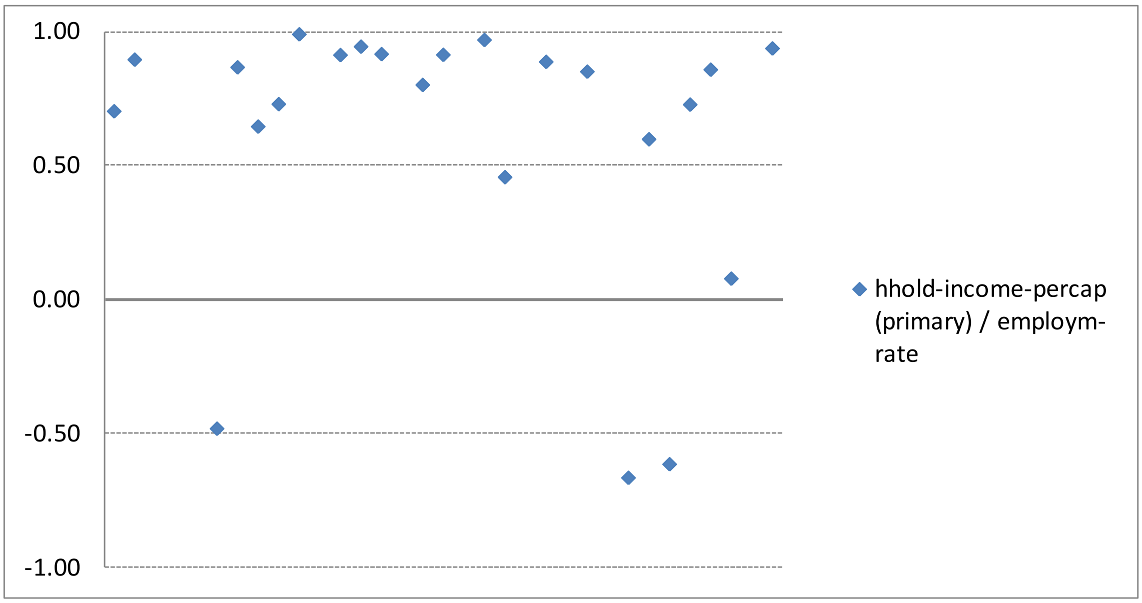

Figure 4-5: Correlation values for selected European countries: household income vs. employment rate

Figure 4-6 reveals some interesting associations between the employment rate and other variables. There seems to be a relatively strong negative correlation between the employment rate (as defined above) and the unemployment rate that shows the fraction of those who would like to work but cannot find a job. This indicates that the higher the employment ratio is, the lower the share of people who are unemployed, implying that more employment creates more jobs and refuting the argument that there is a limited number of jobs in the economy and that early retirement would help the young generation find employment. This negative correlation is even stronger between the employment rate and the long-term unemployment rate.

The negative correlation between the employment rate and the share of people in jobless households is obvious. The larger the fraction of the working age population with jobs, the lower the share of the households in which no one is employed. It is also interesting to observe the high positive correlation between the employment rate and labour productivity, demonstrating that increasing the productivity of the labour force by education, with equipment and technology or in other ways does not reduce the employment opportunities and does not by itself increase joblessness. Finally, the employment rate tends to correlate negatively and rather strongly with government debt, although there are a few special cases, mostly due to historical reasons.

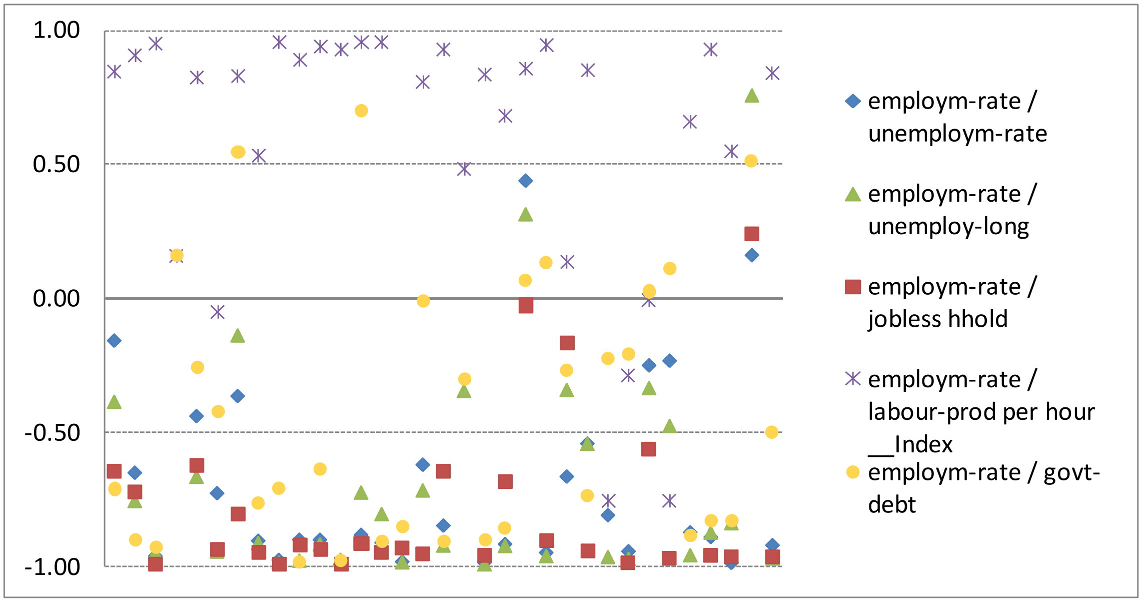

Figure 4-6: Correlation values for selected European countries: employment rate vs. unemployment rate, long-term unemployment, jobless households, labour productivity, and government debt

There is a strong positive correlation between the employment rate and life expectancy for both females and males, as shown in the upper part of Figure 4-7. The associations between the employment rate and the healthy life years expected for both males and females are more diverse across the countries in our study. There are both countries with strong positive and strong negative correlations. The somewhat weaker correlations between employment rate and life expectancy relative to the correlation between GDP per capita and life expectancy (Figure 4-2) suggests a somewhat varied association between GDP and employment rate across the countries in our sample.

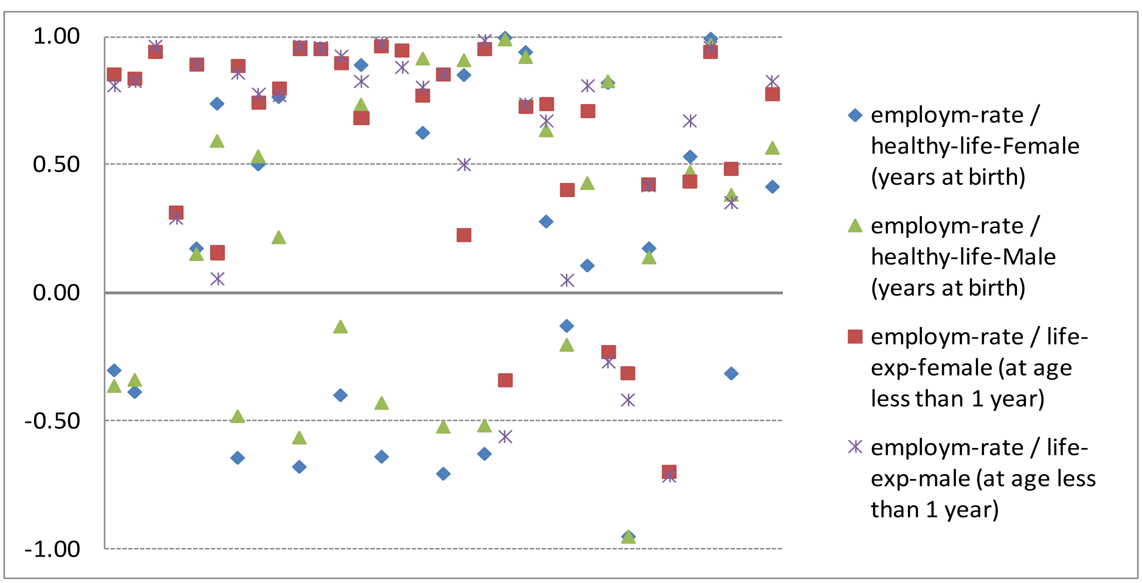

Figure 4-7: Correlation values for selected European countries: employment rate vs. healthy life years, life expectancy

The rather mixed correlations between the employment rate and the completed secondary education among the young generation and in the total population might be somewhat surprising for some observers. Yet the correlation coefficients for the majority of the countries analyzed are located in the upper quarter of Figure 4-8, seemingly confirming the general proposition that a better educated population is more likely to find employment.

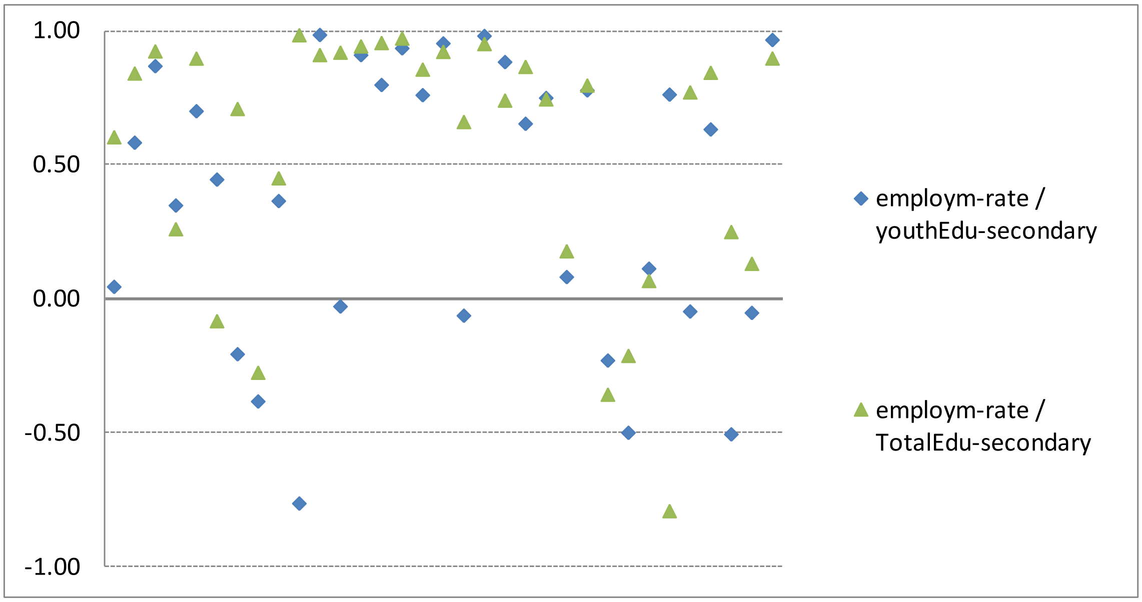

Figure 4-8: Correlation values for selected European countries: employment rate vs. education

Figure 4-9 reveals some interesting correlations between long-term unemployment and other social indicators. First, there is an obvious and strong positive correlation between the rate of long-term unemployment and the share of jobless households. It is more interesting that, except for a few outlier countries, long-term unemployment tends to be negatively correlated with labour productivity. This confirms the earlier observation (Figure 4-6) that the hypothesis that making the labour force more productive will eliminate jobs and put people out of work for long periods of time does not necessarily hold.

Another interesting observation is the strong positive correlation between long-term unemployment and government debts. There are some rather plausible reasons (e.g., unemployed people do not pay any or only little taxes while drawing social benefits and other services provided by the state) but the causal relationships are much more complex. Figure 4-9 also shows that long-term unemployment is negatively correlated with business investments as well as government investments (both of which are expressed in percent of GDP), confirming the long-standing experience that investments create jobs.

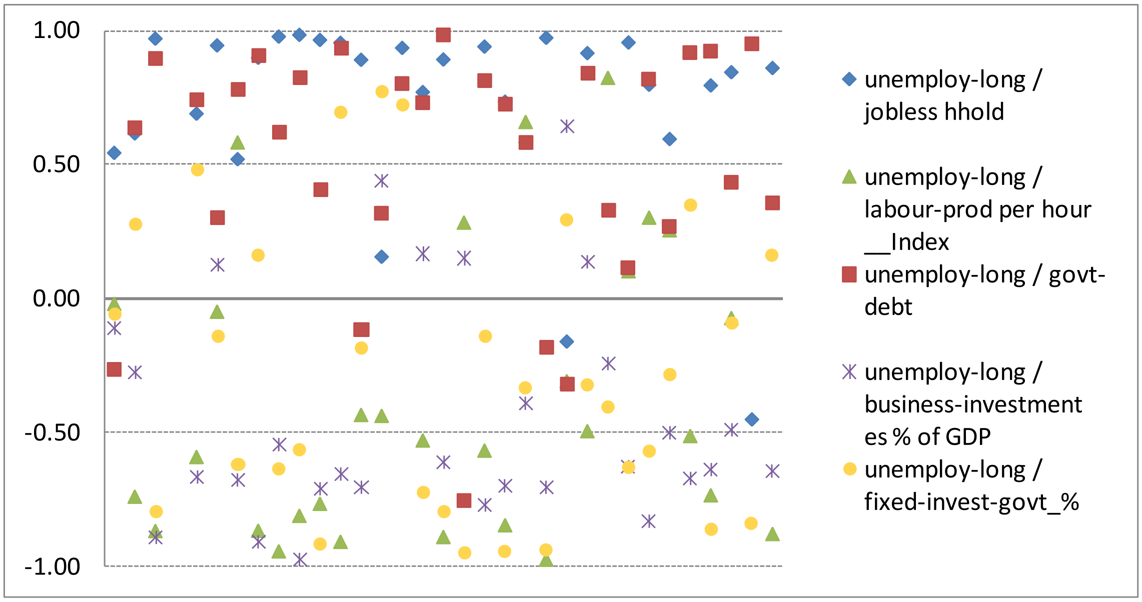

Figure 4-9: Correlation values for selected European countries: long-term unemployment vs. jobless households, labour productivity, government debt, business investment, government fixed investment

The relations between educational achievement and employment are further explored in Figure 4-10. Confirming in part the observation made for Figure 4-8 between employment rate and secondary education, the largely negative correlation between long-term unemployment and secondary education achievement for both the young and overall population confirms that a better educated workforce is less likely to sit idle for longer periods than its less educated counterpart. However, there are a number of notable exceptions. The negative correlations between long-term unemployment and R&D investments as percent of GDP on the one hand and per capita on the other are rather obvious in many countries. This seems to show that innovation is likely to (directly or indirectly) foster employment, but the correlation is loose enough to leave room for many other factors.

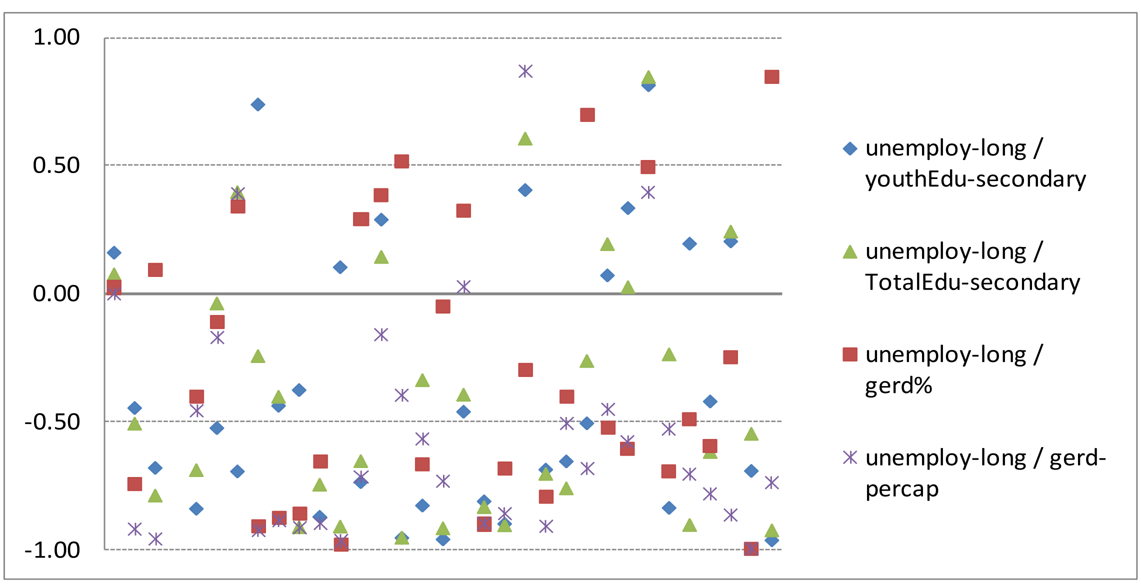

Figure 4-10: Correlation values for selected European countries: long-term unemployment vs. education, expenditure on R&D

The importance of private and government investments in creating opportunities for gainful employment, thereby reducing the share of households in which not a single person is employed, is reinforced by Figure 4-11. The overwhelmingly strong negative correlations provide the evidence.

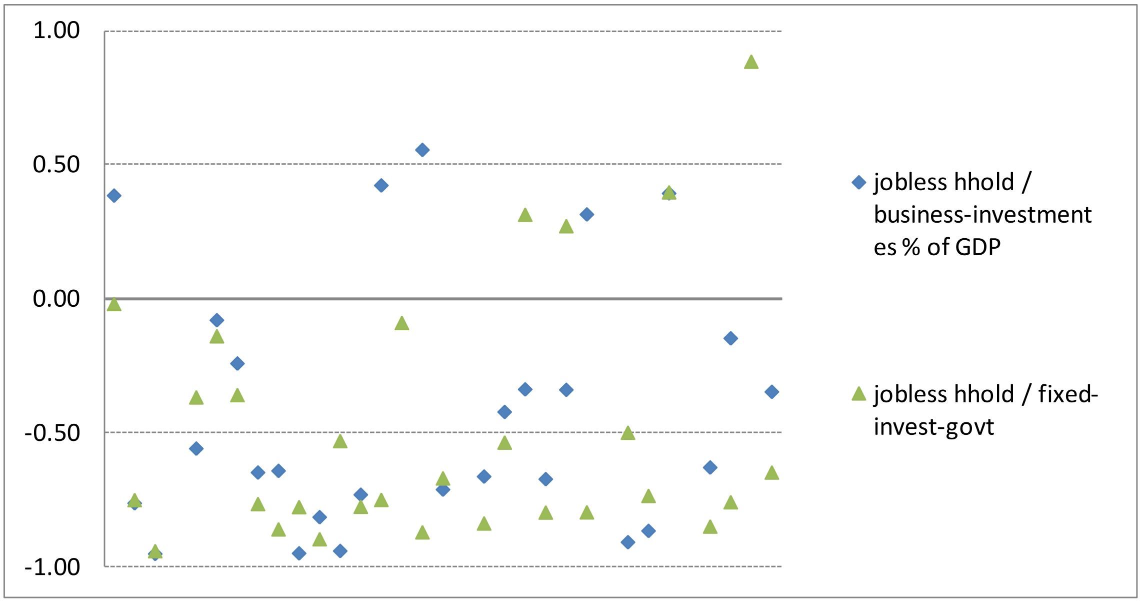

Figure 4-11: Correlation values for selected European countries: jobless households vs. business investment, government fixed investment

The association between the share of jobless households and secondary education achievements is rather mixed, both in the youth and in the total population. Figure 4-12 tends to substantiate modest to rather negative correlations in many countries, but a surprisingly large fraction of the countries in the sample form a cluster in the opposite segment. No causal explanations are available for this group.

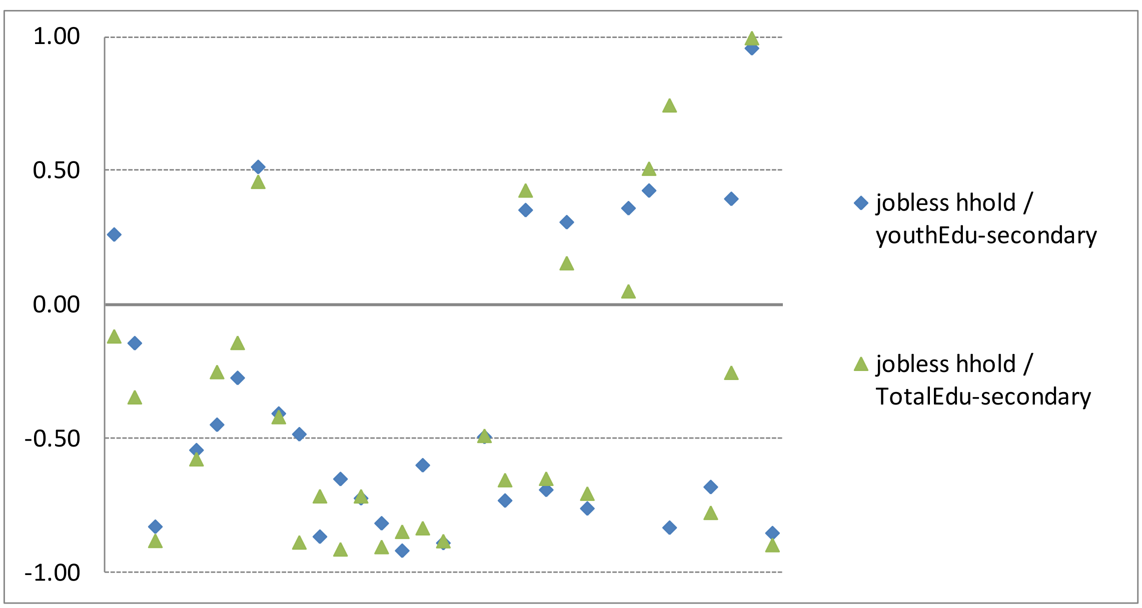

Figure 4-12: Correlation values for selected European countries: jobless households vs. education

Similar to the relation between the rate of long-term unemployment and the R&D investments, the negative correlation between the share of jobless households and R&D investments can also be observed (see Figure 4-13). The explanation concerning the link between innovation and employment is therefore the same.

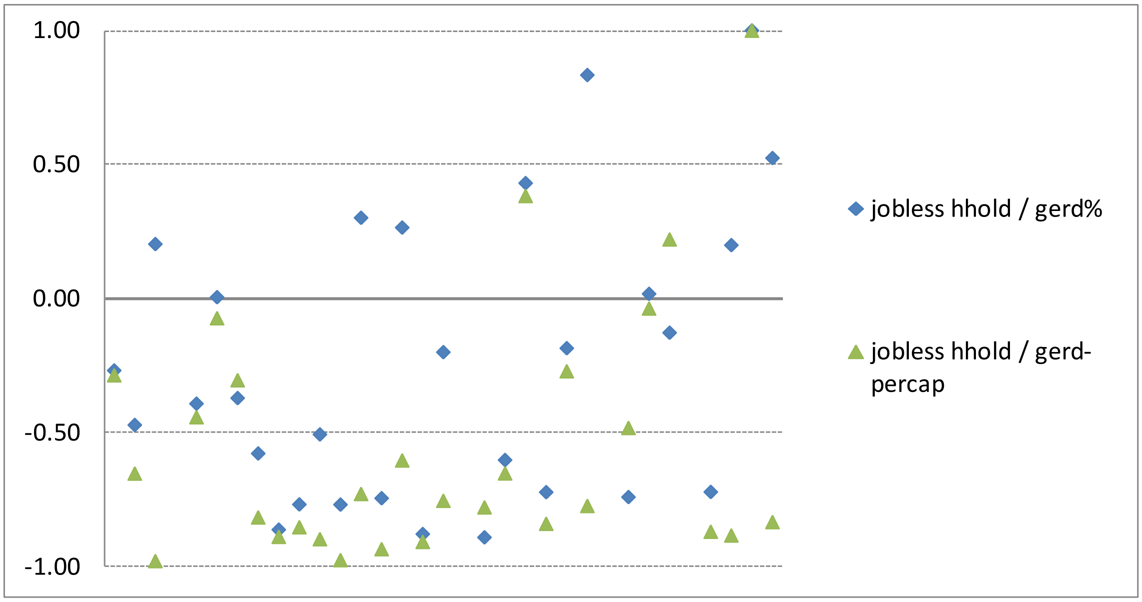

Figure 4-13: Correlation values for selected European countries: jobless households vs. expenditure on R&D

As one would suspect from observed correlations between the variables shown in the previous charts, there is a strong negative correlation between labour productivity and the energy intensity of GDP, as shown in the bottom segment of Figure 4-14. Similarly, the strong positive correlation between labour productivity and life expectancy for both males and females in the upper part of the chart is consistent with our expectations based on the strong association of both with GDP per capita.

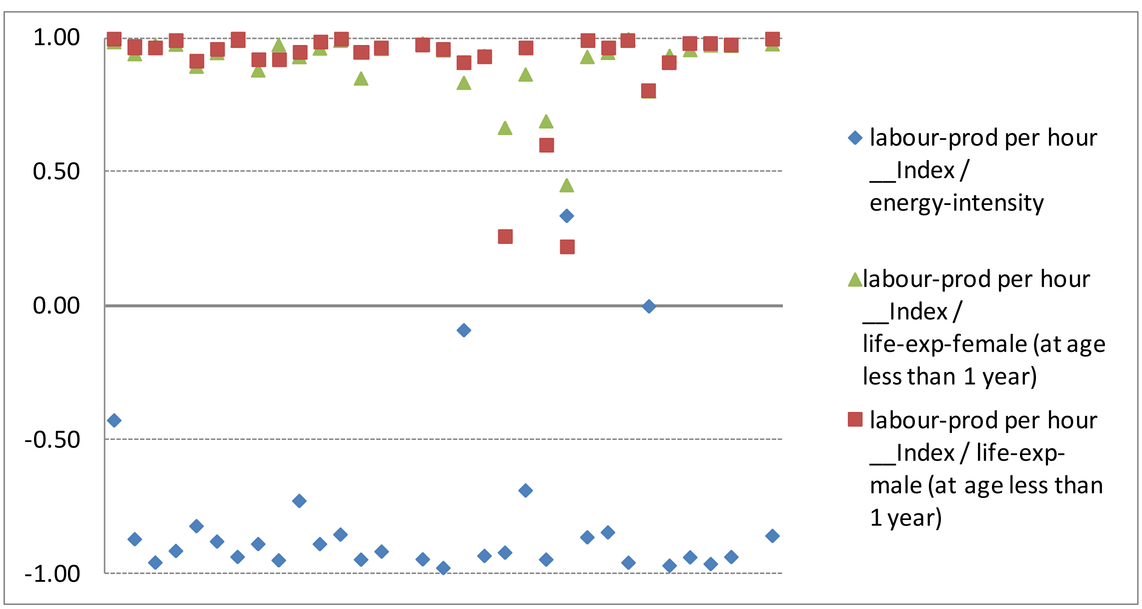

Figure 4-14: Correlation values for selected European countries: labour productivity vs. energy intensity, life expectancy

There seems to be a negative correlation between government debt and business investments measured in percent of GDP, as shown in Figure 4-15. Part of the explanation is the crowding-out effect whereby government borrowing and debt service reduces the amount of capital available for private investments. Yet other factors are seemingly also at work. The correlations between business investments and government R&D expenditures vary widely, indicating that a wide range of factors interact in the processes underlying these indicators.

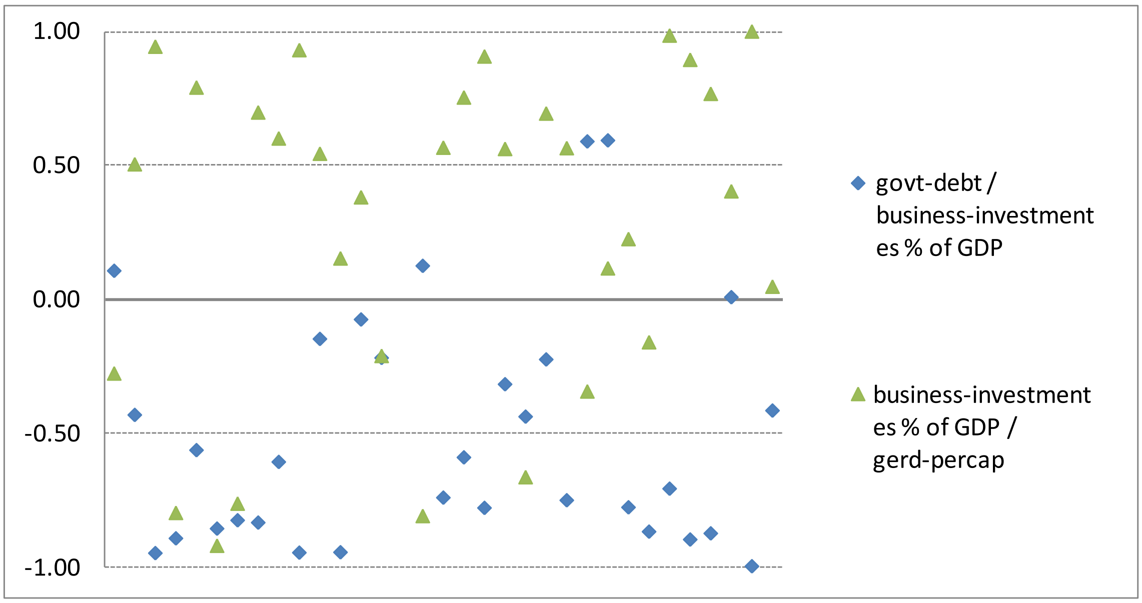

Figure 4-15: Correlation values for selected European countries: government debt vs. business investment, expenditure on R&D

Figure 4-16 shows correlations that could be deduced from earlier charts, but where it would be difficult to establish direct causal linkages. The strong negative correlation between energy intensity and life expectancy (both males and females) reflects the strong association of both indicators with GDP per capita (see Figure 4-1 and Figure 4-2). In contrast, a strong, but not totally uniform tendency towards negative correlation between energy intensity and the R&D expenditures, as shown in the lower segment of the chart, could be at least partly explained by the success of R&D investments in increasing industrial and household energy efficiency.

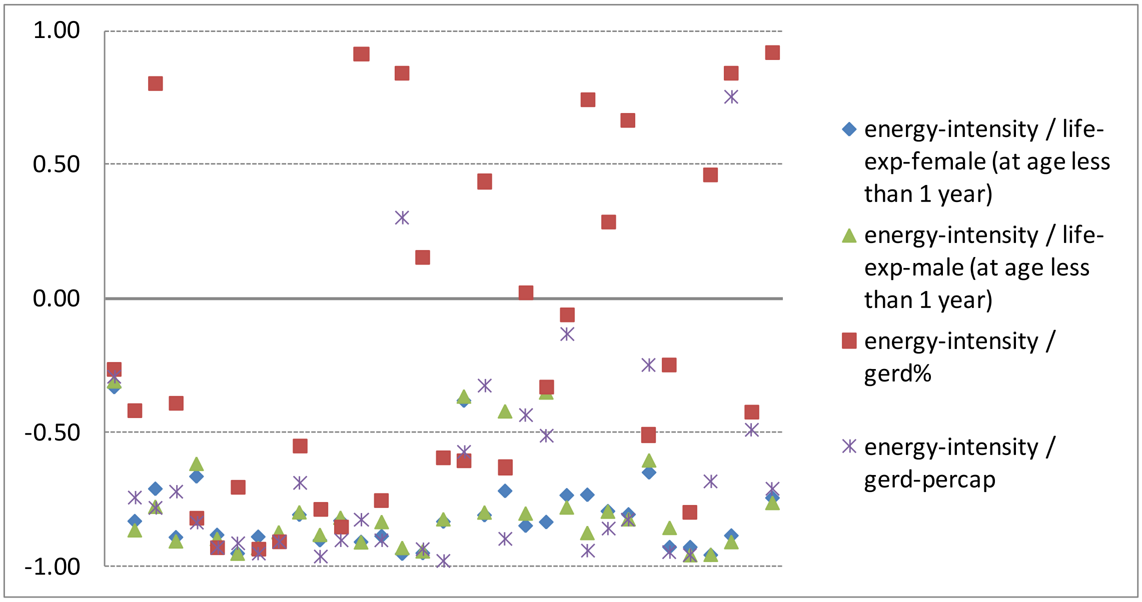

Figure 4-16: Correlation values for selected European countries: energy intensity vs. life expectancy; expenditure on R&D

4.3 IN-STREAM indicators, "beyond GDP" and other indices

As part of the overall IN-STREAM project, we have also extended the literature review assessing the linkages between mainstream economic and sustainability indices (Hizsnyik and Toth, 2010) to include the results of the "beyond GDP" project, especially some of the indexes and indicators included in that project. We collected data from various sources to quantify the "beyond GDP" indicators. Subsequently, we ran extensive correlation analyses between the IN-STREAM indicators and selected "beyond GDP" indexes and their components, as well as between "beyond GDP" indices. The analysis also covered sustainability indices from other sources. This subsection presents selected results from this work.

It is important to note that the arrangement of the charts is different in this subsection. The charts present scatter diagrams of GDP per capita versus selected indices from "beyond GDP" and other sources. Points in the chart represent the corresponding data from the EU-27+ countries. The Pearson correlation coefficient "r" is given in the figure caption.

We start by exploring the relationships between GDP per capita and the Environmental Sustainability Index (ESI), as well as the Stress component of ESI. The stress component includes a range of social and environmental factors of sustainability, ranging from total fertility rates to emissions of various pollutants and use of natural resources (Figure 4-17). The proposition that richer societies are more concerned about and are, subsequently, willing to spend more on improving some elements of social and environmental sustainability is confirmed by the somewhat scattered yet overall positive correlation between GDP and ESI. Interestingly the association between GDP and the STRESS component of ESI is more diverse across countries and is negative for the full sample of the EU27+ countries included here.

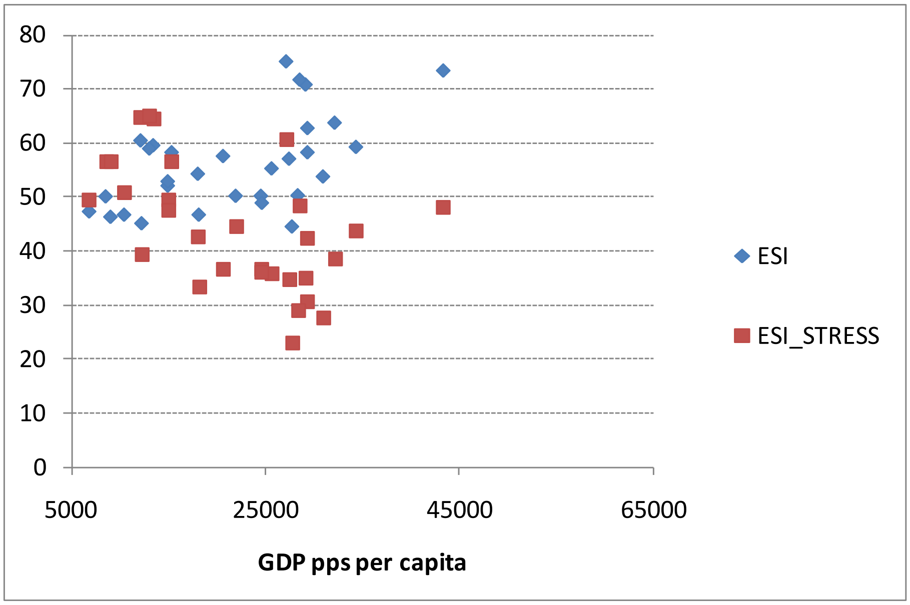

Figure 4-17: Correlation of GDP per capita with ESI (r=0.55) and with its Stress component (r= -0.53)

Two other components of the ESI tend to be more strongly and positively correlated with GDP per capita, although there are some outlier countries, as shown in Figure 4-18. The capacity (CAP) component of ESI measures social and institutional capacity and includes indicators characterizing environmental governance (for example the percentage of total land area under protection or the rule of law); eco-efficiency, private sector features (like the share of ISO 14001 certified companies), science and technology (like an Innovation index, education). The correlation between CAP and GDP is rather strong. The GLOBAL component of ESI integrates various international and global environmental aspects, like carbon emissions per capita and per unit of GDP, as well as participation in international environmental agreements. The picture here is more diverse but the correlation between GLOBAL and per capita GDP is largely positive. Both of these strong positive correlations denote that interest in these components of sustainability increases with income, and that it is mainly these two components that drive the positive correlation between GDP and ESI depicted in Figure 4-17 above.

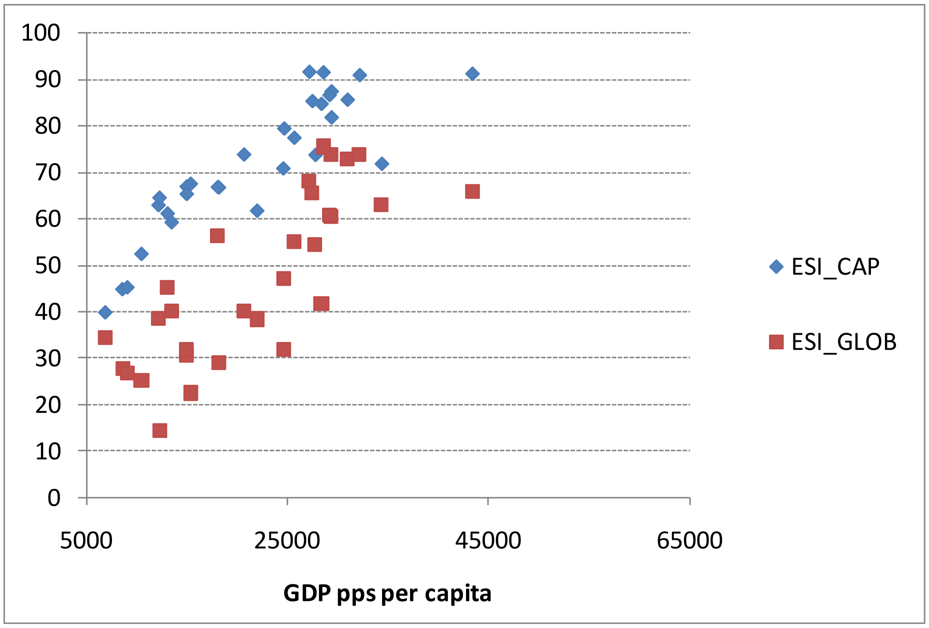

Figure 4-18: Correlation of GDP per capita with the CAP (r=0.88) and Global (r=0.80) component of ESI

An important item discussed in the "beyond GDP" initiative is the Sustainable Society Index (SSI). Figure 4-19 presents the relationships between GDP per capita and two components of the SSI. The Personal Development component of SSI includes six indicators (for example, healthy life, sufficient food or gender equality). Most of the EU-27+ countries have already reached a high level on these indicators, so the correlation with GDP depends on their relative position along the GDP axis.

The Resource component of the SSI is based on indicators of waste recycling, renewable water and energy use. An overall positive correlation with GDP can also be observed.

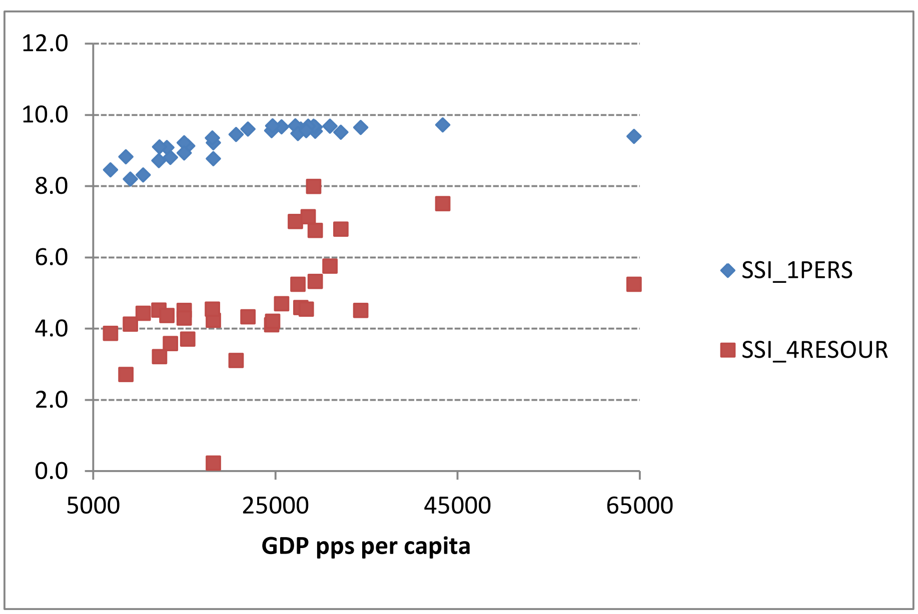

Figure 4-19: Correlation of GDP per capita with Personal Development (r=0.68) and Resource (r=0.53) component of SSI

The World component of SSI covers the so-called "Sustainable World" indicators, including forest area, preservation of biodiversity and the like. As can be seen from Figure 4-20, there is a negative correlation with GDP. The correlation coefficient for the EU-27+ countries is -0.64, which is modestly negative. In contrast to the positive correlations observed between GDP and some components of ESI, this negative correlation indicates that economic growth is negatively associated with forest areas, biodiversity preservations, and other indicators included in the World component of the SSI in the EU-27+ sample of countries. The relation between the composite SSI and GDP is weak; no real trend can be observed in this Index as GDP increases along the horizontal axis in Figure 4-20.

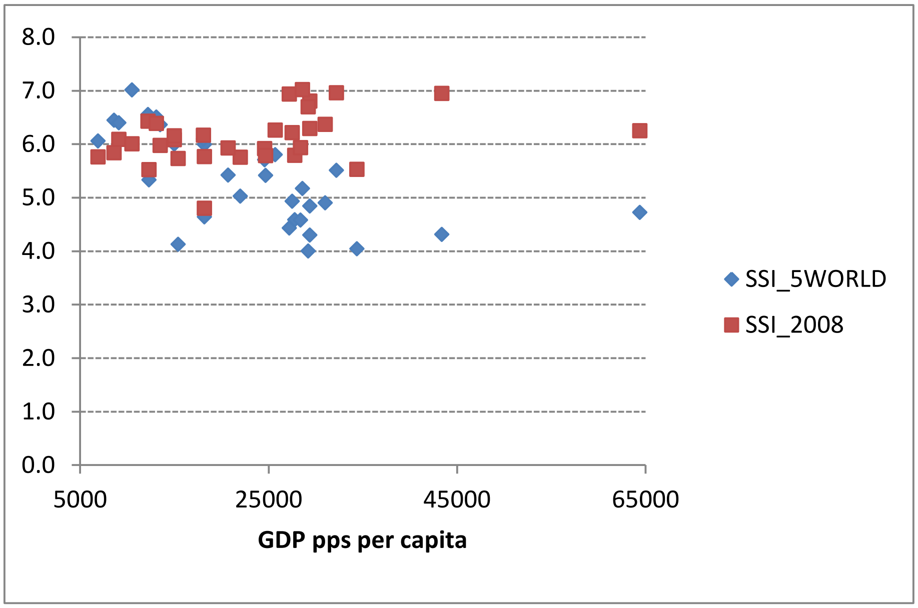

Figure 4-20: Correlation of GDP per capita with SSI (r=0.37) and with its World (r=-0.64) component

Figure 4-21 does not reveal any surprises. The strong positive correlations between GDP and HDI, especially its GDP component, are obvious and expected. The reason for the lack of perfect correlation between GDP and the GDP component of HDI is the different time horizon considered in the HDI analysis.

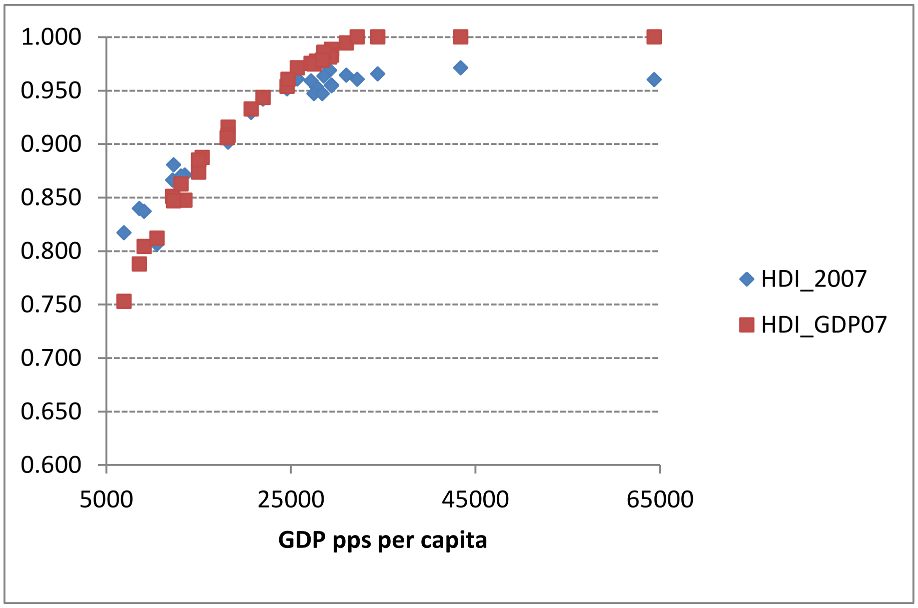

Figure 4-21: Correlation of GDP per capita with HDI (r=0.8) and with its GDP (r=0.83) component

Similarly, there are somewhat weaker but still significant and positive correlations between GDP per capita and the two other components of HDI, as shown in Figure 4-22. The education component is more scattered over the GDP range, and therefore shows a somewhat weaker correlation because this index seems to reach a saturation zone slightly above the 10,000 pps per capita level. In contrast, the Life component, which synthesizes the life expectancy and quality component measures, shows a strong upward trend in increasing GDP, and the saturation zone seems to be closer to the 20,000 pps per capita income level.

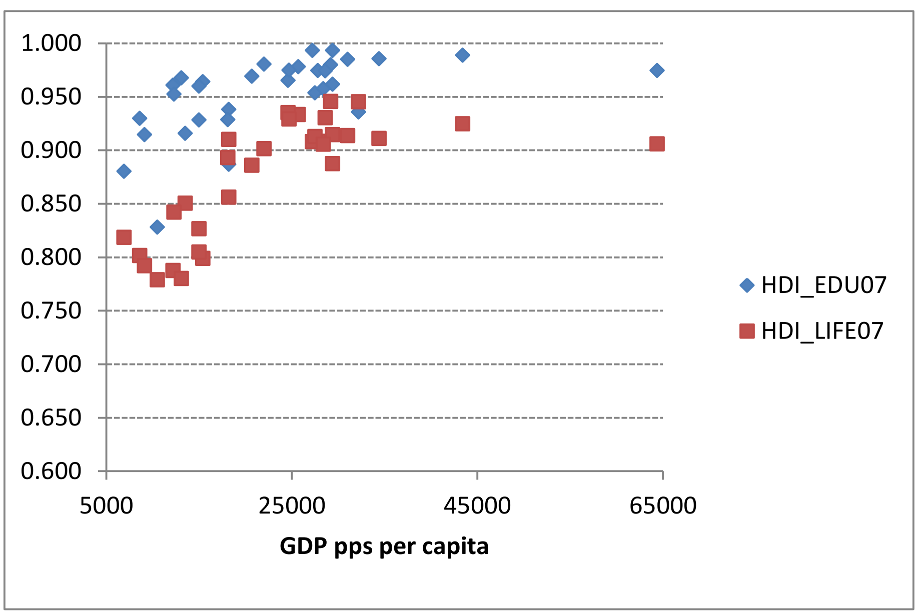

Figure 4-22: Correlation of GDP per capita with the Education (r=0.56) and Life (r=0.70) component of HDI

Another widely known, or at least strongly suspected, correlation is between income and corruption. Figure 4-23 reveals that the relation between GDP per capita and the Corruption index is clearly positive (overall correlation coefficient 0.75) and relatively strong as well. Since higher scores of the Corruption index mean less perceived corruption, this implies that higher income comes with lower corruption. Yet the spread of countries is remarkable, considering the homogeneity of the EU economically and culturally relative to the rest of the world. Similar amounts of corruption plague countries with about 6,000 and 22,000 pps of GDP per capita at the higher end of the corruption level, and 25,000 and 43,000 pps of GDP per capita at the low end of the corruption level (excluding the outlier with 65,000 pps).

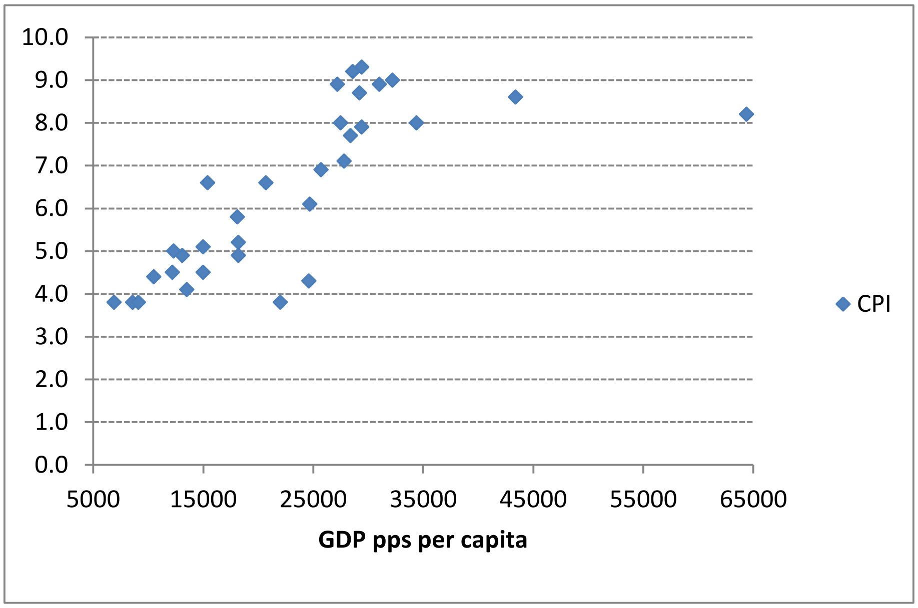

Figure 4-23: Correlation of GDP per capita with CPI (r=0.75)

To many observers, it may come as a surprise that there is a rather strong positive correlation between GDP per capita and the Average Happiness index, as shown in Figure 4-24. The correlation coefficient is 0.77 which means that money plays an important role in determining happiness for many people afterall.

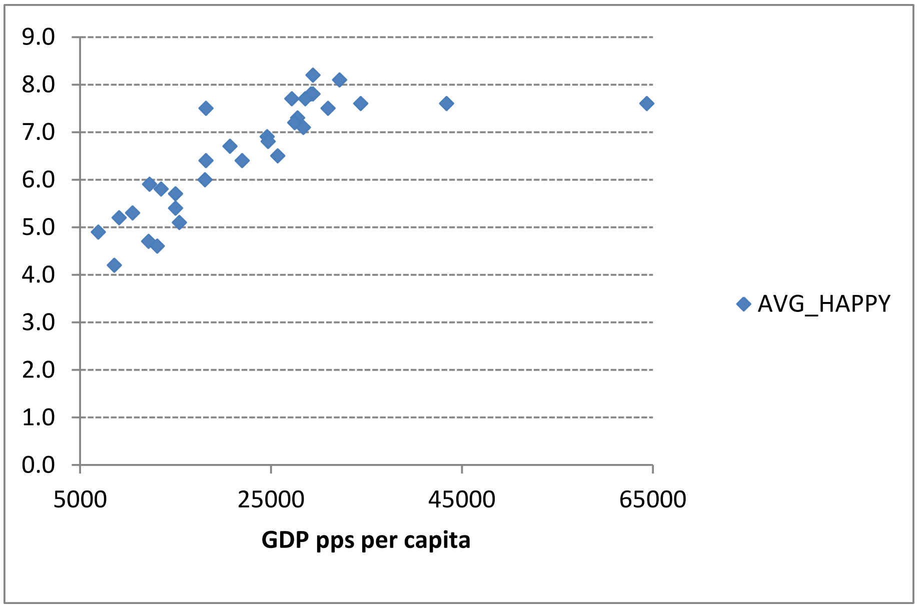

Figure 4-24: Correlation of GDP per capita with Average Happiness (r=0.77)

It is an interesting exercise to plot some of the social indicators against selected indices from "beyond GDP" and othersources. Figure 4-25 and Figure 4-26 plot the ESI and some of its components against the healthy life-years indicator for males. While the overall ESI is scattered around a horizontal line over the range of 50 to 70 healthy life years, the ESI STRESS component shows a modestly persistent decline over the same life-years interval, showing that in societies with lower STRESS indices, healthy life-years tend to be higher. Given the variety of indicators included in the STRESS component of ESI, it is difficult to speculate about the details and causes of this correlation. The CAP component of ESI is spread in a given range, with some positive association with healthy life years. At the same time, the data cloud of the GLOBAL component has a slight upward slope over the same healthy life year span, indicating a positive correlation.

Figure 4-25: Correlation of Healthy life years with ESI (r=0.03) and with its Stress (r=-0.67) component

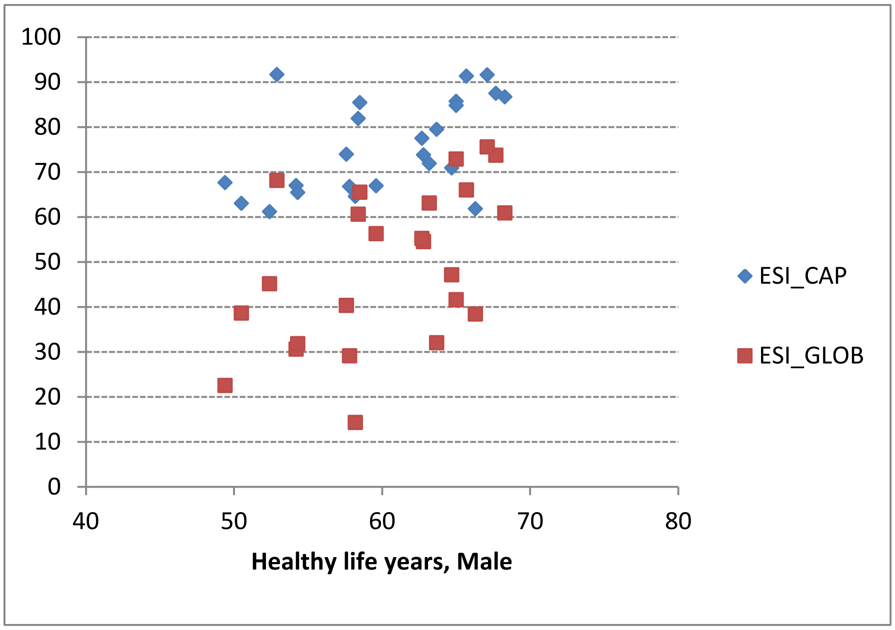

Figure 4-26: Correlation of Healthy life years with the CAP (r=0.52) and Global (r=0.50) component of ESI

Taking the male healthy life-years indicator from the IN-STREAM set and plotting it against the SSI and some of its components shows some remarkable patterns. As Figure 4-27 shows, the range of male healthy life years spans between 50 and 70 years across the countries investigated. The SSI Personal component remains virtually flat across this range while the SSI Resource component is spread in a wide range between level 4 and 8 of this index. High SSI Resource levels are more often associated with higher healthy life year values, but it is difficult to ascertain a clear association rule.

Figure 4-27: Correlation of Healthy life years with the Personal (r=0.56) and Resource (r=0.13) components of SSI

The same pattern emerges from reviewing the WORLD component of SSI and the aggregated SSI in comparison with the male healthy life years indicator (see Figure 4-28). The spread of the two data point clouds are similar: both remain virtually flat over the relatively wide range of healthy life year values.

Figure 4-28: Correlation of healthy life years with the SSI (r=0.08) and with its World (r=-0.33) component

The association between income (here GDP per capita in Euros) and the ecological footprint of consumption (measured in terms of global hectare per capita) seems to be relatively strong also, as indicated by Figure 4-29. This suggests that, despite efficiency improvements expressed in declining amounts of energy, material, water and other natural resource inputs per capita GDP, the broader environmental impacts and resource withdrawal of societies tend to increase as their overall income levels increase.

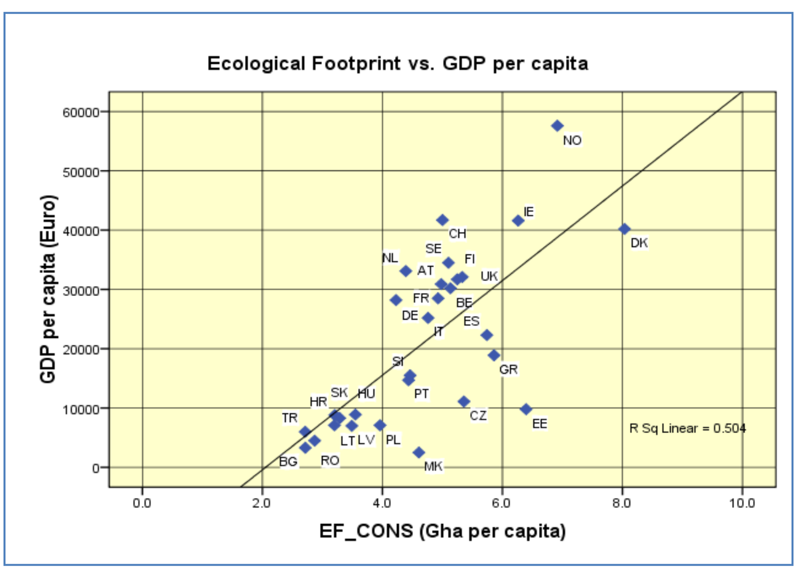

Figure 4-29: Ecological Footprint vs. GDP (r=0.7)

It is interesting to compare this figure with the same association observed in a larger and more diverse global data set in Figure 5-10, where the relationship seems to be even stronger.

4.4 Concluding remarks

The correlations and scatter plots presented in this section provide some interesting results. Exploring linkages between indicators characterizing selected attributes of sustainability partly confirm some well-known correlations. The positive correlation between GDP and labour productivity and the negative correlation between GDP and energy intensity are good examples.

In addition, some less well-known relationships emerged. Examples of such cases include the strong negative correlation between employment rate, on the one hand, and unemployment, long-term unemployment and jobless households, on the other.

Concerning the relationships between the so-called main-stream and the “beyond GDP” indicators, it turns out that despite all of the recognized and criticized deficiencies, GDP is an important component of many “beyond GDP’ indicators. GDP influences the values of the “beyond GDP” indicators and indexes directly (by direct inclusion as a component of an index) or indirectly (as a driver behind the processes represented by some of the components included in an index). These relationships confirm both common and less common expectations: many social and some environmental indicators/indices correlate with GDP, at least to some extent. This also means that using GDP as a proxy for indicators that are not directly observed, measured or modelled could shed light on the approximate value of those indicators. Nonetheless, such exercises require caution and rigorous testing in the geographical, social and economic context in which they are intended for application.

5. Advanced Statistical Analysis

The objective of this analysis is to search for links between macro-economic benchmarks of economic performance and performance in the social and environmental fields. Specifically, we hoped to identify metrics that show:

- Win-win situations, between growth-oriented economics and activities aimed at increasing human well-being and environmental sustainability
- Trade-off situations between economic growth and social or environmental well-being
- Relationships that can add to the existing knowledge base regarding the economy-human-environment triangle.
- Provide insightss for the modelling of indicators covered in other IN-STREAM work packages.

5.1 Individual Analyses

To demonstrate our approach we show Figure 5-1, which displays a selection of bivariate scatterplots relating various versions of GDP to greenhouse gas emissions (GHG). This display demonstrates thatrelationships are generally noisy and that they can also be very diverse, ranging from complete lack of association (e.g., between GDP per oil equivalent and CO_2 emissions per capita) to logarithmic (e.g., CO_2 emissions per GDP and GDP per oil equivalent) and linear correlations (GDP per capita and CO_2 emissions per capita).

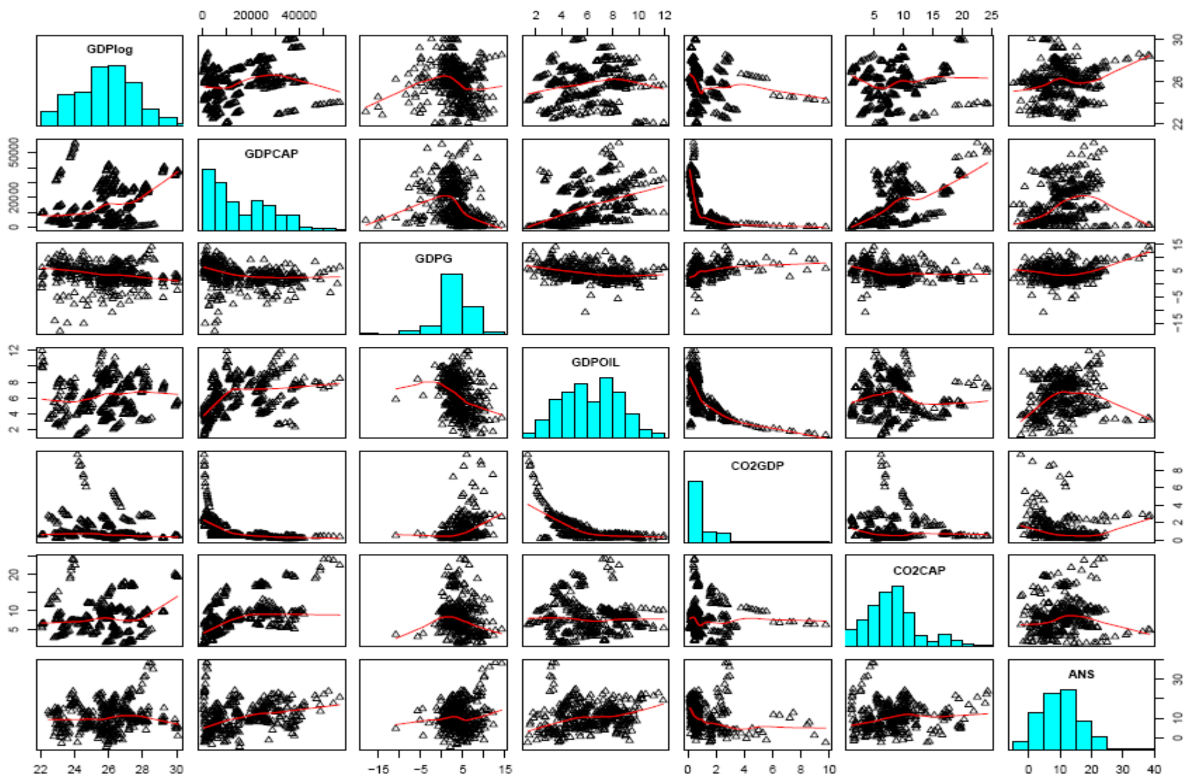

Figure 5-1: Selection of bivariate scatterplots of mainstream economic and environmental indicators.
Note: The abbreviations are: GDPlog=natural logarithm of GDP, GDPCAP=GDP per capita, GDPG=GDP growth, GDPOIL=GDP per ton oil equivalent, CO2GDP=CO2 emissions per GDP, CO2CAP=CO2 emissions per capita, ANS=Adjusted Net Savings. The temporal trajectories of countries for GDP, the positive linear relationship between per capita GDP and CO_2 emissions, and the negative exponential relationship between GDP energy and CO_2 intensity. The red solid lines are locally smoothed regression splines.

We used these simple visual data inspections as the starting point to look for evidence supporting or refuting widely held beliefs about the effects of economic growth on other key economic benchmarks, as well as on society. This is illustrated using the following two widely held premises:

(1) <u>Economic growth is linked to reduction in unemployment:</u> The basic and simplified argument in favour of this premise is that bringing people out of unemployment and into work increases their purchasing power due to the earning of wages and salaries. Portions of this income are then spent to buy groceries and pay rent, as well as to purchase other goods and services,

which in turn increases their demand and spurs economic expansion. A growing economy creates new jobs and hires more unemployed people.

(2) Income inequality hampers economic growth: The argument here goes that high income inequality, i.e., a small share of the population earning a substantially larger share of a nation's income, stifles economic growth. This ostensibly occurs because there is a large number of people earning less than they would consume to meet their basic needs and wants , which depresses demand and hence economic activity. It is well-known that the affluent consume a comparatively smaller share of their disposable income than the poor. Therefore, a more equitable distribution of income would mean that the wealthy can still consume at the same level, but the poor can increase their consumption and thereby spur economic growth.

To examine the first premise we looked at a scatterplot of the unemployment rate and GDP growth rate. Figure 5-2 shows the data for the time period 2000-2008.

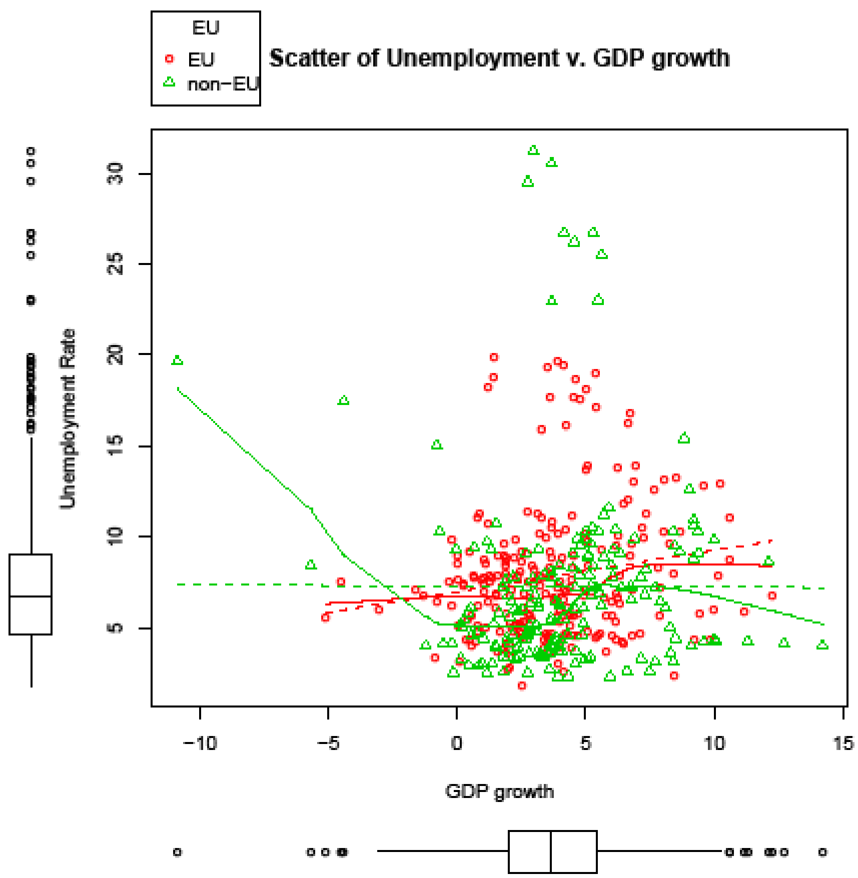

Figure 5-2: Scatterplot of unemployment versus GDP growth for all available countries and the period 2000-2008.

The Figure does not indicate an inverse relationship between the two key benchmarks of economic performance. Declining unemployment is not strongly associated with rising GDP growth, or vice versa (cor=0.11). This is illustrated further through the time paths of six selected and very different countries: Germany, Ireland, Greece, Japan, and South Africa (cf. Figure 5-3). According to the theory, we would expect to see a declining, nearly linear trend over time but the selected countries all exhibit rather unpredictable paths with the possible exception of Latvia, which saw declines in unemployment up until 2007 against modest rises in GDP growth.

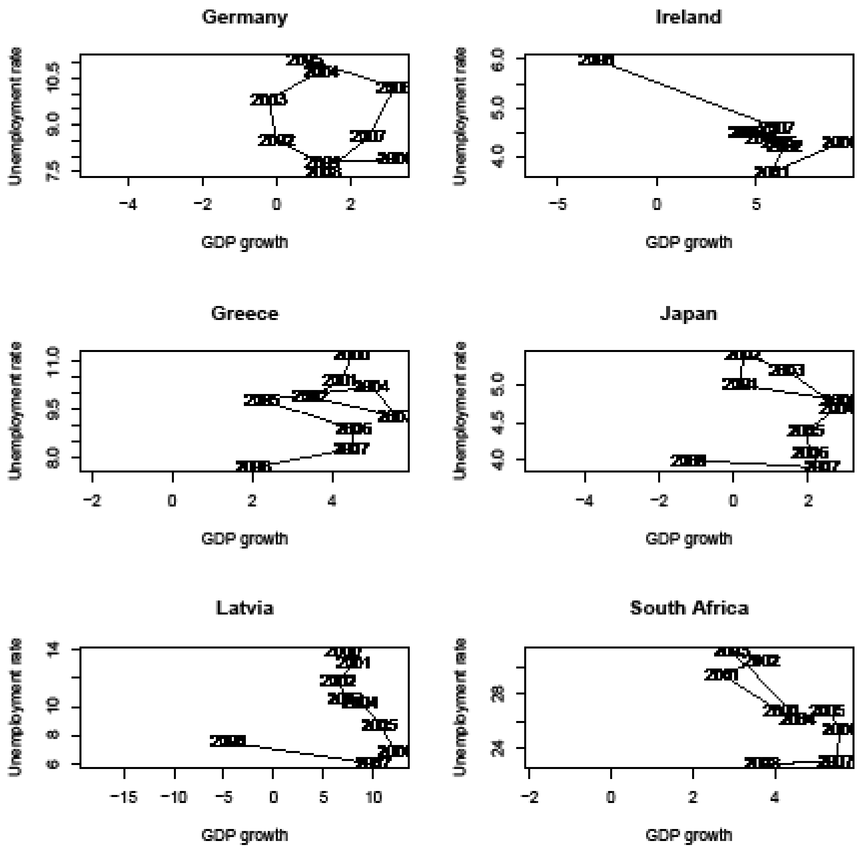

Figure 5-3: Development of GDP growth and unemployment rate over the time period 2000-2008 for selected countries.

A related perspective looks at the relationship between youth unemployment and the true savings rate of a country (as measured by ANS). The ANS emphasizes investment in all three types of capital (economic, environmental and social). Therefore, countries that responsibly work to maintain their capital and to build a sustainable basis for future consumption would invest in their youth by providing education and jobs. We would thus expect a positive relationship between ANS and low youth unemployment. As Figure 5-4 demonstrates, this link is true, albeit the strength of the association is stronger for non-EU countries than for EU Member States. Shown are all data points for 2000-2008.

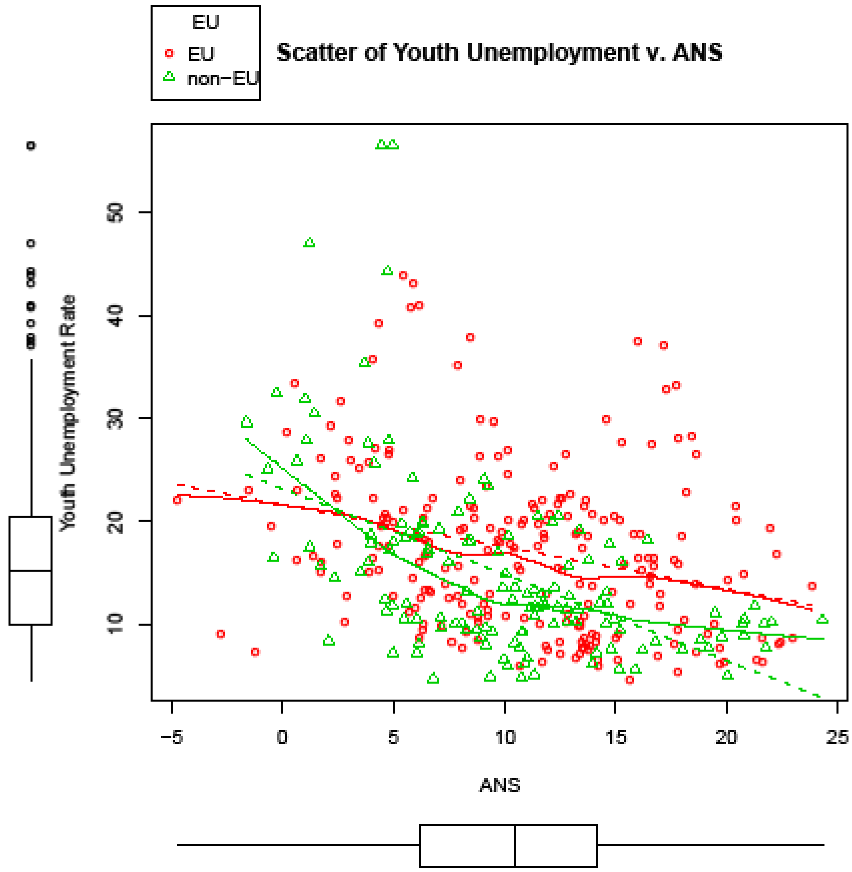

Figure 5-4: Scatterplot of youth unemployment rate versus Adjusted Net Savings for all available countries in the period 2000-2008.

To test the second premise, we plotted economic growth versus income inequality. Since the latter indicator suffers from substantial data gaps, the data basis is limited and we use all available data points for the period 2000-2008 (cf. Figure 5-5).

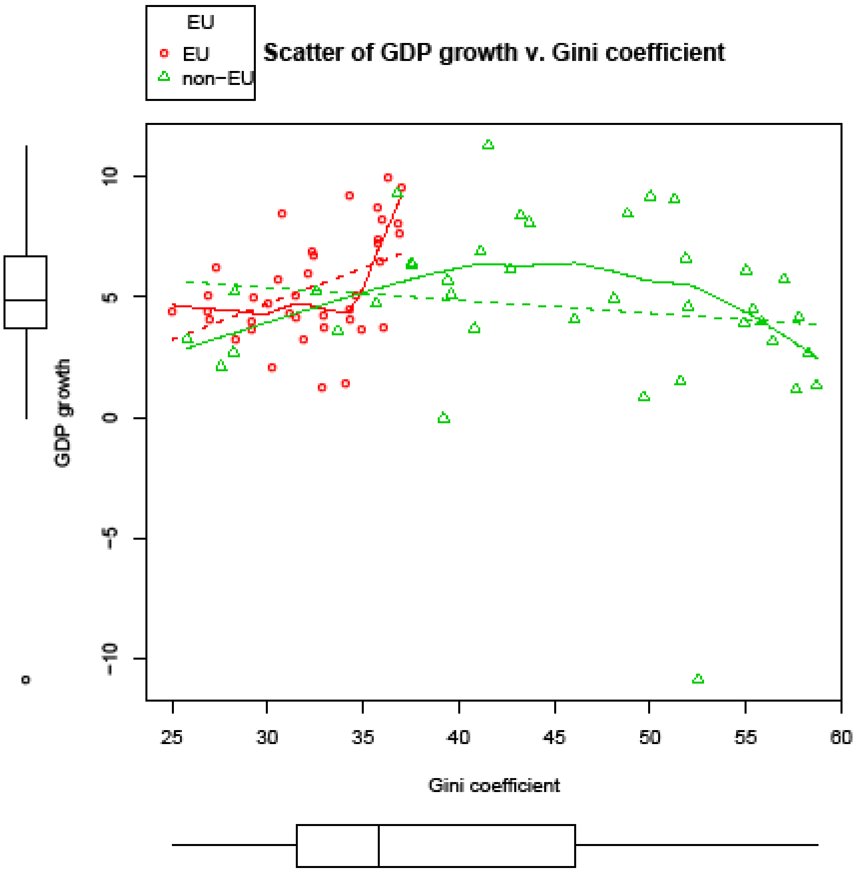

Figure 5-5: Scatterplot of GDP growth versus income inequality for all available countries in the period 2000-2008.

The data for the European Union show increasing variation in GDP growth as income inequality rises, as well as a weak positive relationship, i.e., counter to the prevailing theory. For non-EU countries the relationship appears to be weakly negative (dashed green line) or inverse quadratic (solid green line).

With respect to the social impacts of economic growth, we look at another and related question that is often asked:

(3) Is being rich associated with greater happiness?

Most studies find that happiness increases initially as income rises and helps to secure basic needs such as food, shelter, and access to and ability to pay for primary health care.[8] After that, however, happiness peaks out, albeit different studies estimate different optimal income levels, and subsequently flattens out or even declines.[9] The explanations given for this phenomenon include the idea that high income

[8] See, for example, Richard Easterlin. 2001. Income and Happiness: Towards a Unified Theory. The Economic Journal 111:465-484.

[9] See, for example, The Economist 8 March 2008 “Income and Happiness”, which shows that life satisfaction levels out at incomes of approximately $10,000. Another study by the Gallup World Poll of 450,000 Americans estimated that the optimal income for happiness is $75,000 per year.

comes at the price of social bonds, such as family, friends, and neighbours. Consumption cannot substitute for time lost enjoying the simpler things in life. A second theory cites the so-called "rat-race", according to which higher incomes are associated with higher pressure to maintain a high standard of living despite the social costs involved. The "keeping up with the Joneses" theory states that there is competitive pressure amongst neighbours and friends to outperform each other, which generally translates into a quest for more consumption, not greater happiness.

The New Economics Foundation's Happy Planet Index (HPI) aims to measure the extent to which income is efficiently utilized to generate human and ecological well-being. Thus, the HPI is not a true individual happiness measure but combines environmental impacts with well-being to measure on a country by country basis the environmental efficiency with which, people live long and happy lives. Nonetheless, as Figure 5-6 shows for the sample countries Korea, Norway and the USA, high-income countries are not necessarily the happiest. The USA has one of the highest average per capita incomes in the world, yet its HPI hovers around a score of 30.7 in the most recent edition of the HPI report. In contrast, Norway, which has approximately equal per capita income, has managed to generate increasing returns over the past 20 years and now has an HPI of 40.4. Korea is often used as an example of a dynamic and rapidly growing economy – reflected in the chart by a ten-fold growth in per capita income – but its HPI rose only initially and is now stagnating at 44.4.

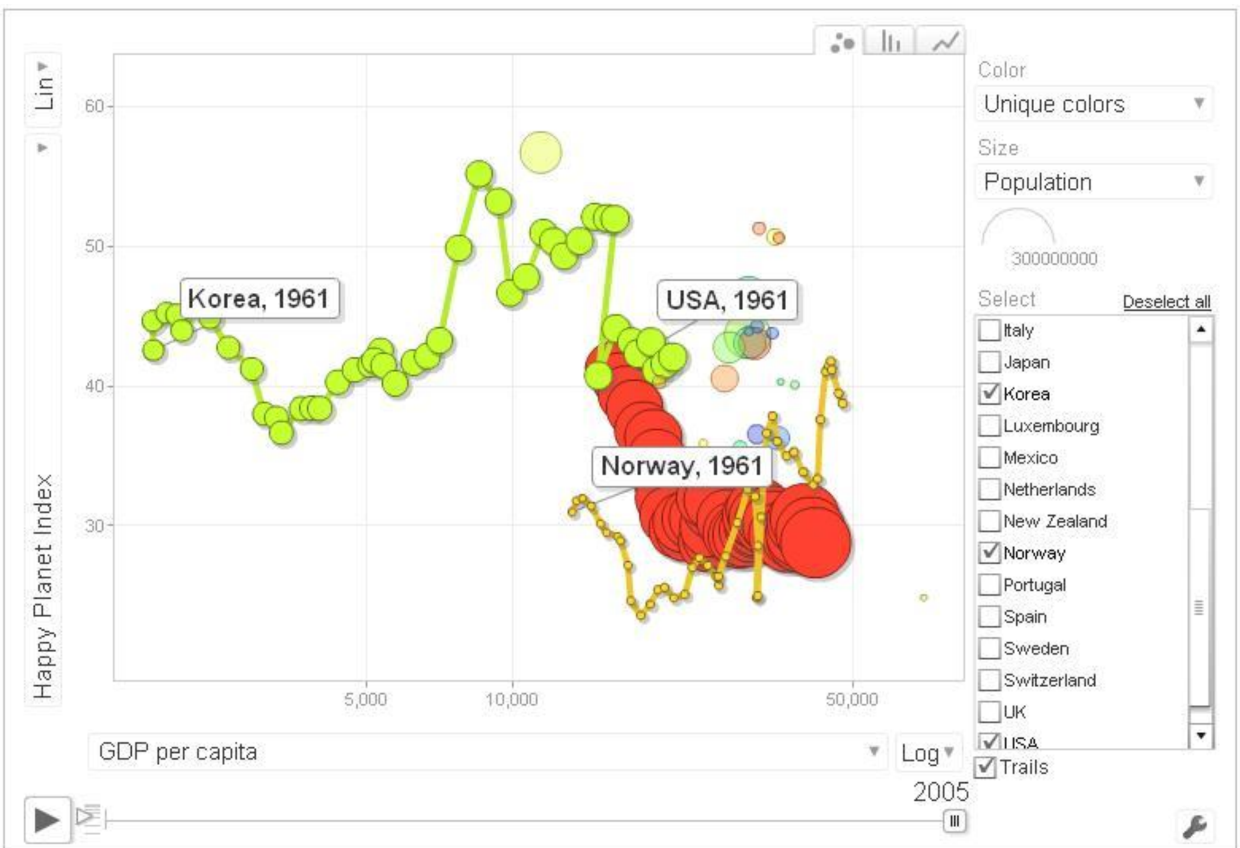

Figure 5-6: The Happy Planet Index versus per capita income for the period 1961 to 2005 for Korea, Norway and the USA. Source: http://www.happyplanetindex.org/explore/historical.html (9 December 2010).

Our database did not include additional metrics for happiness (aside from the HPI), in part because it is notoriously difficult and expensive to measure.

Finally, we examine some major questions on the linkages between economic growth and environmental health and sustainability:

(4) Can economic growth be decoupled from GHG emissions?
(5) Can economic growth be achieved with a more efficient use of natural resources?
(6) What about economic growth and consumption levels (e.g., ecological footprint, environmental performance)?

We present a selection of empirical evidence using the indicators available. First, and perhaps not surprisingly, higher ANS rates are associated with higher investments in fixed capital (cf. Figure 5-7). While this does not permit judgments on the sustainability of the investment per se, it indicates that a shift away from consumption is likely to have positive effects on the long-term ability of countries to sustain consumption levels.

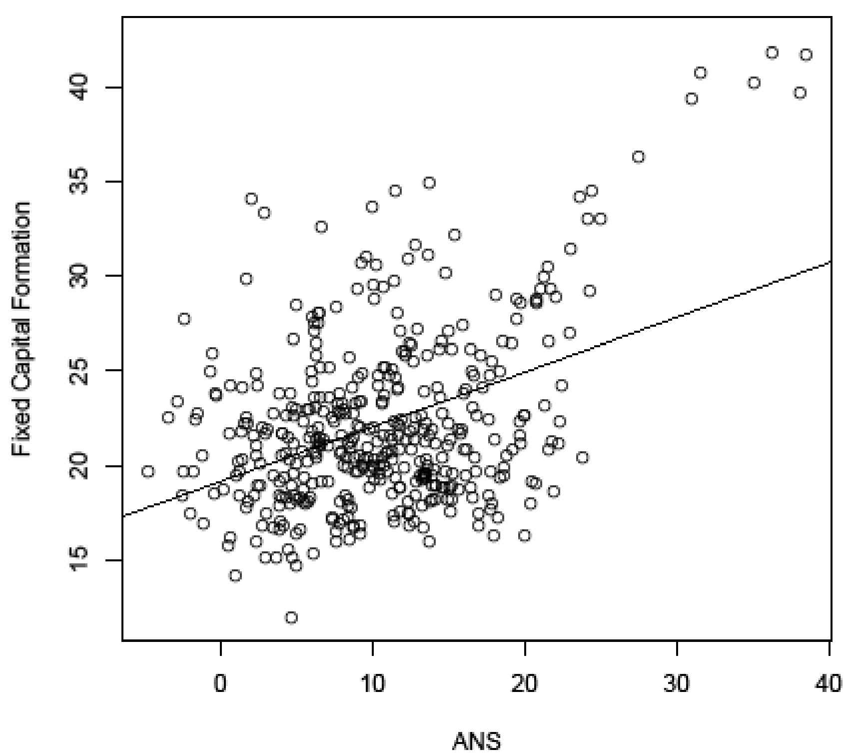

Figure 5-7: Scatterplot of fixed capital formation and Adjusted Net Savings for all available countries in the period 2000-2008.

The emissions intensity of an economy is a widely used indicator to rate its environmental performance. Sustained or even rising incomes at declining levels of greenhouse gas emissions point towards greater resource use efficiency and/or the outsourcing of polluting activities. We have no data to disentangle these two factors but Figure 5-8 shows that richer nations are indeed the most efficient ones when it comes to generating wealth at comparatively low emission rates. The time paths shown also help to identify if countries are becoming more efficient over time. The picture is mixed: some countries see their emissions rise in lock-step with incomes (e.g., Saudi Arabia, Norway), others stagnate (e.g., Italy) and others are showing signs of decoupling (e.g., Sweden, Germany).

It is also evident that most gains have been achieved at the low- and middle-income levels. In particular, the former communist countries benefited indirectly as a result of the dramatic economic transition following the collapse of the Eastern Bloc. It remains to be seen if they can maintain or even widen these gains in the future as their economies continue to expand.

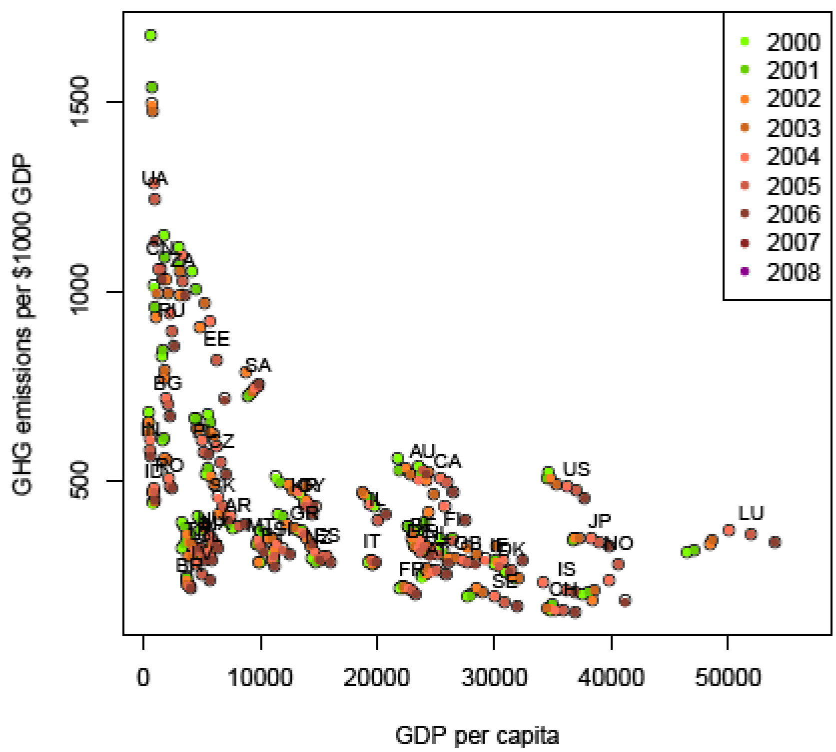

Figure 5-8: Scatterplot of greenhouse gas emissions per GDP versus per capita GDP for all available countries for the period 2000-2008.

Overall, environmental performance has been shown to correlate strongly with income, albeit the direction depends on what metrics are considered.[10] The positive relationship (cor=0.41) between

[10] The Ecological Footprint, which measures consumption levels in terms of global hectares necessary to sustain them, consistently ranks the high-income countries atas the worst offenders. In contrast, maintaining healthy

Environmental Performance Index (EPI) and income is fairly well known (cf. Figure 5-9).[11] In the EPI, high-income countries fare better – on average – than many lower income countries. This is due, in part, to the heavy weighting of public health, which has been shown to benefit greatly and rapidly from economic growth (although governance plays a role in how many dollars actually end up reaching the people). Nonetheless, the plot also shows that at similar income levels environmental performance can vary substantially, e.g., US, Japan, Norway, and Iceland.

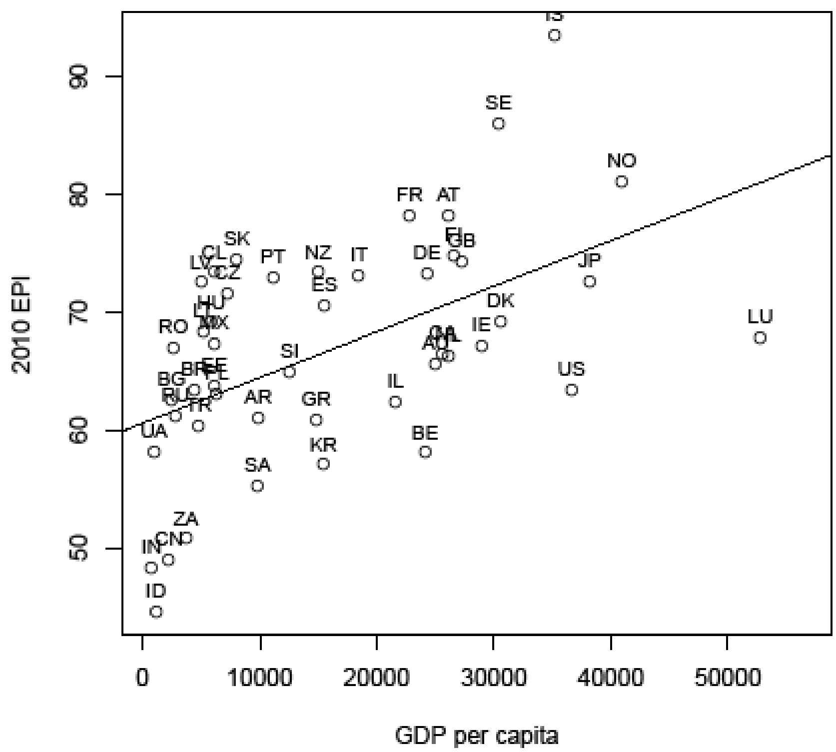

Figure 5-9: Scatterplot of the 2010 EPI versus GDP per capita.

In contrast, the Ecological Footprint[12] is strongly negatively associated with per capita GDP (R^2=0.71) as Figure 5-10 shows. The more affluent a nation becomes, the greater its natural resource needs become in order to sustain the goods and services it consumes. Neither the EPI nor the EF associations with income shown here provide new insights, but we included them nonetheless because they are important reminders that economic growth has different impacts on the environment and requires a comprehensive strategy to harness the benefits while minimizing the negative impacts.

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environmental quality and protecting water and other resources requires financial and human resources that developed countries are most likely to have and provide. They therefore tend to rank higher than poor countries on metrics tracking the ability of countries to provide them.

[11] See http://yale.edu/epi (9 December 2010) for more information.

[12] For more information, please see http://www.footprintnetwork.org/en/index.php/GFN/ (9 December 2010).

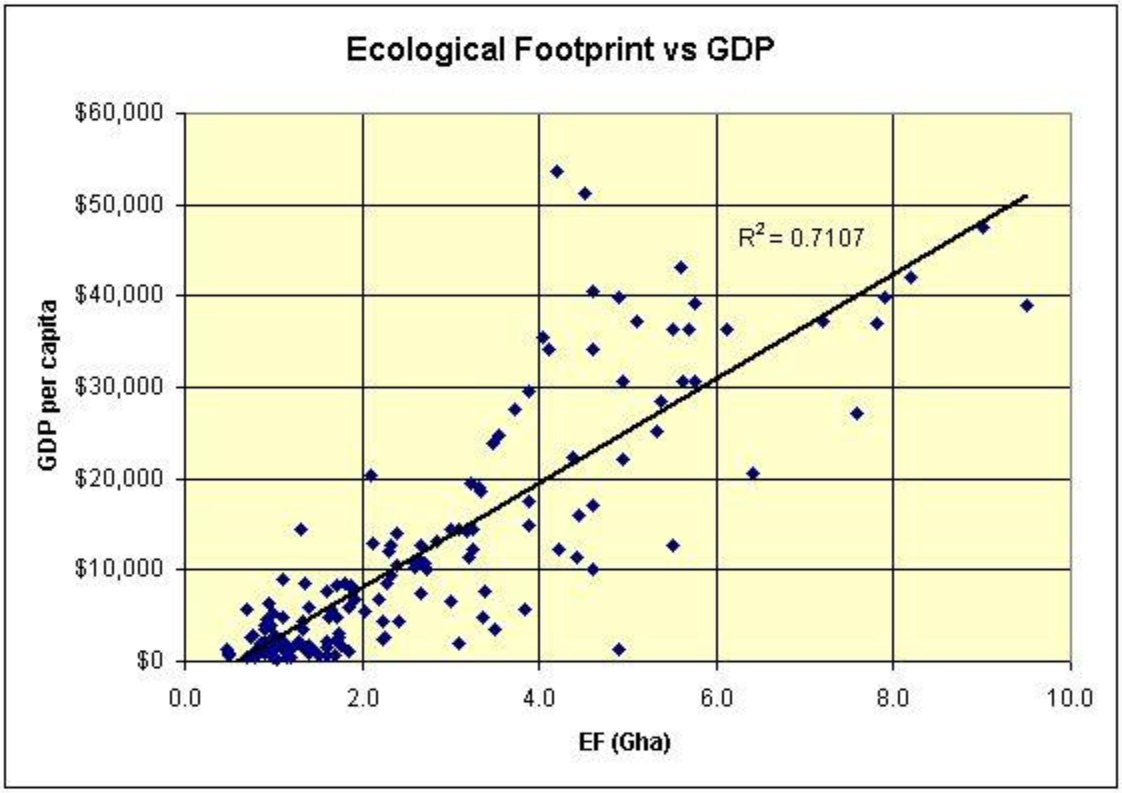

Figure 5-10: Scatterplot and regression line of per capita income and the Ecological Footprint.

The final example of a bivariate representation of mainstream economic and alternative measures of well-being shows that not every alternative metric is associated with a conventional economic performance metric. This, in and of itself, creates interesting challenges for their joint interpretation. We chose the Zero Carbon Capacity Index developed by the Environment Institute at University College London (commissioned by RICS)[13]. The purpose of the so-called ZC2 index is to highlight which countries are developing the capacity to make progress towards the aspirational goal of a zero-carbon built environment. Since buildings worldwide are the greatest emitter of greenhouse gases, they are a primary target for efficiency gains.

However, as Figure 5-11 shows, there is virtually no relationship between GDP per capita and the 2008 ZC2 index.

[13] For more information, please see http://www.rics.org/site/scripts/download_info.aspx?fileID=6883 (9 December 2010).

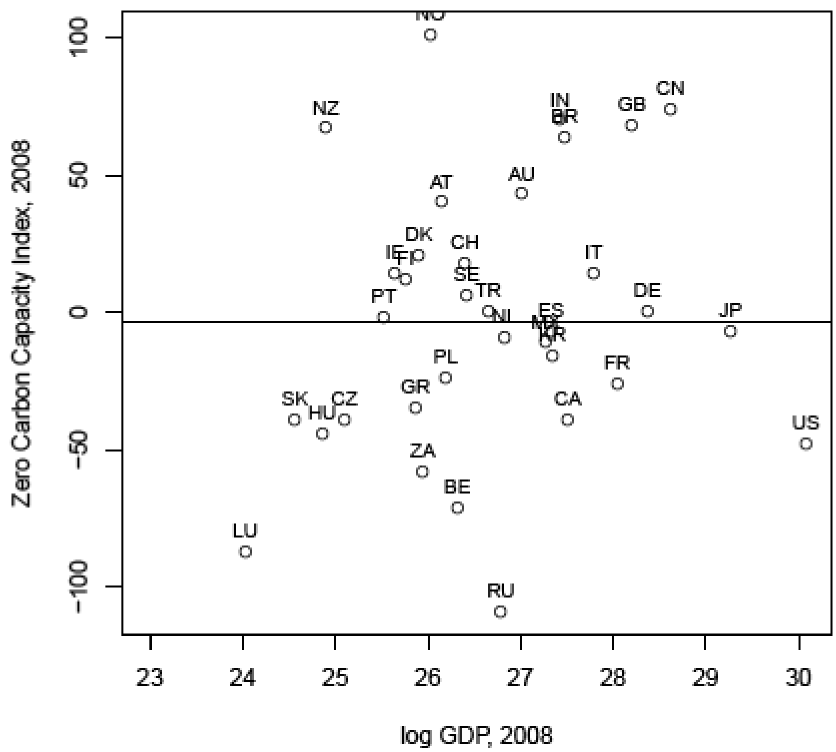

Figure 5-11: Scatterplot of the Zero Carbon Capacity Index 2008 versus log GDP for all available countries in 2008.

A hypothesis that remains to be tested is that a transition to carbon neutrality in the building sector may be independent of the attained level of wealth.

5.2 Time Series Analysis

Time series plots can shed light on systematic trends or cycles over time. We present here data primarily for the EU27 countries since we have time series data available from the Eurostat structural indicators database. Except for the waste generation indicators, data are available for 2000-2008 (cf. Table 8.1 in the Appendix). They show, for example, the steady rise of per capita GDP in all EU27 Member States during the period from 2000 to 2007, and the decline due to the financial and economic recession that started in late 2007 (cf. Figure 5-12). The impact of the recession is particularly visible in the sharp drop in GDP growth which started in 2007 and peaked in 2009 (cf. Figure 5-13).

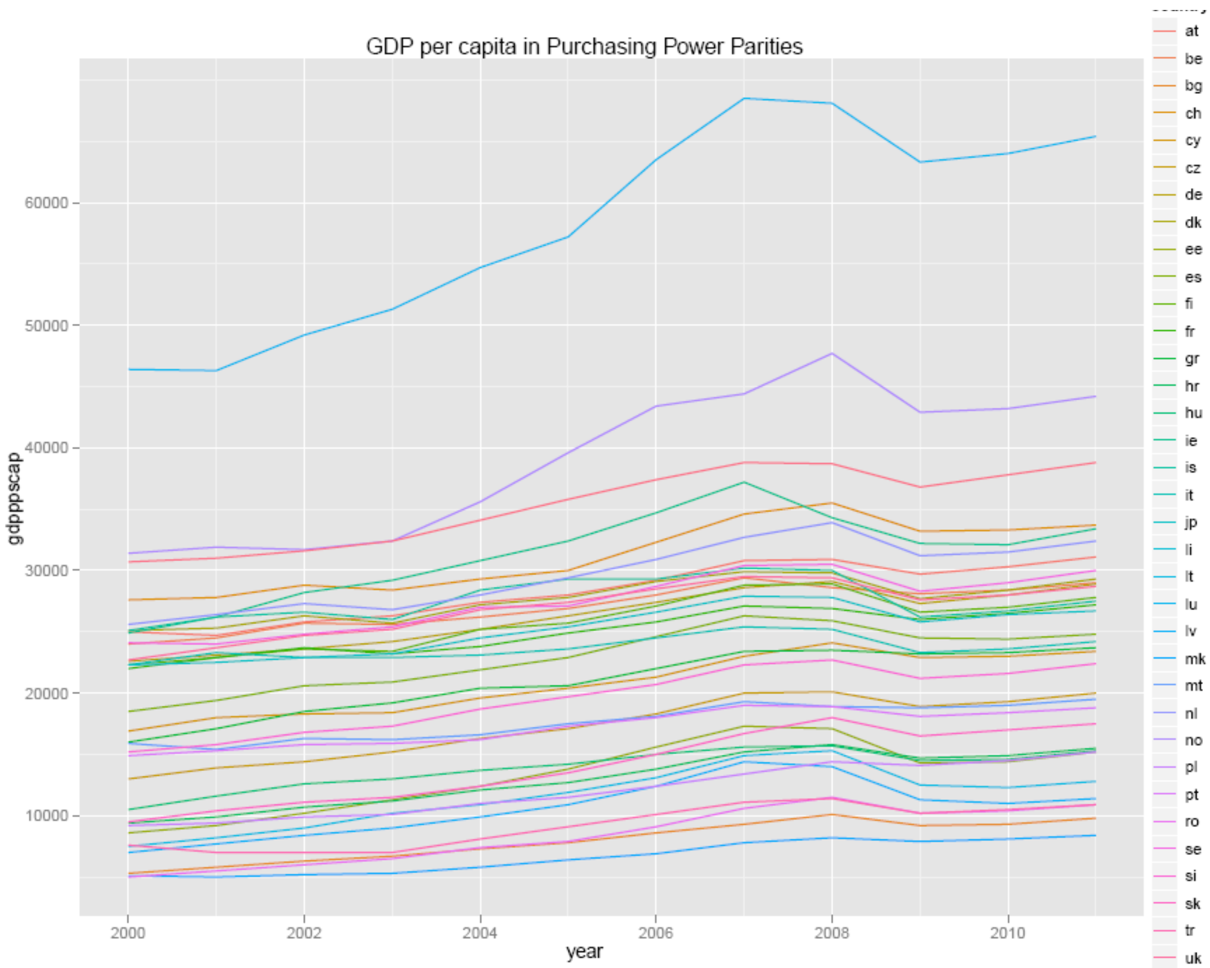

Figure 5-12: Time series of per capita GDP in PPPs for selected countries for the period 2000-2011.
Note: 2010 and 2011 are projections.

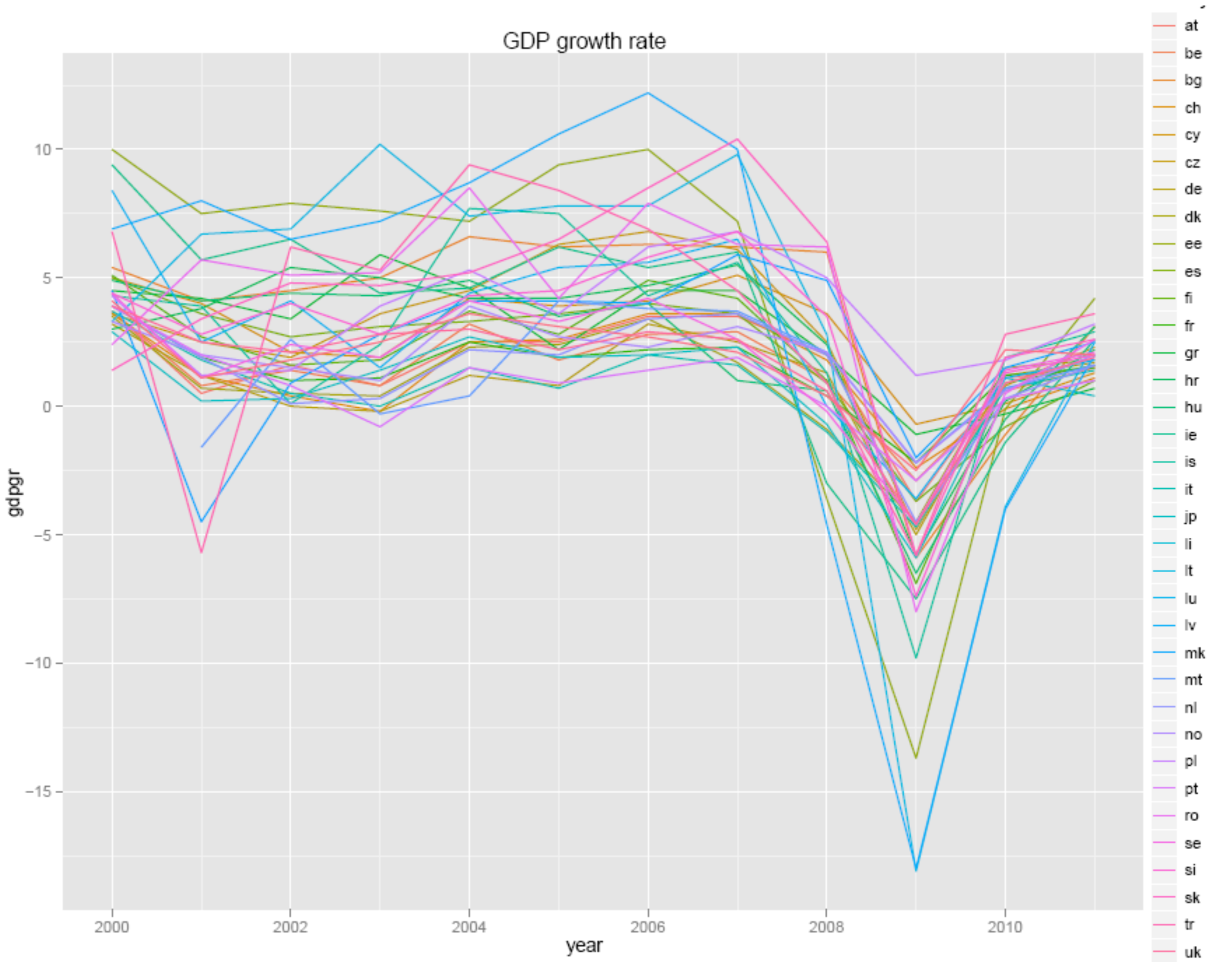

Figure 5-13: GDP growth rate for selected countries for the period 2000-2011.
Note: 2010 and 2011 values are projections.

These homogeneous trends across EU27 Member States are contrasted by very different levels and patterns in income inequality, although incomplete data hamper the drawing of too many conclusions (cf. Figure 5-14). It is notable, though, that the financial and economic crisis did not lead to a uniform increase in inequality.

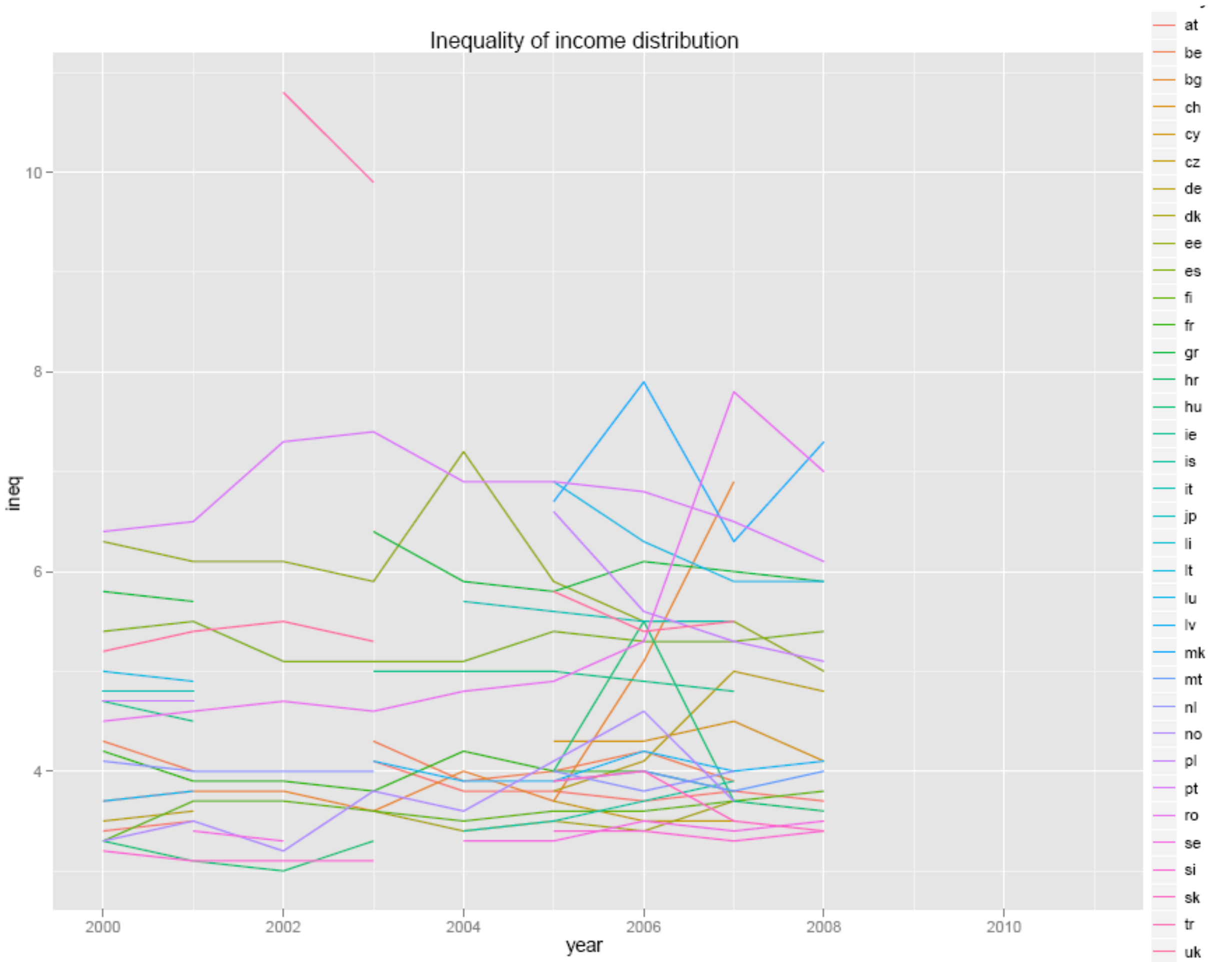

Figure 5-14: Income inequality as measured by the Gini coefficient for selected countries for the period 2000-2008.

Positive trends are visible in employment indicators, which showed a convergence to lower unemployment in general, despite the economic and financial crises, albeit starting from different baselines in 2000 (cf. Figure 5-15). An especially interesting and positive trend is the measurable decline in the long-term unemployment rate, a trend that started around 2002 and has continued through 2008, although again Member States started at very different baseline levels that range from 10% to nearly 0% (cf. Figure 5-16).

Figure 5-15: Total employment rate for selected countries for the period 2000-2008.

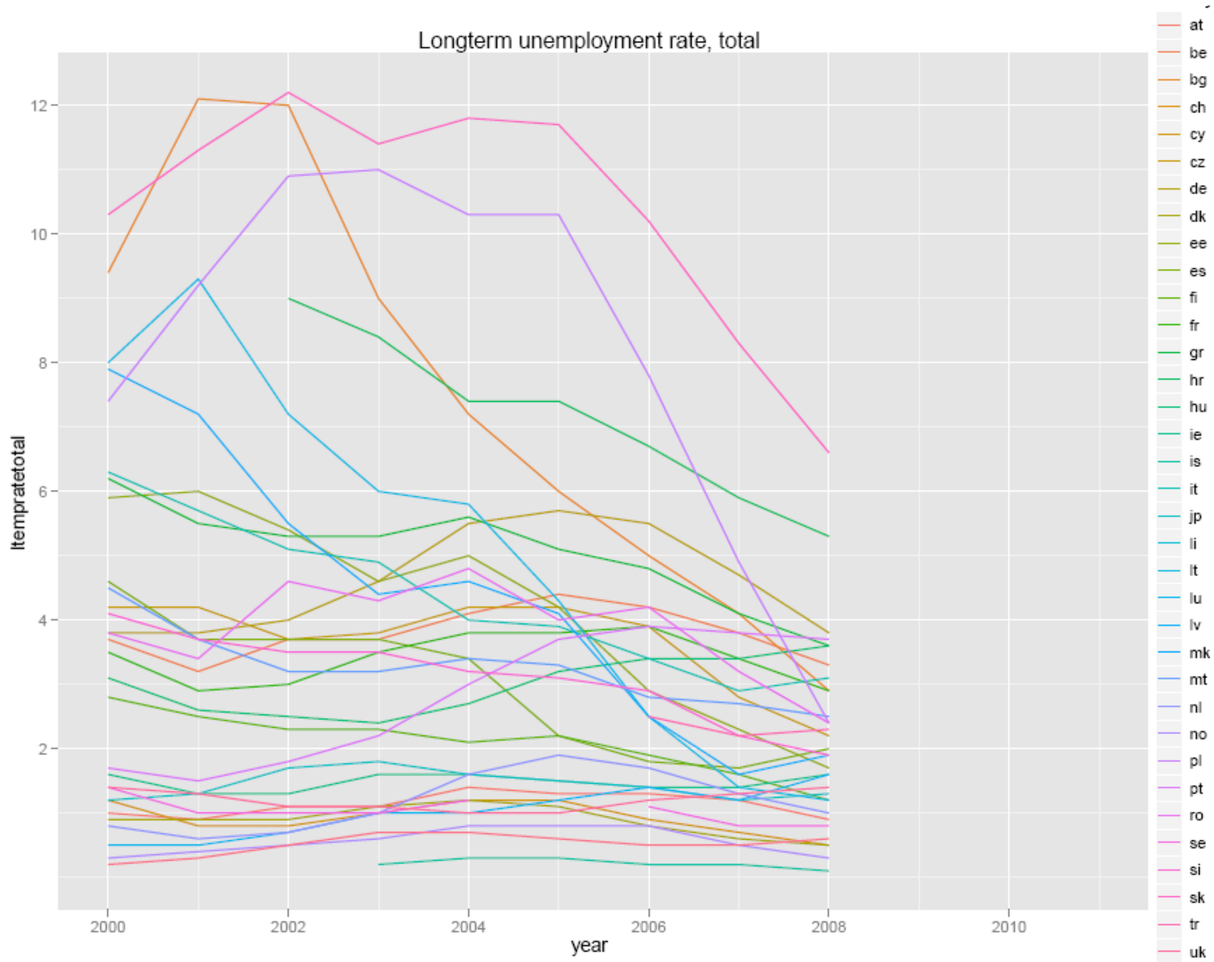

Figure 5-16: Long-term unemployment rate for selected countries for the period 2000-2008.

Although the key economic benchmarks of GDP and unemployment show positive trends, labour productivity has remained fairly flat over the 2000-2008 time period and is showing little convergence among Member States (cf. Figure 5-17). This is also noteworthy since, in times of recession, labour productivity usually increases because industries shed workers, especially in areas that can be outsourced or automated.[14]

[14] Prominent examples include the shift by airlines to use electronic check-in terminals and the widespread use of call centers in India and other locations with low labour costs.

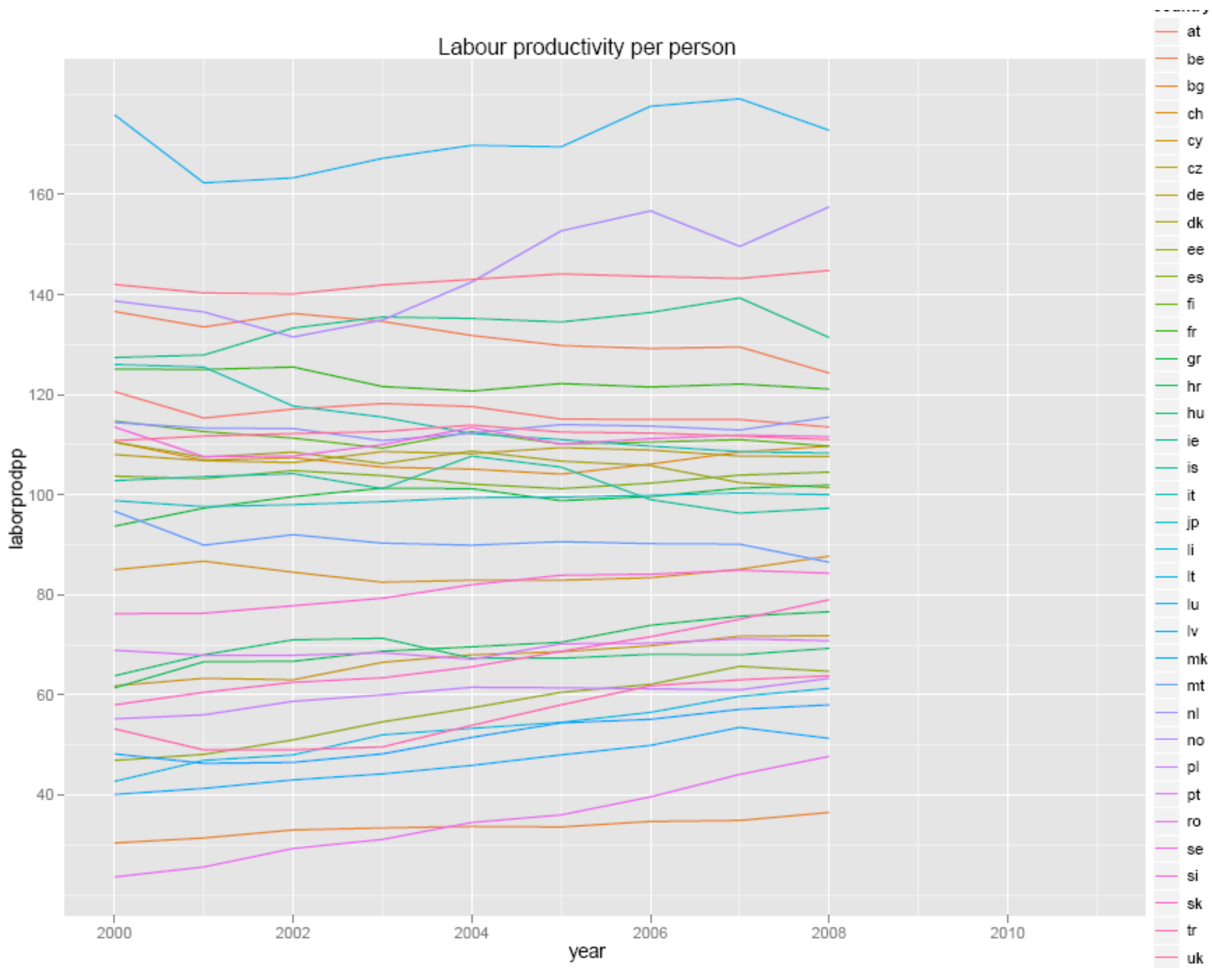

Figure 5-17: Labour productivity per person for selected countries for the period 2000-2008.

A very interesting story is told by road freight volume in transport, which is indexed to 2000 and shows the whole spectrum of trends for the EU Member States, from stagnation and increase to decoupling (cf. Figure 5-17).

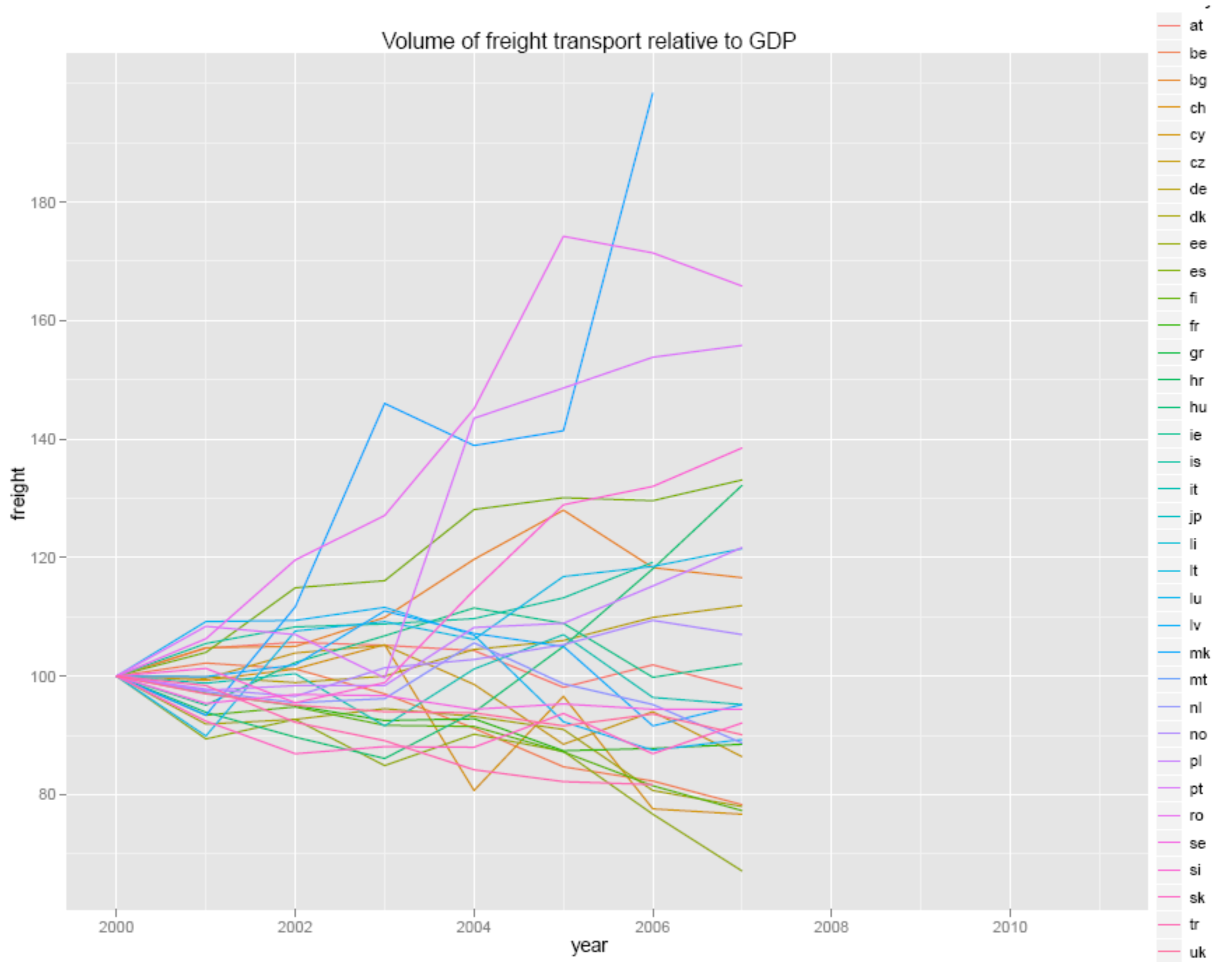

Figure 5-18: Road transport relative to GDP, indexed to 2000, for selected countries for the period 2000-2008.

Youth education, an important measure of general economic competitiveness and innovation shows little upward trends for the leaders and majority in the middle, but the laggards are catching up at a steady pace (cf. Figure 5-19).

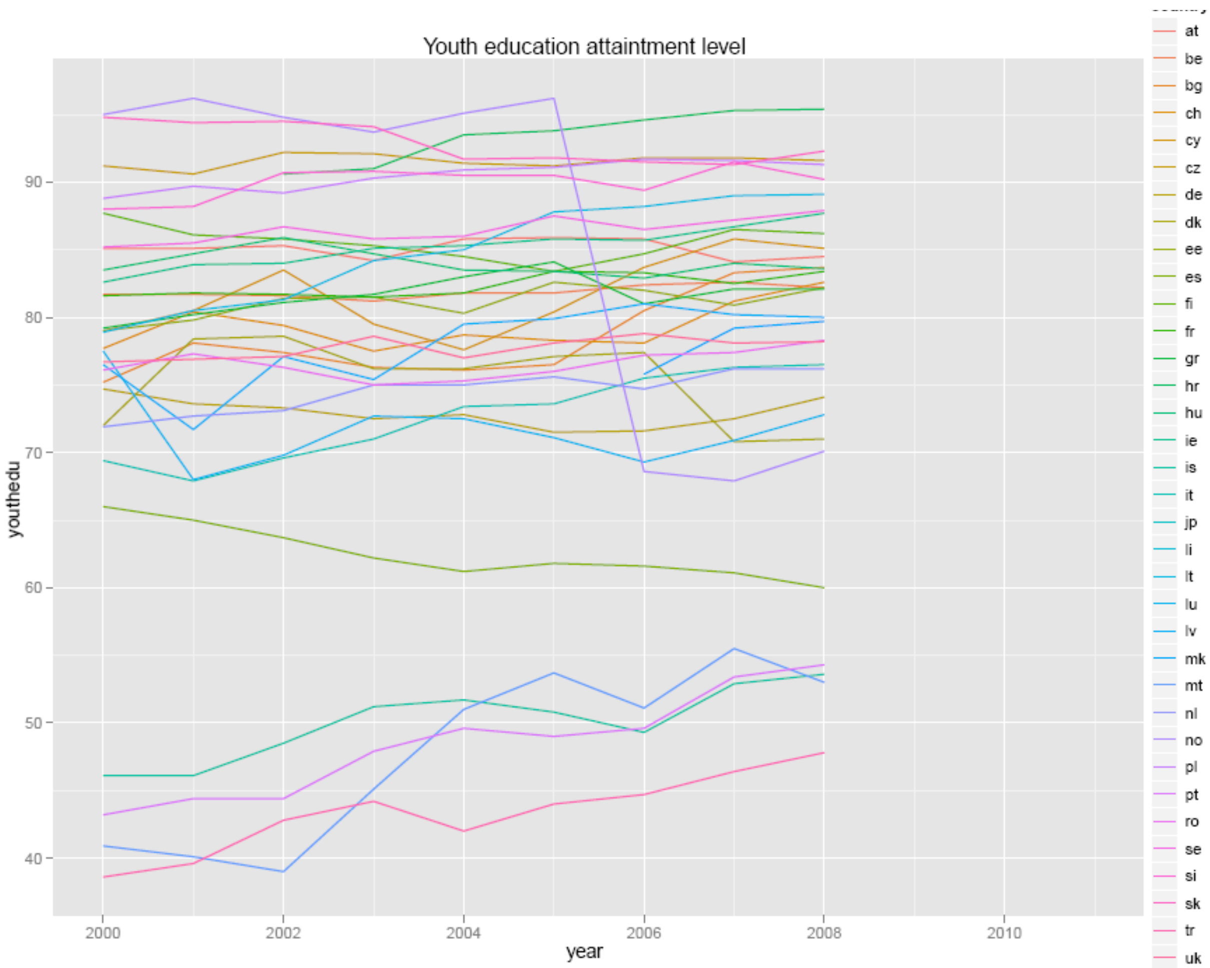

Figure 5-19: Total youth education attainment for selected countries for the period 2000-2008.

Another important socio-economic benchmark is the at-risk-of-poverty rate, defined as the percentage of individuals living in households where the total equivalized household income is below 60% of national equivalized median income, after social transfers. Social transfers are programs aimed at increasing low-income households' standard of living by providing tax credits, food stamp programs, etc. The findings shown in Figure 5-20 reveal a very mixed picture across the EU Member States. Few countries succeeded in continuously reducing the share of people at risk of income poverty and, indeed, for some the share rose substantially.

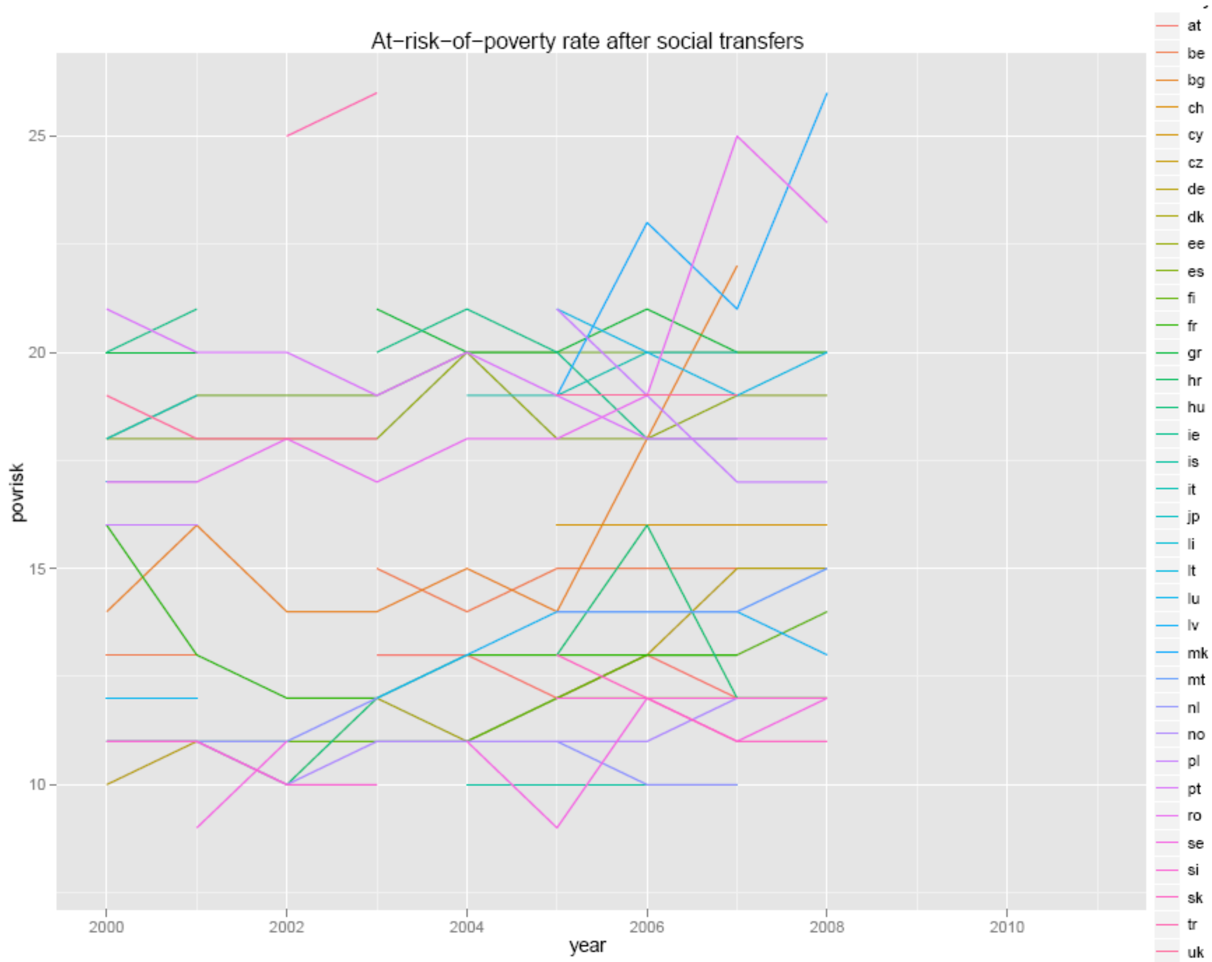

Figure 5-20: Share of the population at-risk-of poverty, adjusted for social transfers for selected countries for the period 2000-2008.

Overall, the time series analysis and plots discussed in this report both affirm existing knowledge and also give actual empirical insights into how theory may or may not play out in reality. One example that may merit further investigation is the decline in long-term unemployment in nearly all EU Member States, even during times of substantial economic and financial distress.[15] The observations only date to 2008[16] and there is hence a possibility that long-term unemployment, while not immediately affected, may still have increased again since then. The example serves to illustrate that time series data offer valuable information that snapshot studies cannot provide, and that even for mainstream macro-economic indicators theory and practice do not always line up perfectly.

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[15] TheFor example, the Brookings Institute found that, during the "Great Recession" of 2007-2009 in the U.S.., the number of long-term unemployed rose sharply, with more than 50% of unemployed staying out of work for more than 21 weeks, more than 25% for more than a year and 10% for more than two years. See http://www.brookings.edu/opinions/2010/1105_jobs_greenstone_looney.aspx (10 December 2010) for more information.

[16] We locked down the database before new data became available.

5.3 Principal Component Analysis

Principal Component Analysis (PCA) is a statistical method to reduce dimensionality in high-dimensional datasets and search for underlying latent concepts such as competitiveness, intelligence, and environmental conscience. Therefore, it was of interest to us to examine how the selected indicators relate to each other. The results do not deliver strong evidence for the existence of latent constructs, but do show that the indicators are not entirely independent of each other (as already shown in the correlation analysis, which is used by the PCA as well to determine the principal components). When we consider the proportion of variance explained by the principal components, we can identify four, perhaps five main components. The scree-plot in Figure 5-21 shows that the explained amount of variation declines markedly after the fifth principal component. A Biplot of these is shown in Figure 5-22.

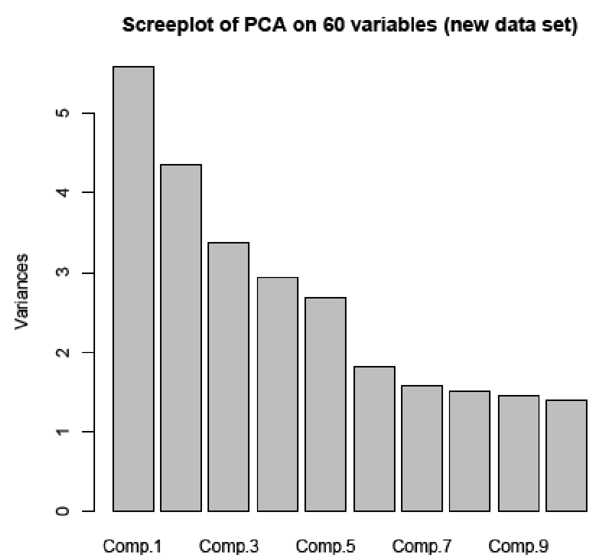

Figure 5-21: Scree-plot of the variance explained by each principal component.

PCA relies not only on mathematical relationships among the selected indicators, but also on the cautious and well-informed interpretation of the loadings and determination of potential underlying latent constructs by the analyst. In addition to this potential weakness in using PCA, we also note that for this analysis missing data were replaced by the median of the respective indicator. This causes changes in the distribution of the data and therefore also affects the results of the PCA.[17]

The main principal components that emerge from the PCA contain some interesting groups of indicators, shown in Table 5-1 for the first four components.

[17] Here we replaced between 0% and 25% of missing values per indicator. A total of 13% of data gaps were imputed, a moderate amount.

Table 5-1: The principal components and indicators loading most strongly on them.

1^{st} component	2^{nd} component	3^{rd} component	4^{th} component
Unemployment	Debt	Government expenditures	Household consumption
Youth unemployment	Exports	Government spending on education	Final consumption
GDP growth	Total Trade	Tertiary enrollment	
Fixed capital formation	Trade in services	CO_2 emissions per capita	
CO_2 emissions per GDP	ANS	GDP per capita	
	Current account balance	Energy intensity of GDP	

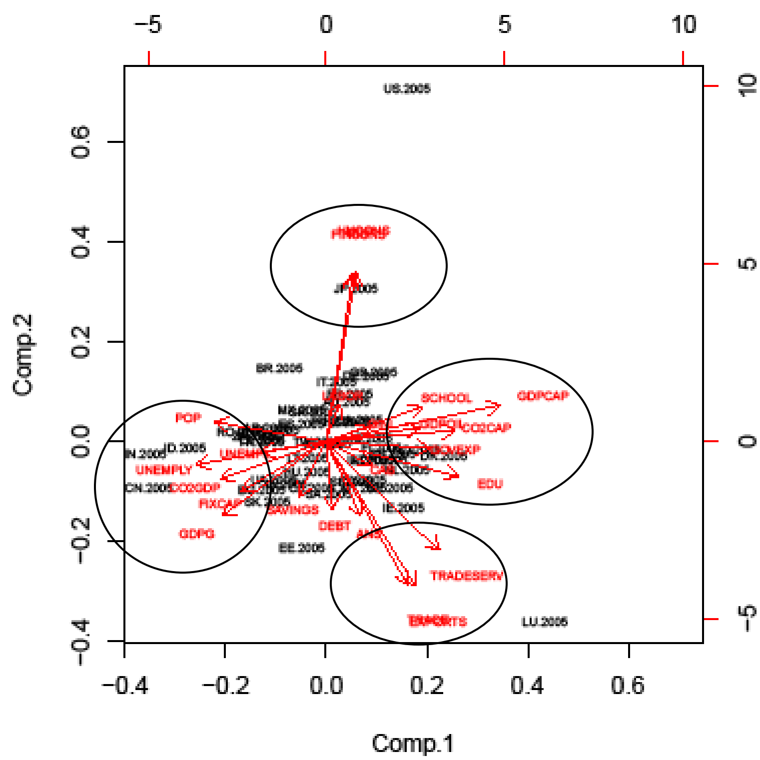

Figure 5-22: Biplot showing the principal components and indicator loadings.

5.4 Cluster Analysis

We were also interested in understanding which countries are more similar to each other with respect to the selected indicators. A cluster analysis refers to a suite of statistical methods for classifying units (e.g., countries) into groups, such that units within a group are as similar to each other as possible while units in different groups are as different as possible with respect to a set of metrics of interest.

The cluster analysis we performed did not provide any dramatic new insights or surprises, but mostly confirmed the general perception that the big four EU countries (Germany, Great Britain, France, and Italy) form a cluster while the smaller EU members and the new members form separate clusters. Of potential interest is the fact that the US – if added to the country list – stands out as being very different, insofar asit forms its own cluster.[18]

6. Summary and conclusions

This deliverable presented a series of quantitative analyses of mainstream economic indicators and selected alternative measures as a contribution to the efforts to integrate mainstream economic indicators with sustainable development objectives and to bridge the gap between these two main types of indicators. The analyses involved: examining scatterplots of selected variable pairs and searching for linear correlations between them; statistical analyses investigating the existence of latent variables; and charting temporal trends of selected indicators and their comparison across countries.

The correlations and scatter plots between indicators characterizing selected attributes of sustainability confirm some well-known linkages, such as the positive correlation between GDP and labour productivity and the negative correlation between GDP and energy intensity. In addition, the correlations revealed some less well-known relationships. For example, there was a strong negative correlation between employment rate, on the one hand, and long-term unemployment and the share of jobless households, on the other.

The relationships between the so-called main-stream indicators and the "beyond GDP" indicators demonstrate that GDP is an important component of many "beyond GDP' indicators, notwithstanding all of its recognized and criticized deficiencies as a measure of wellbeing and progress. GDP can influence the values of the "beyond GDP" indicators directly, by direct inclusion as a component of a composite indicator, or indirectly as a driver behind the processes represented by an indicator or composite indicator. These connections not only confirm conventional expectations about the misleading signals that GDP can send, for example, with respect to sustainable natural resource use and consumption patterns, but also unveil empirical information on a few controversial associations. For example, many social and some environmental indicators/indices correlate with GDP, at least to some extent, in some cases indicating positive relationships between them. In addition to indicating that economic performance, as measured by GDP, is not always detrimental to the environment or society, this also

[18] In the Appendix, we show heat maps for each year in the period 2000-2008 (also to look at changes over time) that reflect this individual position as well as showing the results of the complete cluster analysis.

means that GDP could be used to estimate the values of indicators that are not directly observed, measured or modelled.

The report also presents a series of plots on the temporal trend in selected economic, social and environmental indicators. They show that, in some cases, the examined EU countries followed similar paths, albeit at different levels (e.g., labour productivity), while in other cases, countries began to diverge, such as in the freight transportation sector. Long-term unemployment has seen positive declines in several countries with above average rates, but has largely stagnated in countries at or below the EU's average, highlighting the need for continued efforts in this important aspect of human wellbeing and economic capacity. Income inequality remains high in several countries and has also shown slightly upward trends in many others. This development is at least partially attributable to the economic and financial crises that unfolded in 2007 and 2008, whose effects are still felt throughout the Union. The immediate impact of these crises is most impressively visualized in the large drop of GDP growth and, to a lesser extent, in the stagnation or decline in per capita purchasing power. In general, the time series plots help to discern if outliers or unusual correlations are indicative of errors in the data or represent relevant developments.

The database explored in this work package consists of more than 70 indicators and issues that are closely related. It therefore seemed prudent to examine opportunities to reduce the dimensionality of the data set to a few meaningful and empirically supported latent concepts (or principal components). The Principal Component Analysis (PCA) was also carried out to examine what indicators are associated with the same latent variable. For example, would many of the mainstream economic performance indicators load heavily on what could be termed an "economic productivity and performance" axis while indicators associated with environmental protection and conservation would load strongly on an opposing axis?

The findings indicate that this is not necessarily the case. The main principal component, for example, is a mixture of economic performance indicators, such as GDP growth and fixed capital formation, but it also reflects on the status of people's participation in the economic sector through the unemployment and youth unemployment rates. According to welfare theory, economic progress is, inter alia, only sustainable if it is generated and shared by the majority of the citizens of a country. Youth unemployment is considered a signal indicator for growing problems in the future and a structural weakness in a country's economic capacity.

Similarly, the second principal component primarily describes a country's international strength in a globalized economy: debt, exports, trade balance and current account balance are all benchmark economic indicators used to examine economic competitiveness, dependency on world markets and access to credit. Yet, the well-known sustainability metric of Adjusted Net Savings (ANS) belongs to this component as well. Since ANS measures the true rate of savings of an economy more correctly and comprehensively than Net National Income or other aggregates of the national accounts, it sheds light on both the country's ability to produce economic gains and its likely ability to sustain them. This analysis and interpretation of the results of the PCA can be carried on for components three and four, and they support the conclusion that economic, social and environmental factors can work in tandem, rather than in opposition, which is a relevant insight for the “beyond GDP” debate.

7. Statistical Appendix

7.1 Structural Indicators

Table 7-1: Summary of indicators from the EU structural indicator database, their coverage, and classification as economic, social, and environmental indicators

Indicator	Type of Indicator	Data Source	Time Period	Coverage
GDP total in market prices	Economic	EUROSTAT Structural Indicators	2000-2011	36 countries
GDP total at market prices (in PPS)	Economic	EUROSTAT Structural Indicators	2000-2011	35 countries
GDP per capita in PPS	Economic	EUROSTAT Structural Indicators	2000-2011	35 countries
GDP growth rate	Economic	EUROSTAT Structural Indicators	2000-2011	36 countries
Income of households, primary	Economic	EUROSTAT Structural Indicators	1995-2006	23 countries
Income of households, disposable	Economic	EUROSTAT Structural Indicators	1995-2006	23 countries
Inequality of income distribution	Social	EUROSTAT Structural Indicators	1997-2008	31 countries
Employment rate, total	Economic/Social	EUROSTAT Structural Indicators	1997-2008	35 countries
Employment rate, females	Economic/Social	EUROSTAT Structural Indicators	1997-2008	35 countries
Employment rate of elderly workers (55-64 yrs)	Economic/Social	EUROSTAT Structural Indicators	1997-2008	35 countries
Longterm unemployment rate, total	Economic/Social	EUROSTAT Structural Indicators	1992-2008	35 countries
Labour productivity per person	Economic	EUROSTAT Structural Indicators	1997-2008	35 countries
Labour productivity per hour	Economic	EUROSTAT Structural Indicators	1997-2008	31 countries
Labour productivity growth per hour	Economic	EUROSTAT Structural Indicators	1997-2008	30 countries
Dispersion of regional employment rates	Economic	EUROSTAT Structural Indicators	1999-2007	19 countries
Gross fixed capital formation (million Euro)	Economic	EUROSTAT Structural Indicators	2006q4-2009q2	30 countries
General government fixed investments (million Euro)	Economic	EUROSTAT Structural Indicators	1997-2008	30 countries
Government fixed investment (percent of GDP)	Economic	EUROSTAT Structural Indicators	1997-2008	31 countries
General gross consolidated government debt (percent of GDP)	Economic/Social (inter-generational equity)	EUROSTAT Structural Indicators	1997-2008	35 countries
Comparative price level indices (EU27=100)	Economic	EUROSTAT Structural Indicators	1997-2008	39 countries
Comparative price level of final consumption by private households (EU27=100)	Economic	EUROSTAT Structural Indicators	1997-2008	35 countries
Gross fixed capital formation by the private sector (percent of GDP)	Economic	EUROSTAT Structural Indicators	1997-2008	30 countries
Gross inland consumption of energy divided by GDP (kilogram of oil equivalent per 1000 Euro)	Environmental	EUROSTAT Structural Indicators	1996-2007	34 countries
Total waste generation	Environmental	EUROSTAT Structural Indicators	MRYA	29 countries
Hazardous waste generation	Environmental	EUROSTAT Structural Indicators	MRYA	29 countries
Non-hazardous waste generation	Environmental	EUROSTAT Structural Indicators	MRYA	29 countries
Total waste generation	Environmental	EUROSTAT Structural Indicators	MRYA	29 countries
GHG emissions (CO2 equivalents)	Environmental	EUROSTAT Structural Indicators	1996-2007	33 countries
GHG emissions indexed	Environmental	EUROSTAT Structural Indicators	1990-2007	33 countries
Volume of freight transport relative to GDP	Environmental	EUROSTAT Structural Indicators	1996-2007	29 countries

Youth education attaintment level	Social	EUROSTAT Structural Indicators	1997-2008	33 countries
Youth education attainment level, females	Social	EUROSTAT Structural Indicators	1997-2008	33 countries
Youth education attainment level, males	Social	EUROSTAT Structural Indicators	1997-2008	33 countries
Gross domestic expenditure on R&D	Economic	EUROSTAT Structural Indicators	1997-2008	34 countries
At-risk-of-poverty rate after social transfers	Social	EUROSTAT Structural Indicators	1997-2008	29 countries

Table 7-2: Matrix of correlations between selected economic, social and environmental indicators.

(example shows the case of Germany)

DE			102	103	104	201	202	203	301	302	303	305	401	402	601	701	801	802	803	901	1001	1002	1003	1004	1201	1301	1601	1801	1901	1902	1904	2001	2002
			gdp-perca	ppp-pe	p-gr-ra	e-perca	t-incom	sposab	loym-r	nploym	mploy-l	aged 1	prod pe	per hc	ovt-deb	npPrice	stment	-invest-	vest-g	gy-inter	male (y	Male (ye	at age l	age le	on-bird	-emiss	ghtTrar	ni-coef	du-sec	du-sec	ed 18-2	gerd%	rd-perca
	gdp-percap	102	1.00																														
	gdp-ppp-pe	103	0.98	1.00																													
	gdp-gr-rate	104	0.11	0.06	1.00																												
	hhold-incom	201	0.99	0.96	-0.02	1.00																											
	net-nat-incon	202	0.98	1.00	0.08	0.96	1.00																										
	net-nat-dispc	203	0.98	1.00	0.09	0.96	1.00	1.00																									
	employm-rat	301	0.93	0.89	0.17	0.87	0.89	0.89	1.00																								
	unemploym-	302	0.37	0.12	-0.11	0.38	0.13	0.13	-0.36	1.00																							
	unemploy-lo	303	0.47	0.36	0.17	0.51	0.38	0.38	-0.14	0.92	1.00																						
	jobless hhol	305	-0.09	-0.54	-0.17	-0.28	-0.53	-0.52	-0.81	0.81	0.52	1.00																					
	labour-prod	401	-0.59	-0.56	0.43	-0.17	-0.54	-0.54	-0.43	-0.11	-0.14	0.14	1.00																				
	labour-prod	402	0.97	0.98	0.11	0.95	0.97	0.97	0.83	0.46	0.58	-0.01	-0.55	1.00																			
	govt-debt	601	0.92	0.88	0.07	0.79	0.88	0.88	0.55	0.68	0.78	0.32	-0.47	0.93	1.00																		
	compPriceL	701	-0.78	-0.87	-0.10	-0.78	-0.85	-0.86	-0.78	-0.24	-0.44	0.35	0.49	-0.92	-0.85	1.00																	
	business-inv	801	-0.82	-0.73	0.23	-0.82	-0.71	-0.71	-0.28	-0.66	-0.68	-0.24	0.54	-0.87	-0.83	0.67	1.00																
	fixed-invest-	802	0.20	0.29	-0.05	0.12	0.26	0.26	0.09	0.00	0.03	-0.15	-0.29	0.35	0.30	-0.58	-0.14	1.00															
	fixed-invest-	803	-0.08	0.00	-0.05	-0.08	-0.02	-0.02	-0.54	0.00	-0.04	0.03	-0.11	0.07	0.08	-0.35	0.06	0.96	1.00														
	energy-inten	901	-0.94	-0.95	-0.29	-0.92	-0.93	-0.93	-0.93	-0.40	-0.53	0.10	0.44	-0.94	0.73	0.89	0.77	-0.24	-0.01	1.00													
	healthy-life-F	1001	-0.75	-0.77	-0.14	-0.64	-0.80	-0.80	-0.65	-0.65	-0.83	0.07	0.16	-0.69	-0.85	0.60	0.62	0.03	0.21	0.62	1.00												
	healthy-life-M	1002	-0.39	-0.40	-0.18	-0.23	-0.45	-0.45	-0.48	-0.60	-0.72	-0.14	-0.05	-0.27	-0.55	0.18	0.26	0.28	0.37	0.22	0.87	1.00											
	life-exp-fema	1003	0.98	0.99	0.17	0.93	0.98	0.98	0.89	0.42	0.57	-0.07	-0.57	0.99	0.79	-0.92	-0.83	0.34	0.06	0.20	-0.74	-0.34	1.00										
	life-exp-male	1004	0.97	0.99	0.12	0.95	0.98	0.98	0.86	0.42	0.57	-0.08	-0.59	0.99	0.75	-0.91	-0.86	0.33	0.05	0.14	-0.74	-0.34	0.99	1.00									
	common-bir	1201	-0.70	-0.89	-0.08	-0.91	-0.87	-0.87	-0.71	-0.39	-0.57	0.02	0.33	-0.78	-0.57	0.77	0.77	-0.12	0.06	0.82	0.45	0.00	-0.77	-0.81	1.00								
	ghg-emissio	1301	-0.95	-0.93	-0.20	-0.86	-0.90	-0.91	-0.84	-0.55	-0.65	-0.11	0.51	-0.96	-0.87	0.92	0.81	-0.27	-0.05	-0.35	0.67	0.28	-0.97	-0.95	0.73	1.00							
	freightTransp	1601	0.95	0.96	0.30	0.91	0.97	0.97	0.90	0.34	0.60	-0.39	-0.34	0.91	0.84	-0.82	-0.63	0.11	-0.12	-0.92	-0.82	-0.52	0.95	0.94	-0.81	-0.90	1.00						
	gini-coeff.	1801	0.62	0.50	-0.02	0.02	0.53	0.53	0.94	-0.25	-0.10	-0.53	-0.42	0.39	0.27	-0.04	-0.34	-0.36	-0.53	-0.26	-0.37	-0.49	0.38	0.41	0.08	-0.11	0.40	1.00					
	youthEdu-se	1901	-0.81	-0.72	0.00	-0.77	-0.70	-0.70	-0.21	-0.62	-0.70	-0.28	0.45	-0.90	-0.94	0.89	0.82	-0.66	-0.50	0.75	0.59	0.18	-0.86	-0.85	0.62	0.85	-0.68	0.14	1.00				
	TotalEdu-se	1902	0.85	0.87	0.09	0.85	0.86	0.86	0.71	0.28	0.39	-0.15	-0.60	0.83	0.66	-0.70	-0.77	0.03	-0.23	-0.85	-0.54	-0.14	0.83	0.85	-0.85	-0.80	0.76	0.56	-0.55	1.00			
	early-school-	1904	-0.46	-0.40	0.44	-0.19	-0.39	-0.39	-0.33	0.03	-0.01	0.18	0.57	-0.42	-0.20	0.19	0.52	0.14	0.39	0.11	0.02	-0.13	-0.36	-0.41	0.24	0.02	-0.09	-0.60	0.22	-0.62	1.00		
	gerd%	2001	0.63	0.91	0.00	0.91	0.88	0.88	0.78	0.12	0.34	-0.37	-0.60	0.72	0.47	-0.88	-0.64	0.37	0.11	-0.70	-0.48	-0.02	0.71	0.76	-0.85	-0.62	0.79	0.30	-0.70	0.79	-0.32	1.00	
	gerd-percap	2002	0.87	0.96	0.10	0.95	0.94	0.94	0.90	0.20	0.39	-0.30	-0.61	0.91	0.72	-0.88	-0.76	0.35	0.07	-0.91	-0.58	-0.14	0.91	0.94	-0.91	-0.86	0.88	0.40	-0.77	0.85	-0.38	0.93	1.00

7.3 Time Series Analysis

The following graphs show additional time series plots that were not presented or discussed in the main part of the report.

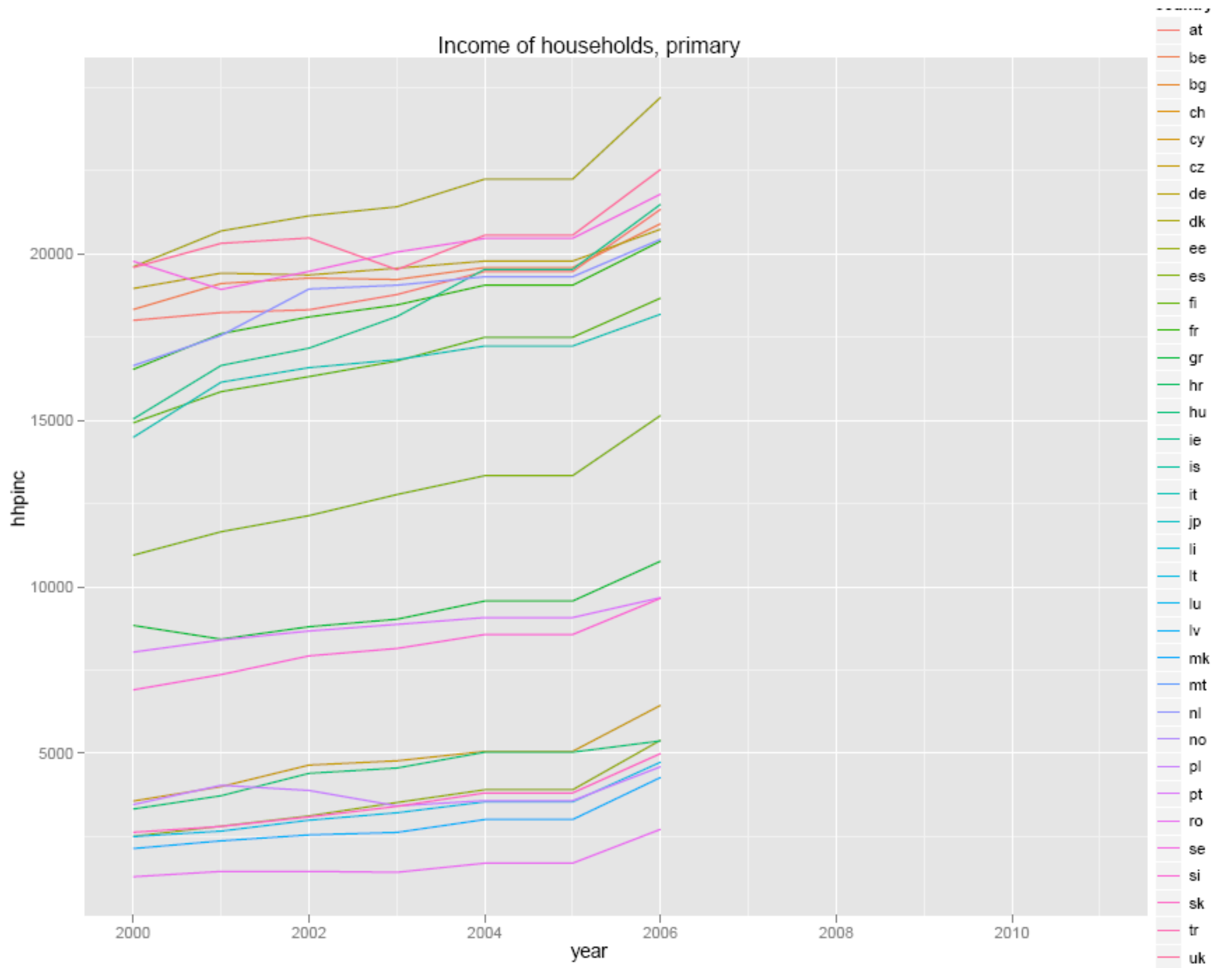

Figure 7-1: Primary household income for selected countries for 2000-2006.

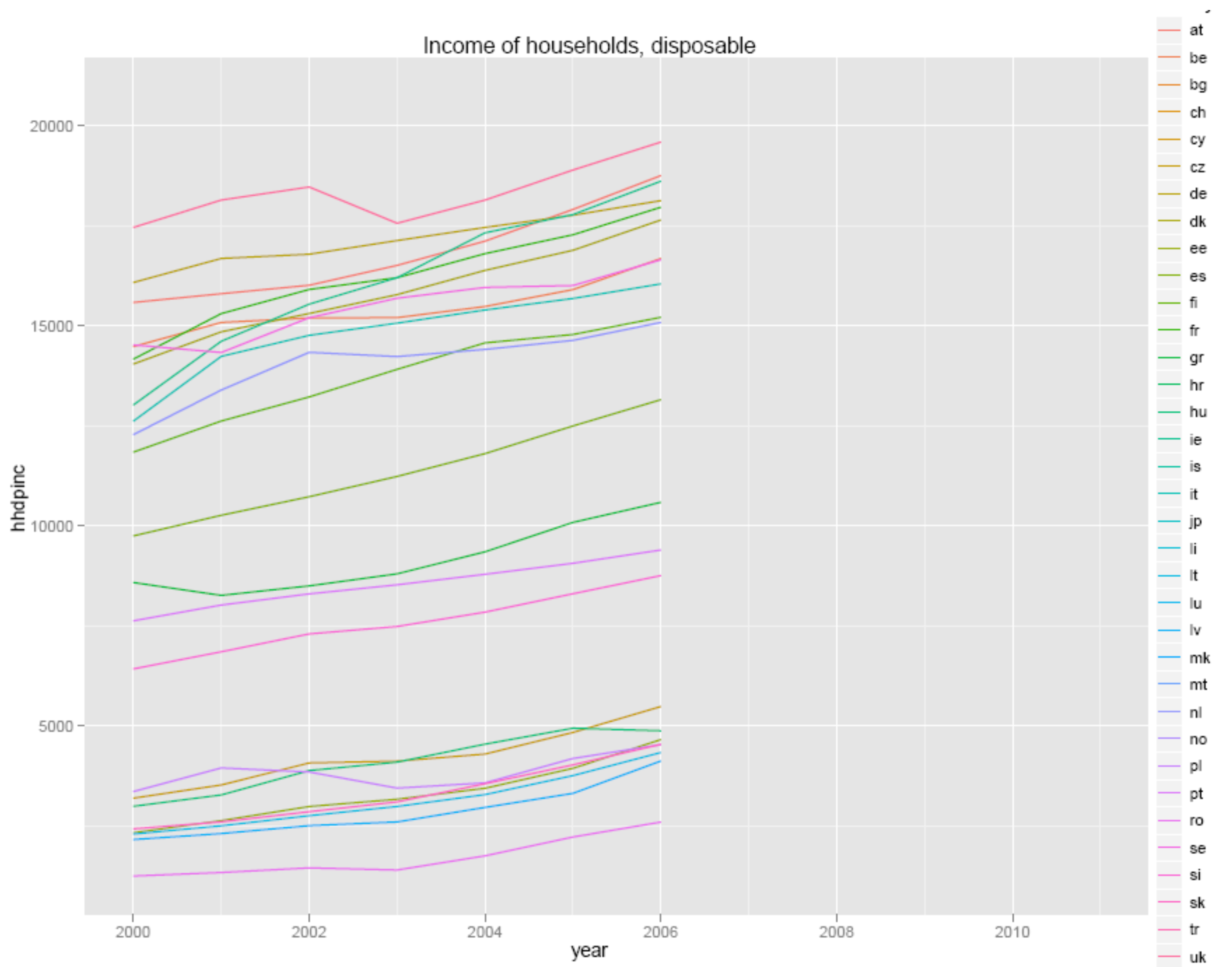

Figure 7-2: Disposable household income for selected countries for 2000-2006.

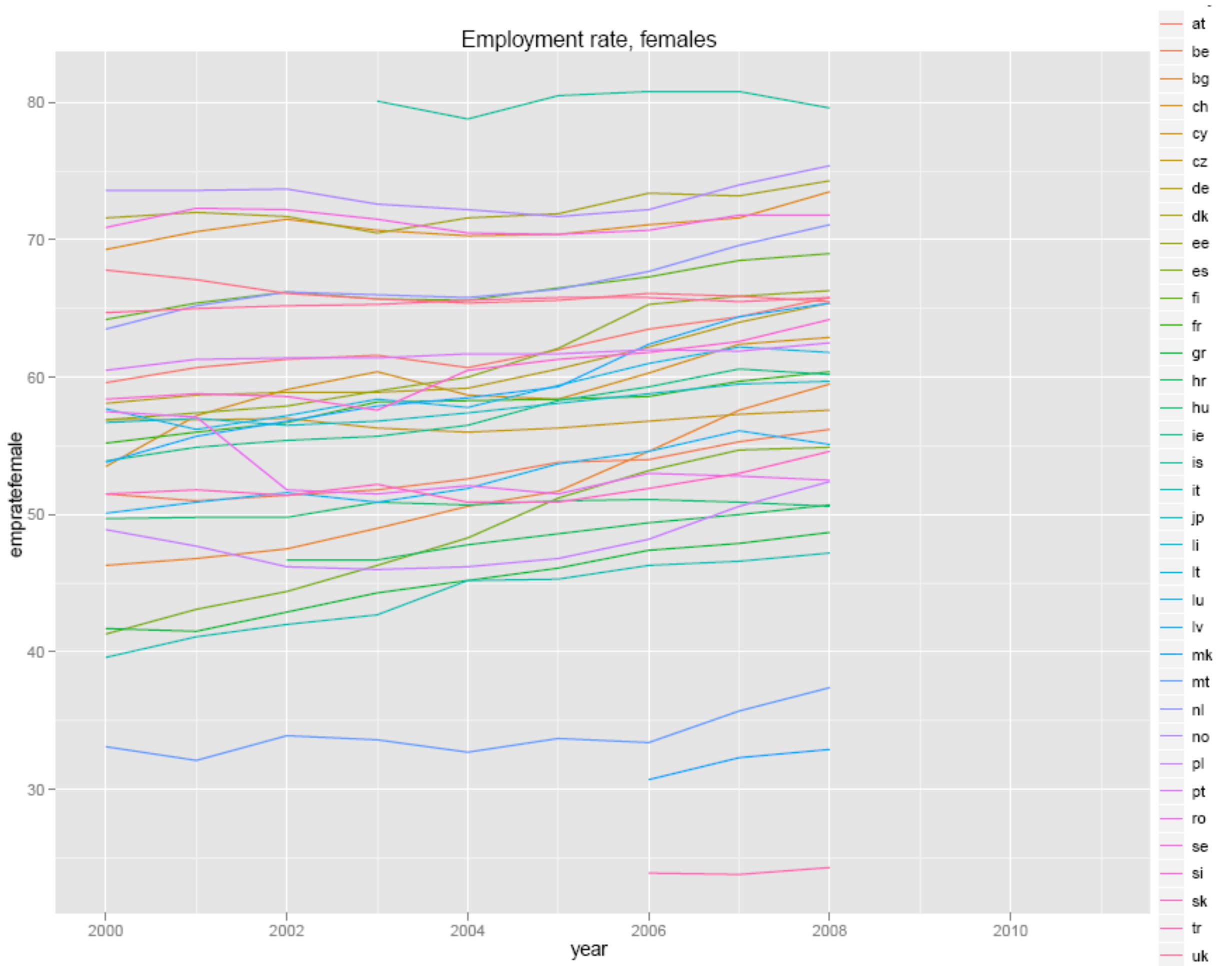

Figure 7-3: Female employment rate for selected countries for 2000-2008.

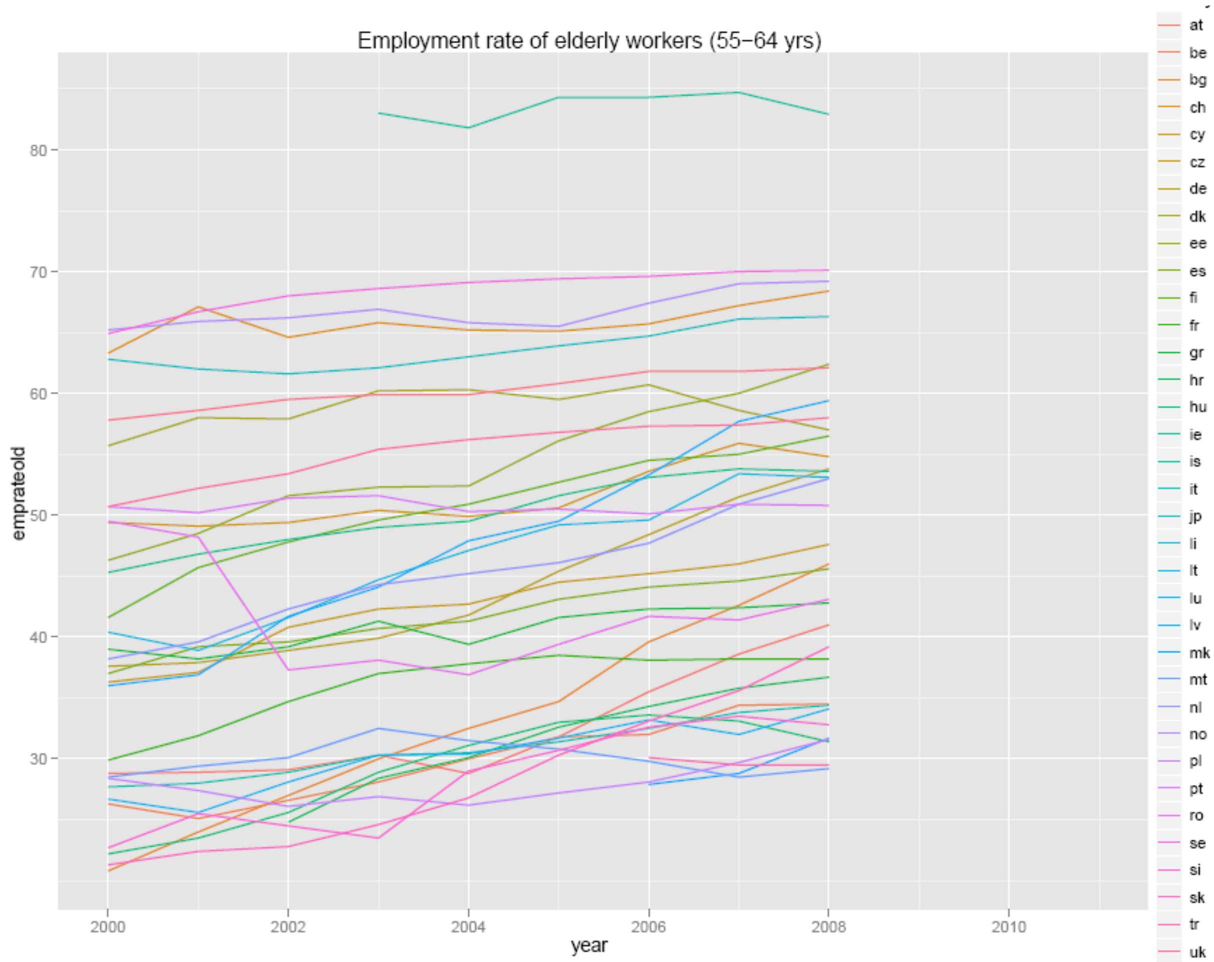

Figure 7-4: Employment rate of elderly workers (aged 55-64 years) for selected countries for 2000-2008.

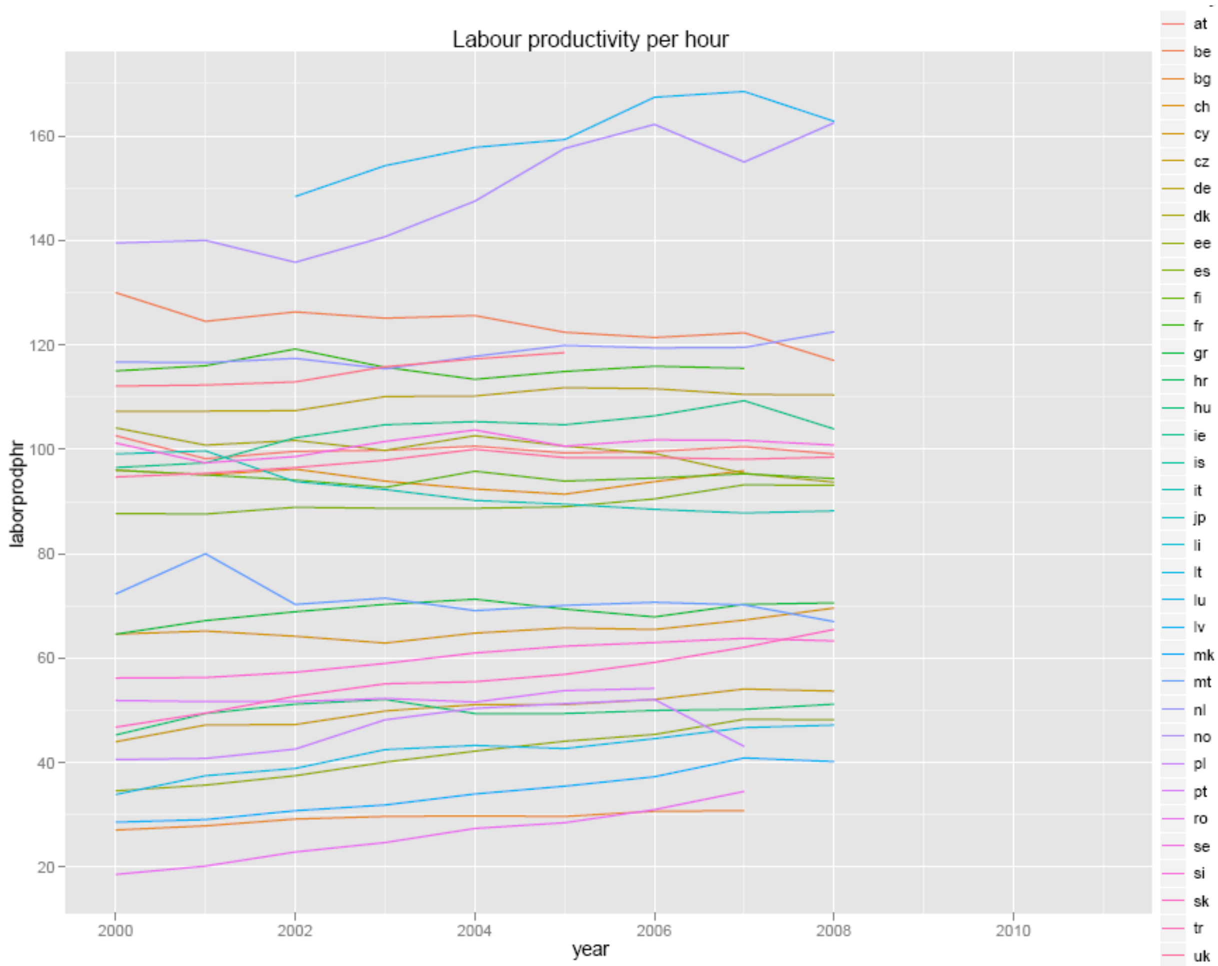

Figure 7-5: Labour productivity per hour worked for selected countries for 2000-2008.

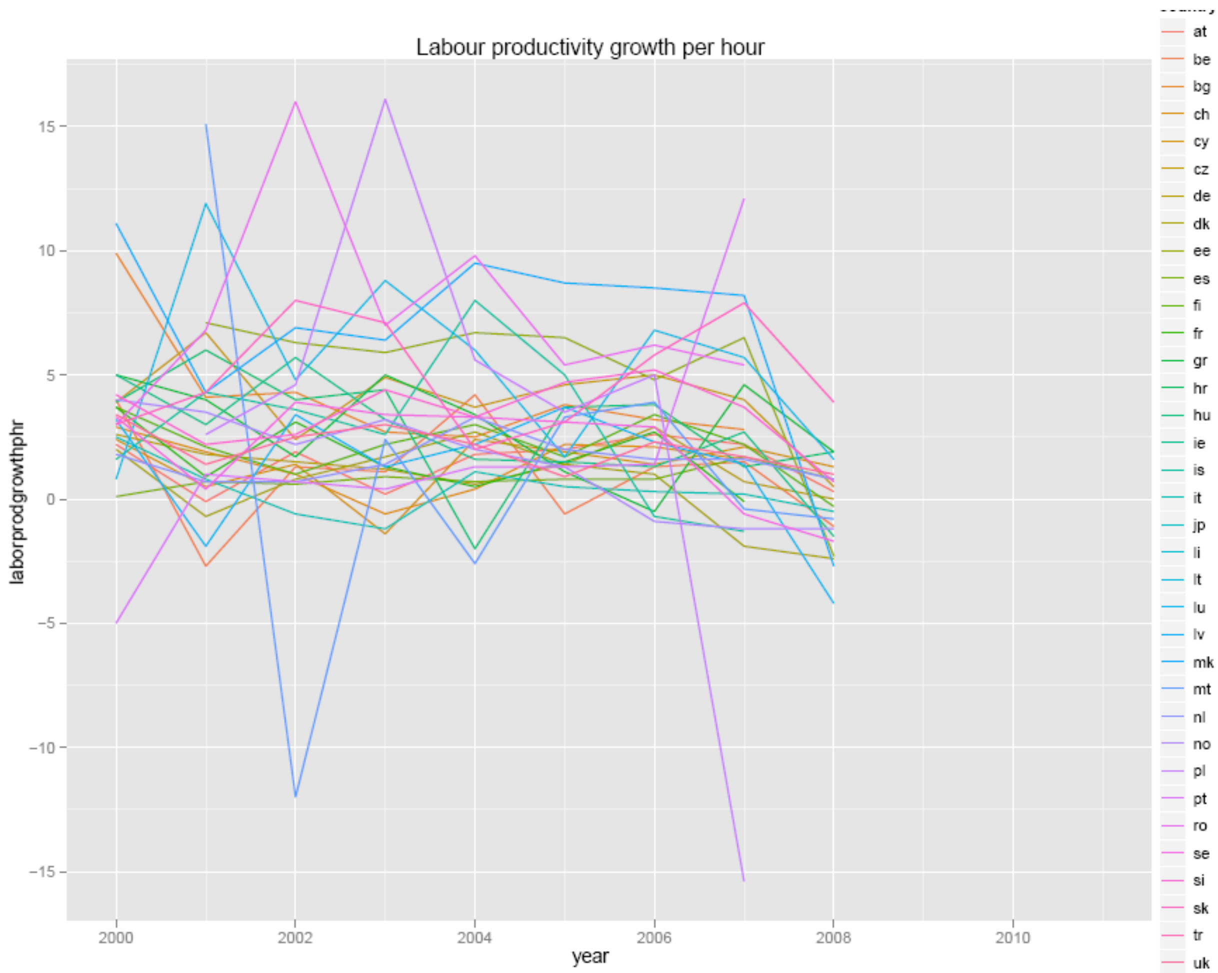

Figure 7-6: Growth in hourly labour productivity for selected countries for 2000-2008.

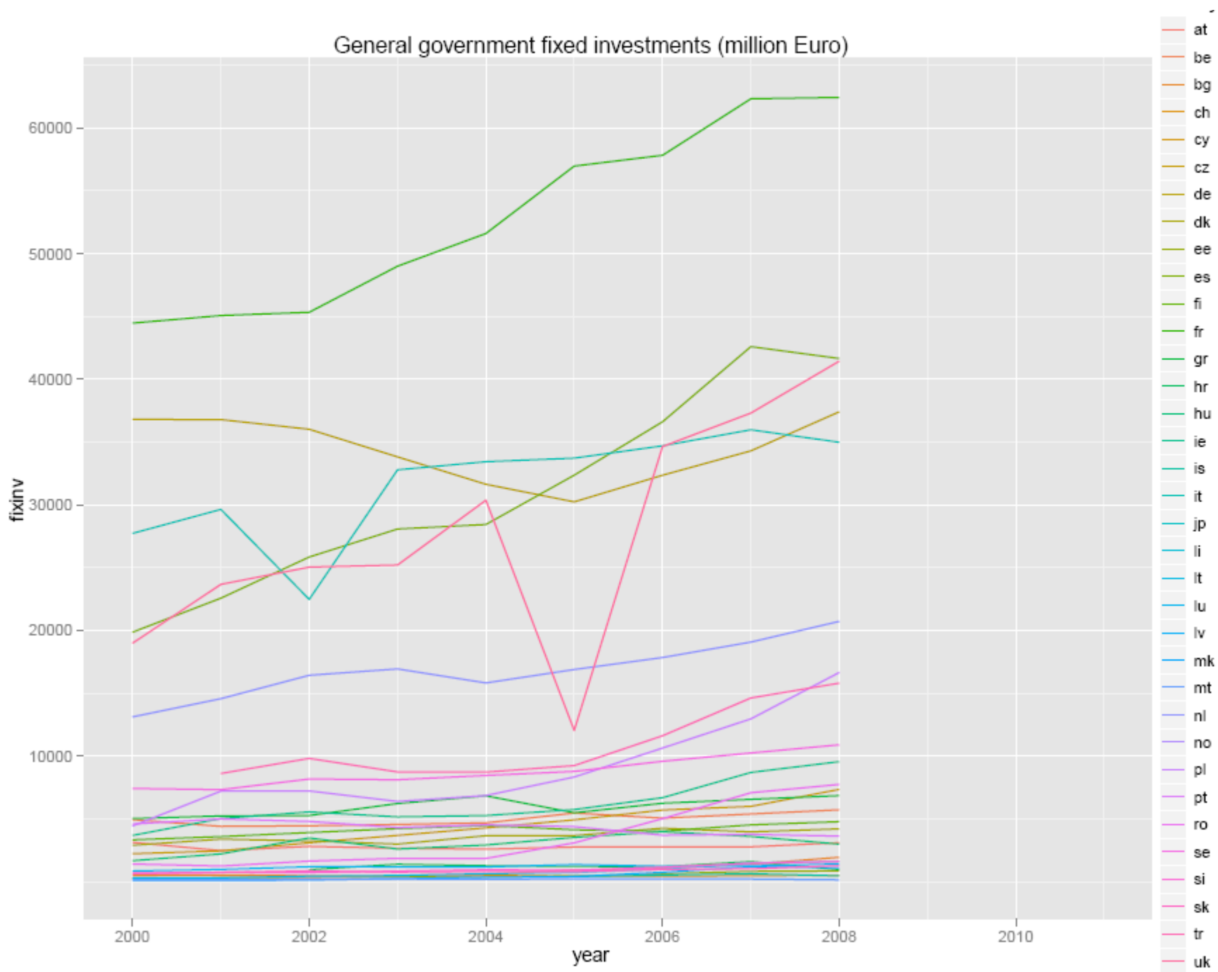

Figure 7-7: Levels of general government fixed investments in million € for selected countries for 2000-2008.

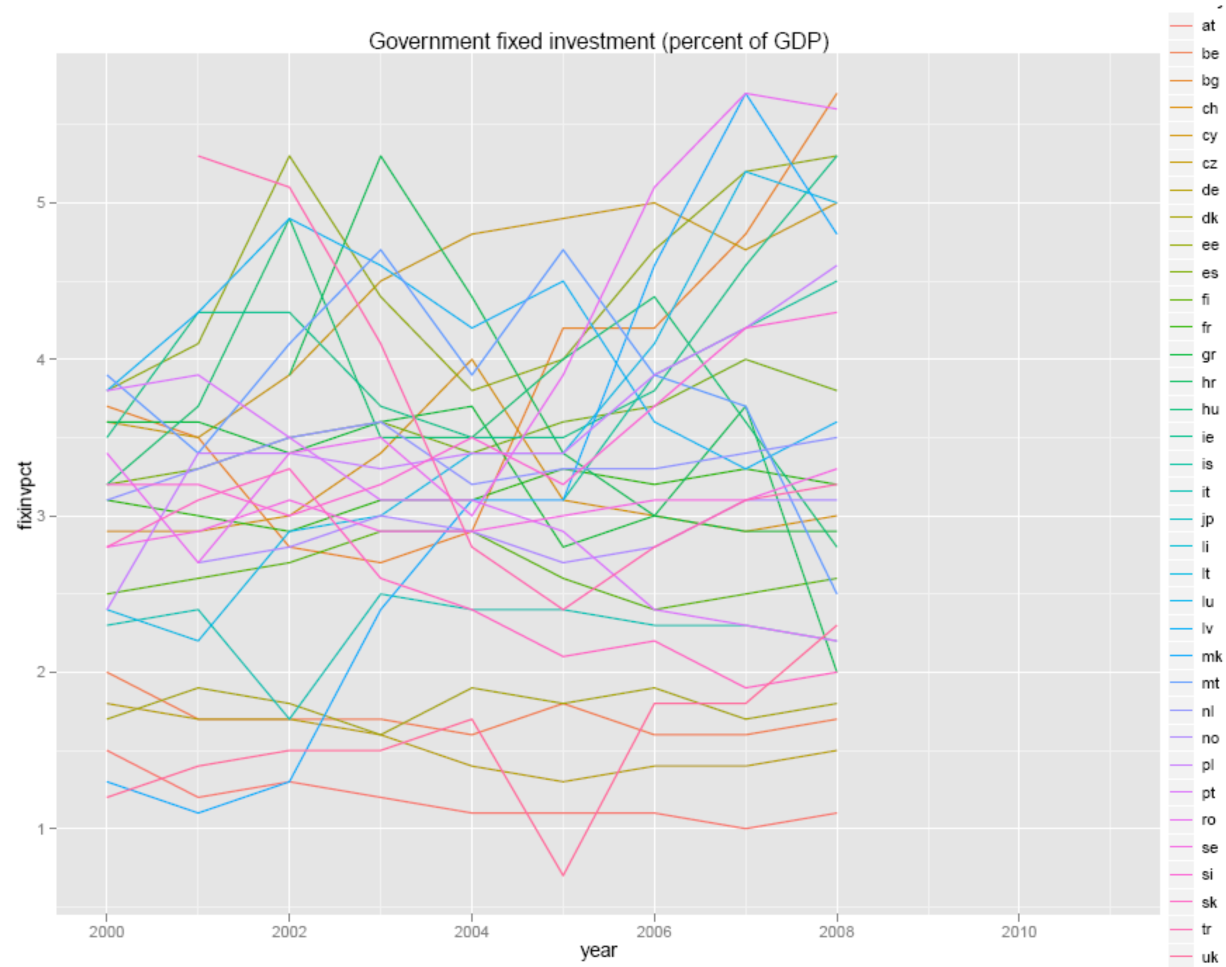

Figure 7-8: Government fixed investment as percent of GDP for selected countries for 2000-2008.

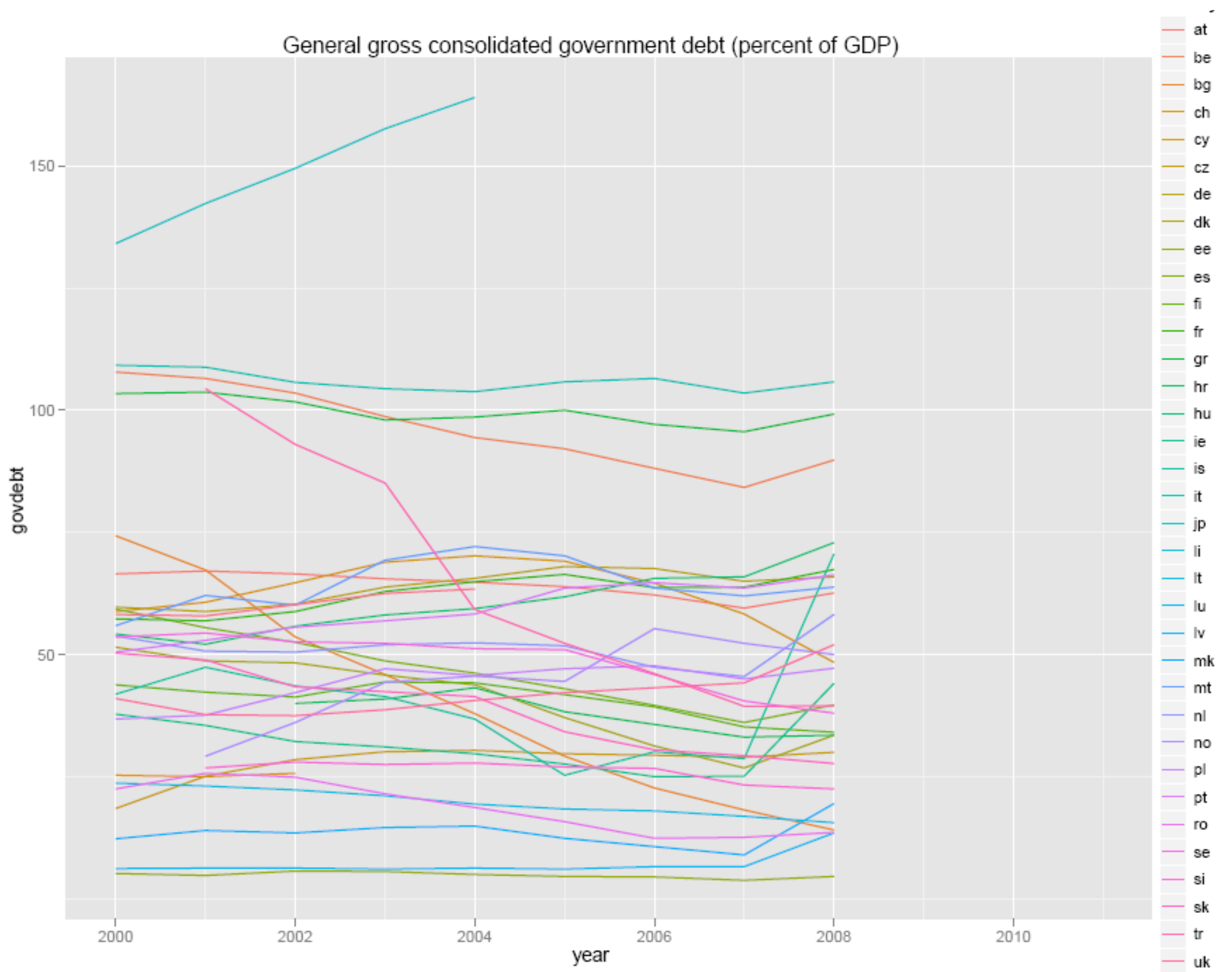

Figure 7-9: Government debt (consolidated) as percent of GDP for selected countries for 2000-2008.

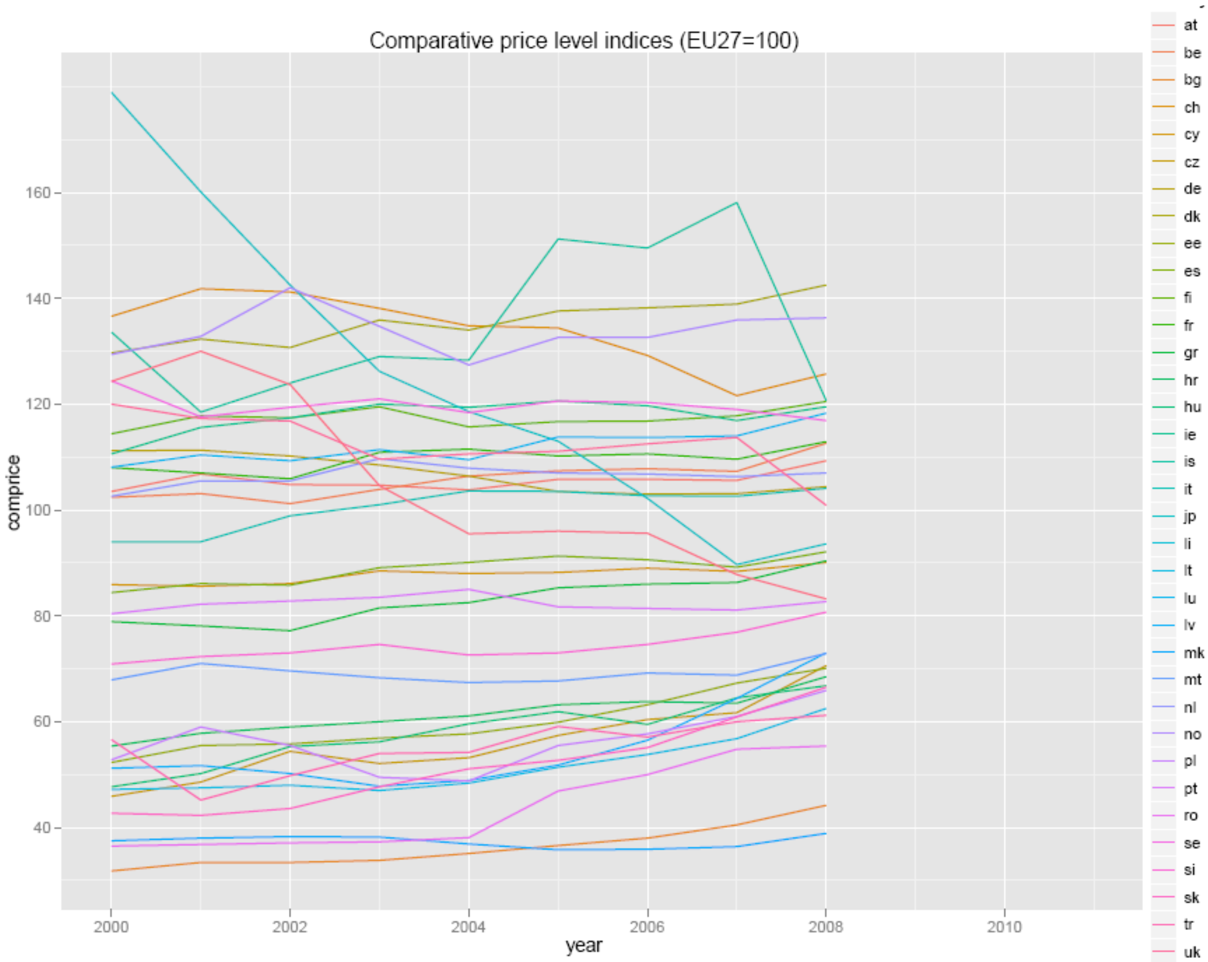

Figure 7-10: Comparative price levels compared to the EU27 index (=100) for selected countries for 2000-2008.

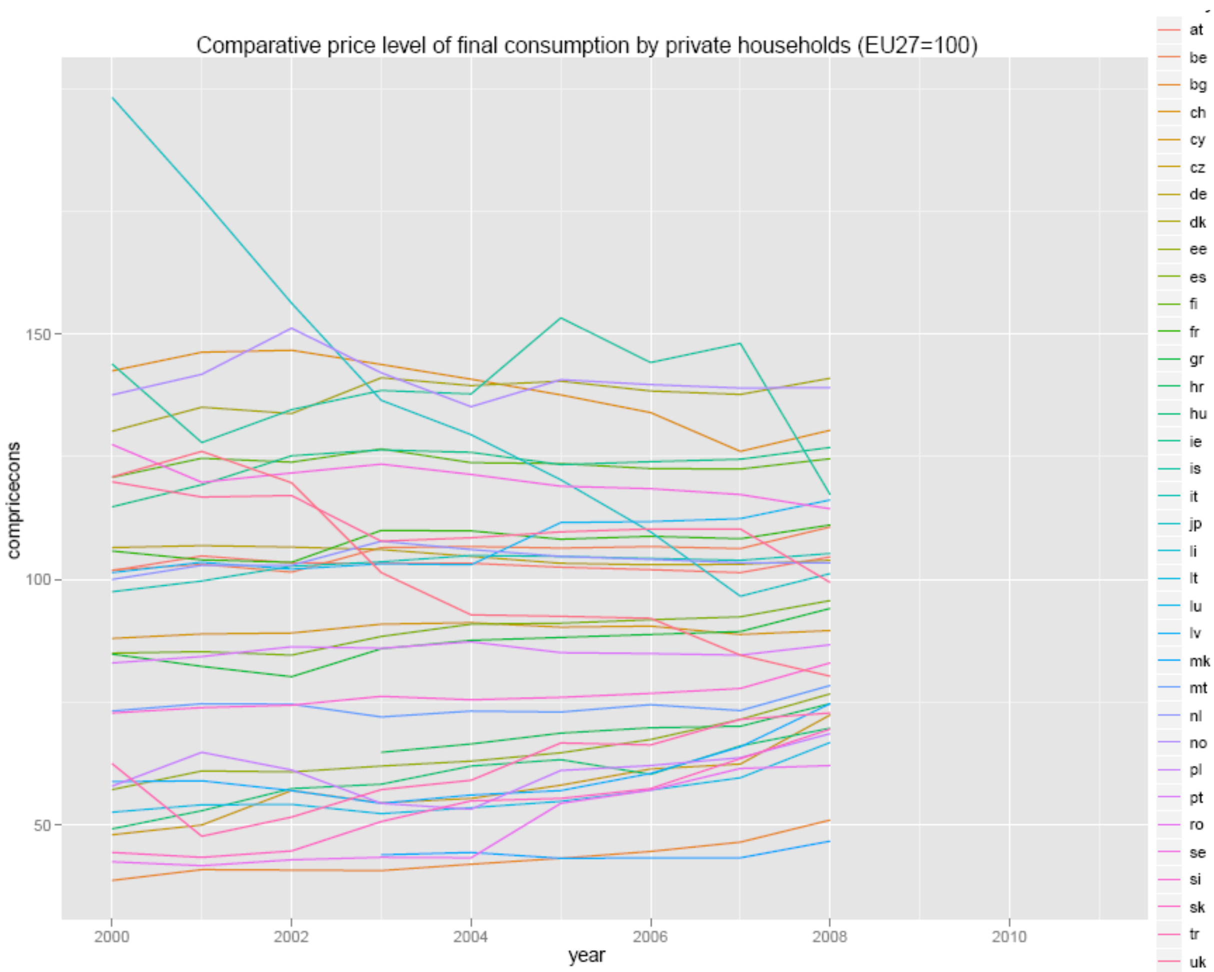

Figure 7-11: Comparative price levels of household final consumption compared to EU27 index (=100) for selected countries for 2000-2008.

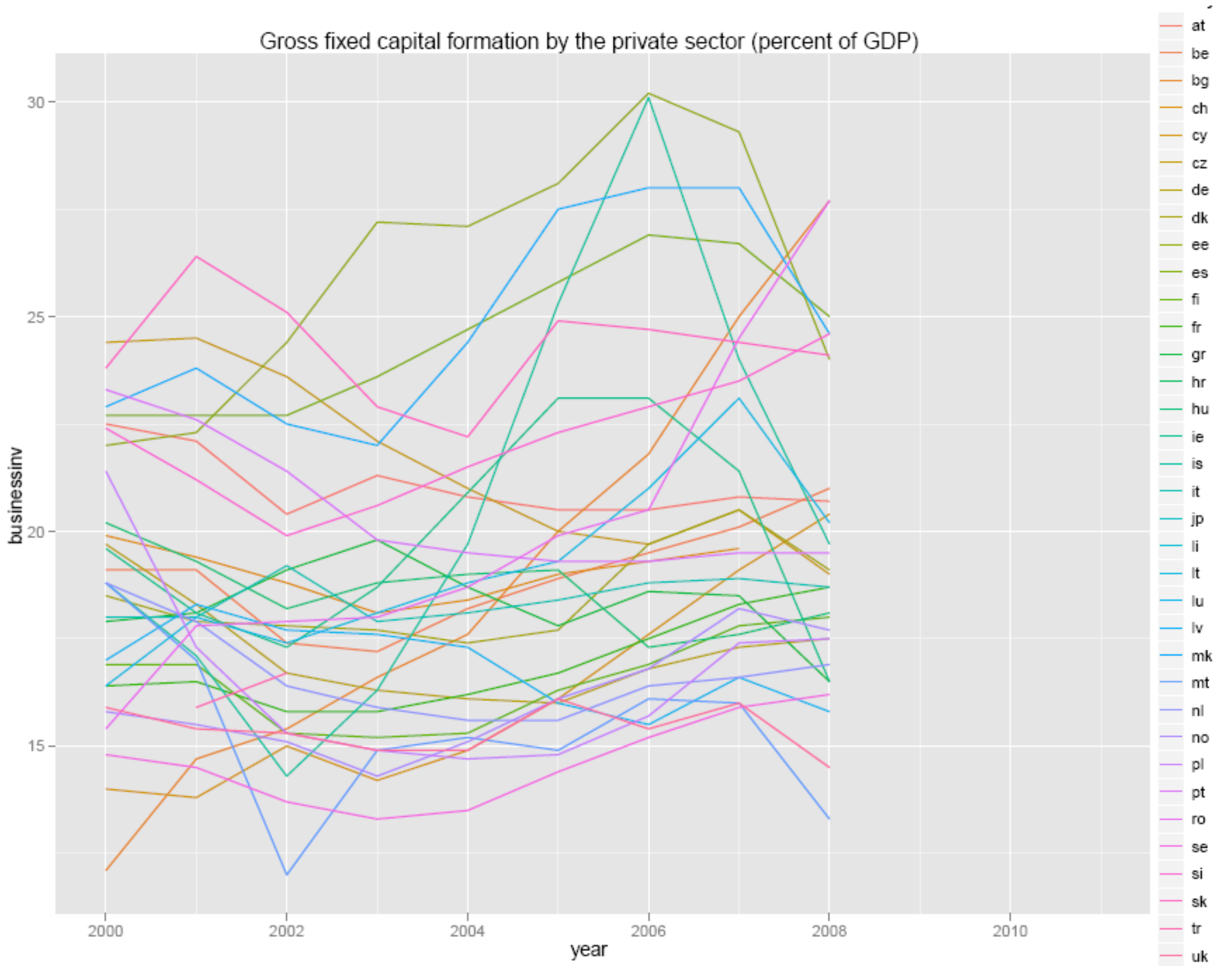

Figure 7-12: Gross fixed capital formation by the private sector as percent of GDP for selected countries for 2000-2008.

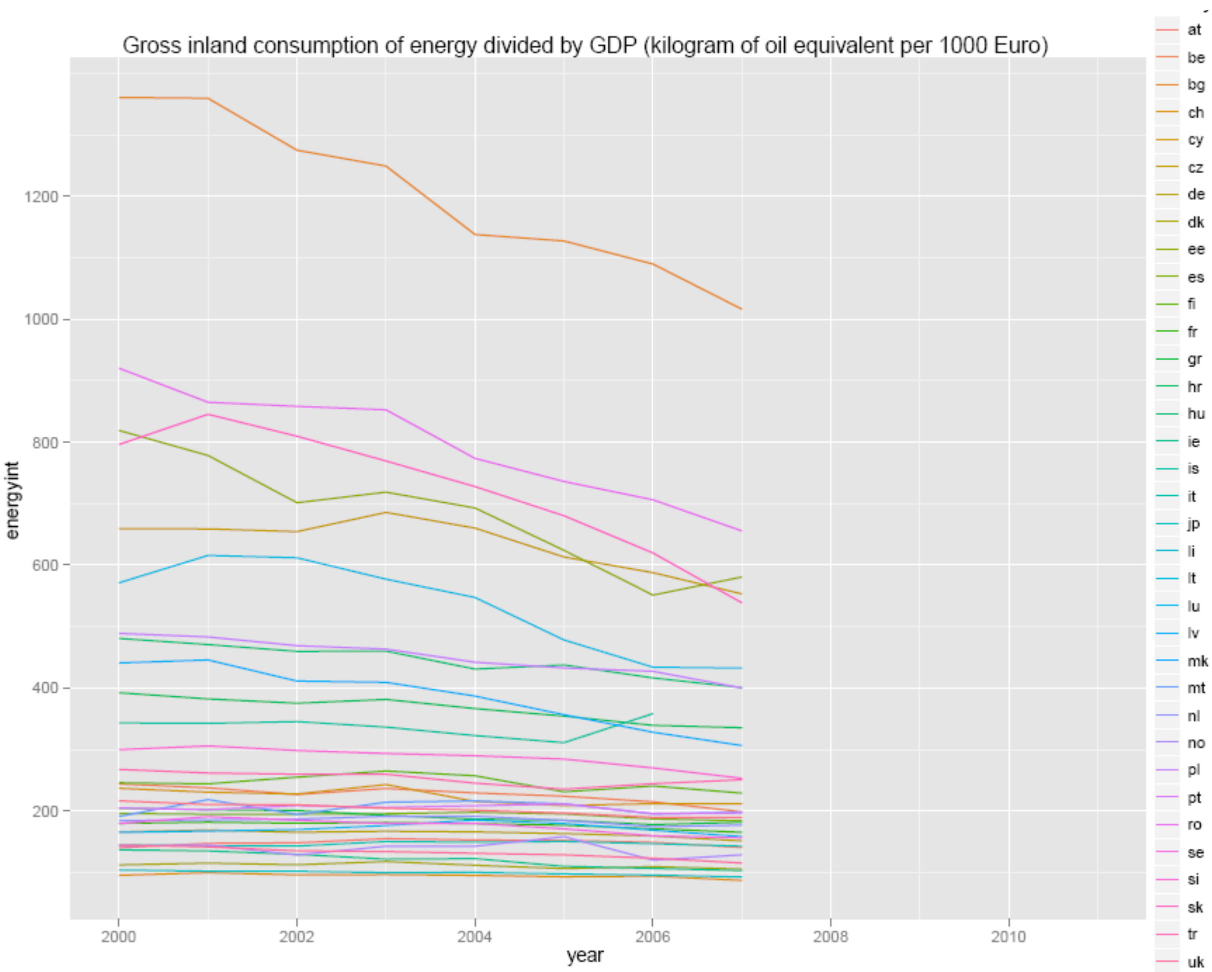

Figure 7-13: Gross inland energy efficiency of the economy measured in kilograms of oil equivalent per 1000€ for selected countries for 2000-2007.

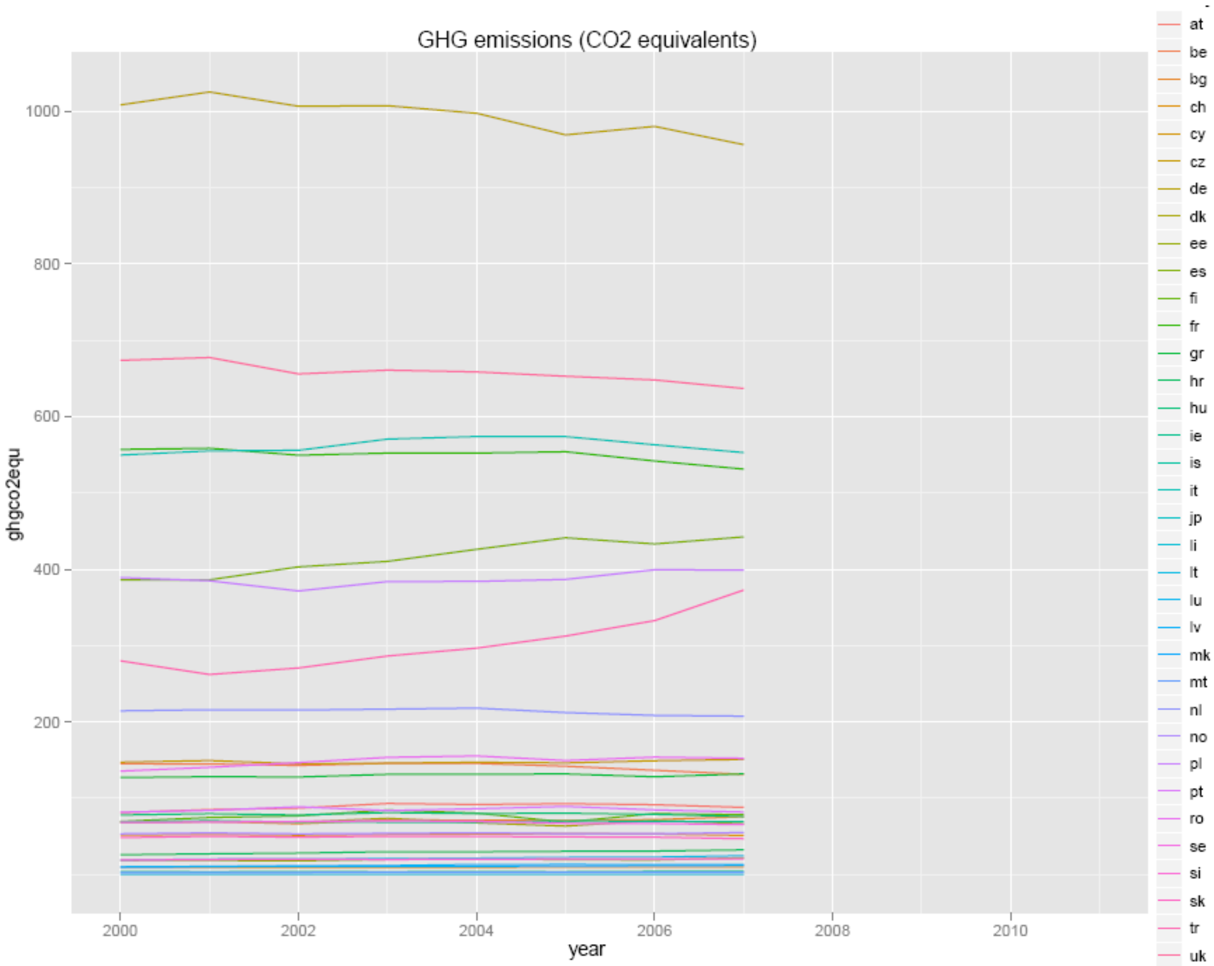

Figure 7-14: Greenhouse gas emissions in gigagrams of CO2 equivalent for selected countries for 2000-2007.

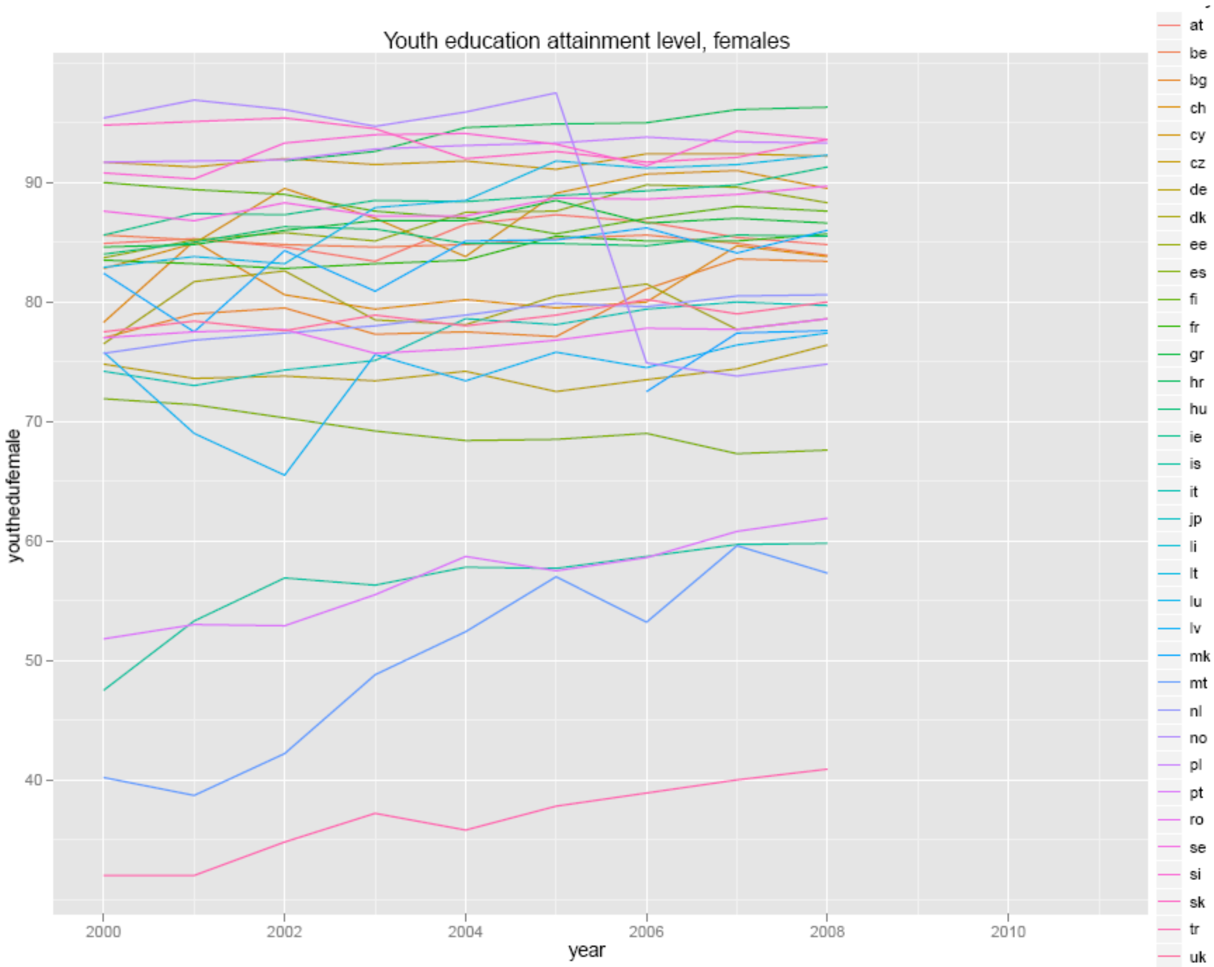

Figure 7-15: Female youth education attainment levels measured as a percentage of the population aged 20 to 24 having completed at least upper secondary education for selected countries for 2000-2008.

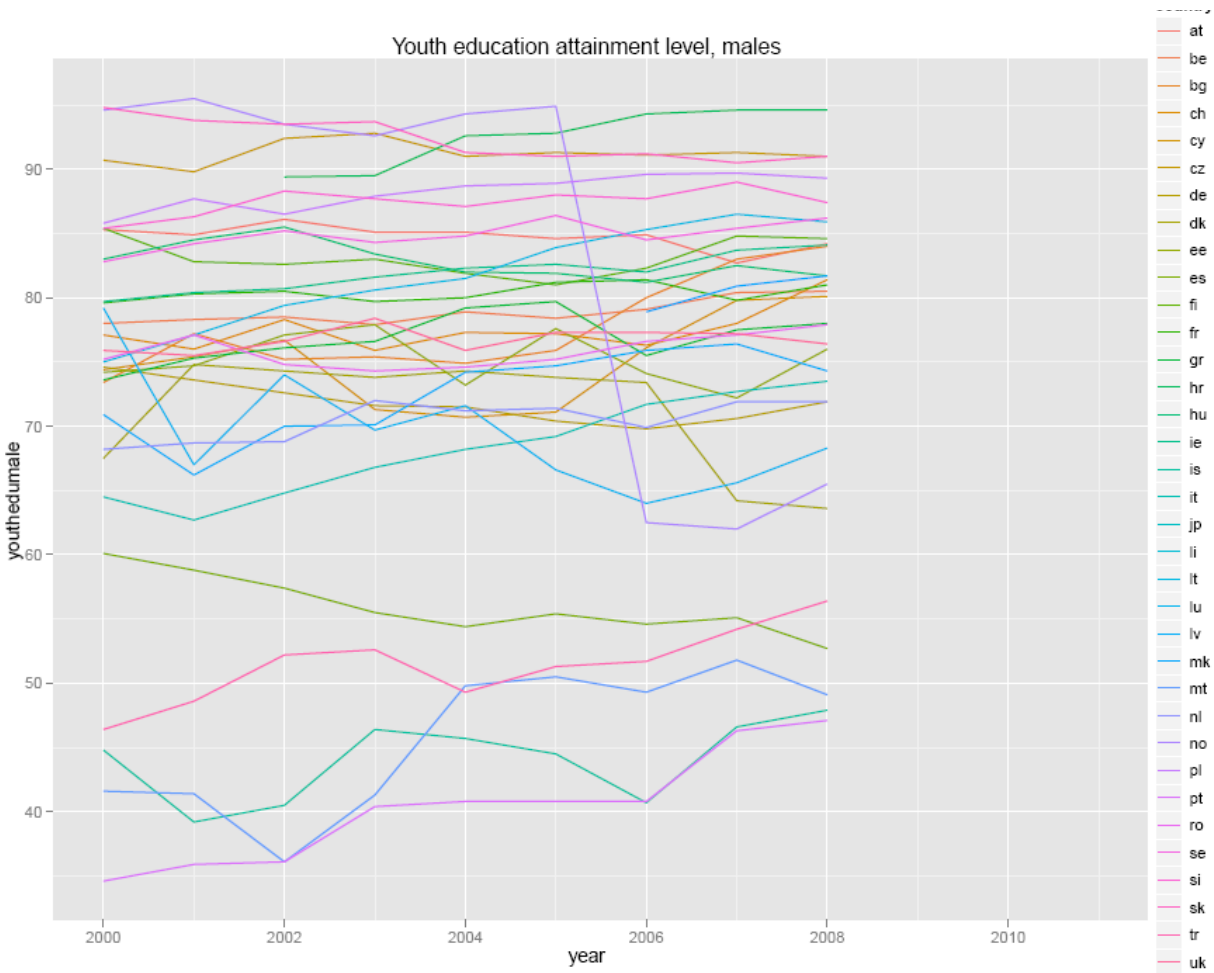

Figure 7-16: Male youth education attainment levels measured as a percentage of the population aged 20 to 24 having completed at least upper secondary education for selected countries for 2000-2008.

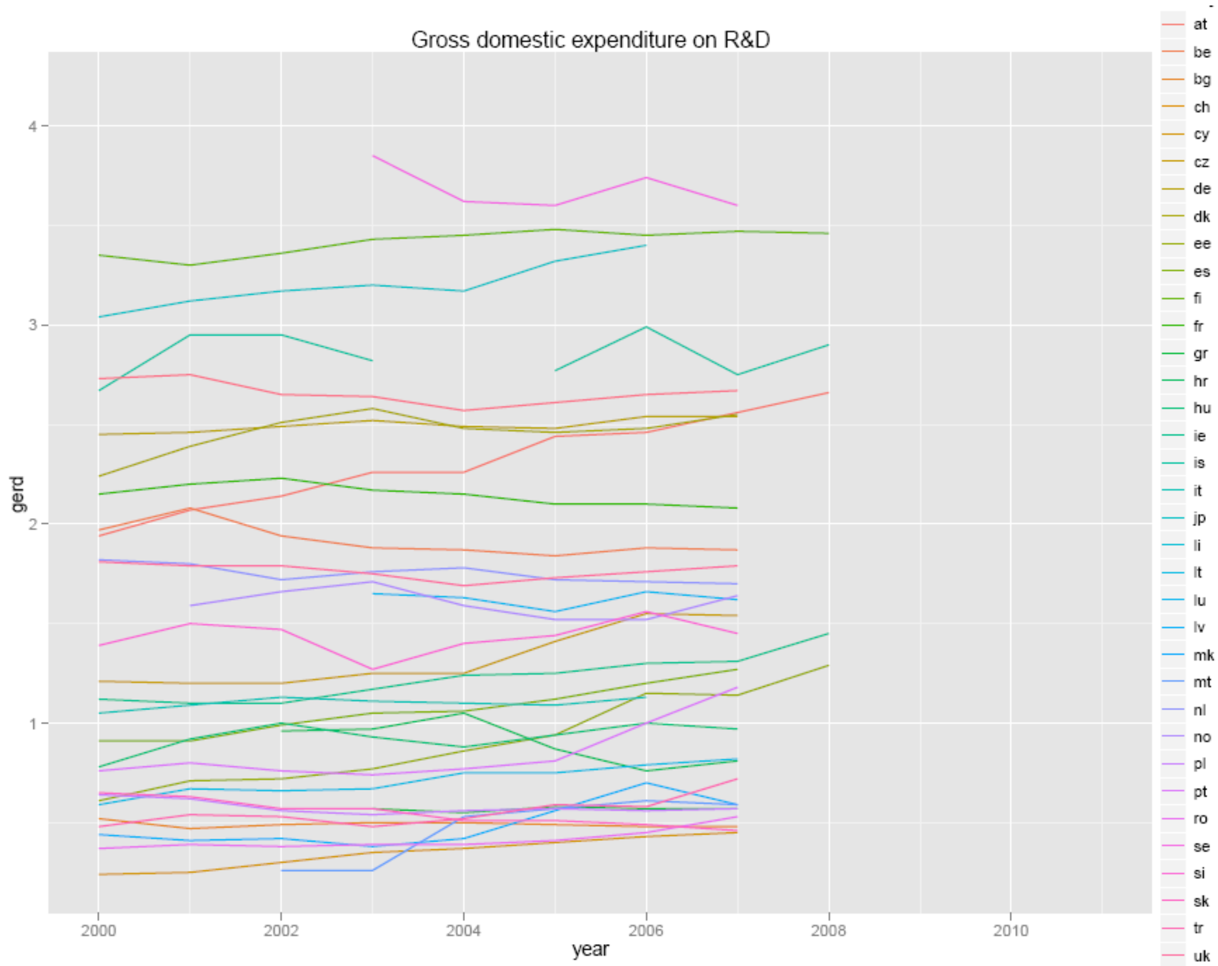

Figure 7-17: Gross domestic expenditure on Research and Development as a percent of GDP for selected countries for 2000-2008.

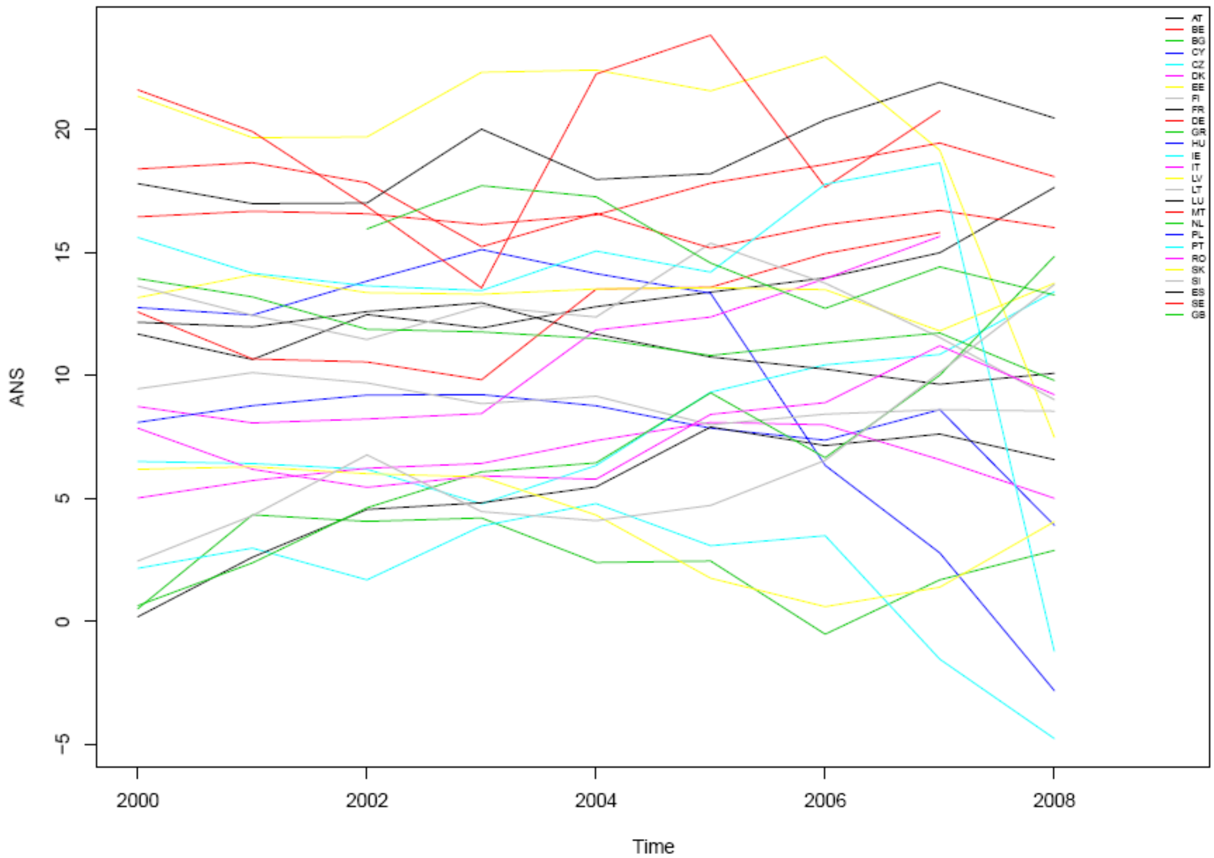

Figure 7-18: Adjusted Net Savings for selected EU countries for 2000-2008.

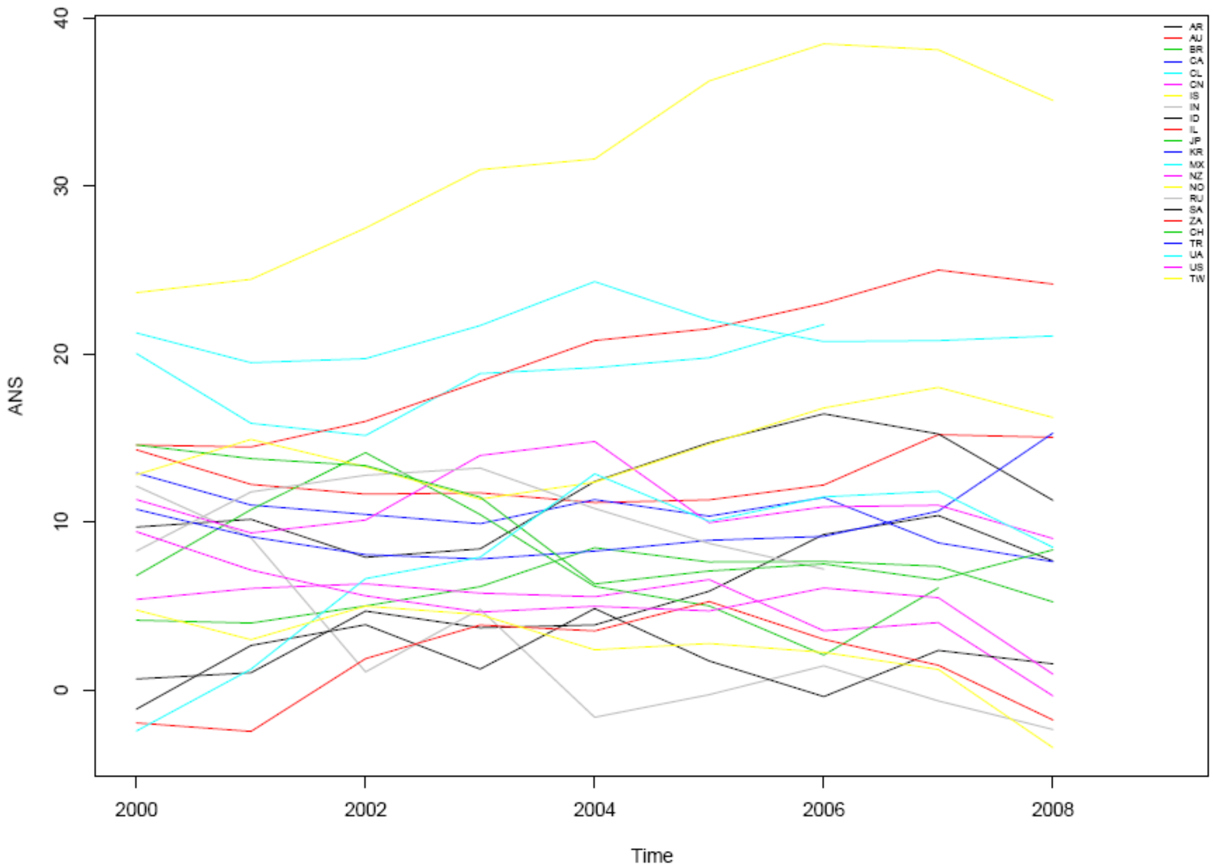

Figure 7-19: Adjusted Net Savings for selected non-EU countries for 2000-2008.

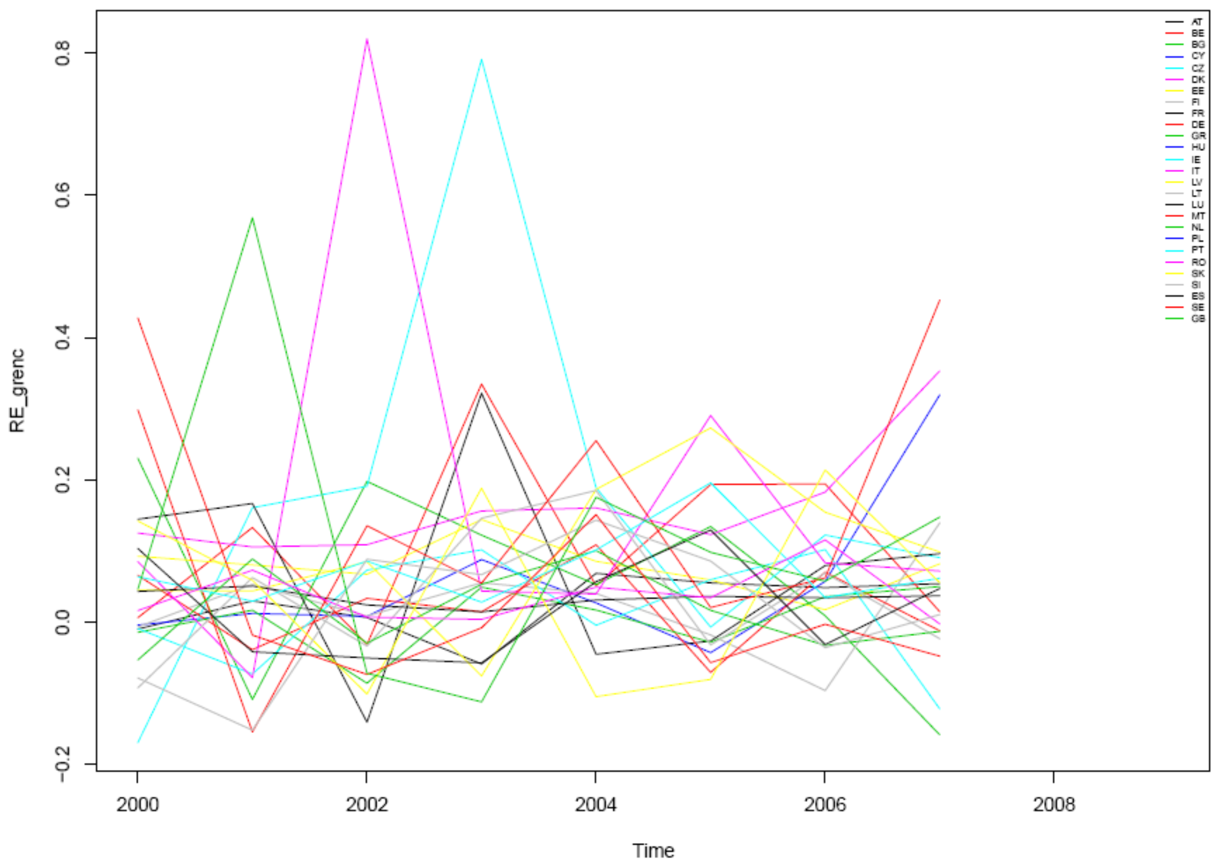

Figure 7-20: Growth in renewable energy capacity for selected EU countries for 2000-2007.

7.4 Cluster Analysis

The following graphics show so-called heat maps, and are an output of the cluster analysis of selected EU and non-EU countries and selected structural indicators. Heat maps are false colour images with dendrograms added to the left side and to the top showing the results of the clustering. The colour shows the strength of the similarity of the units.

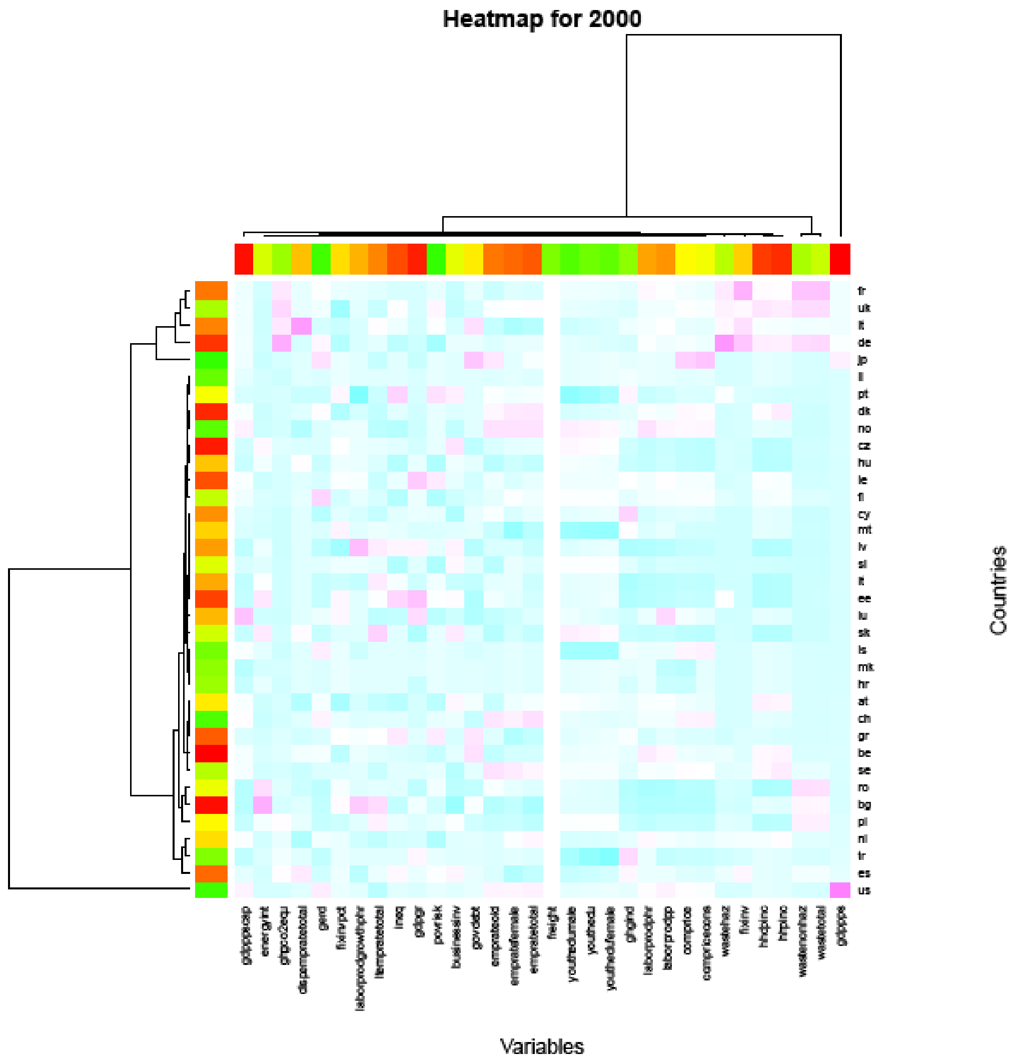

Figure 7-21: Heat map for 2000.

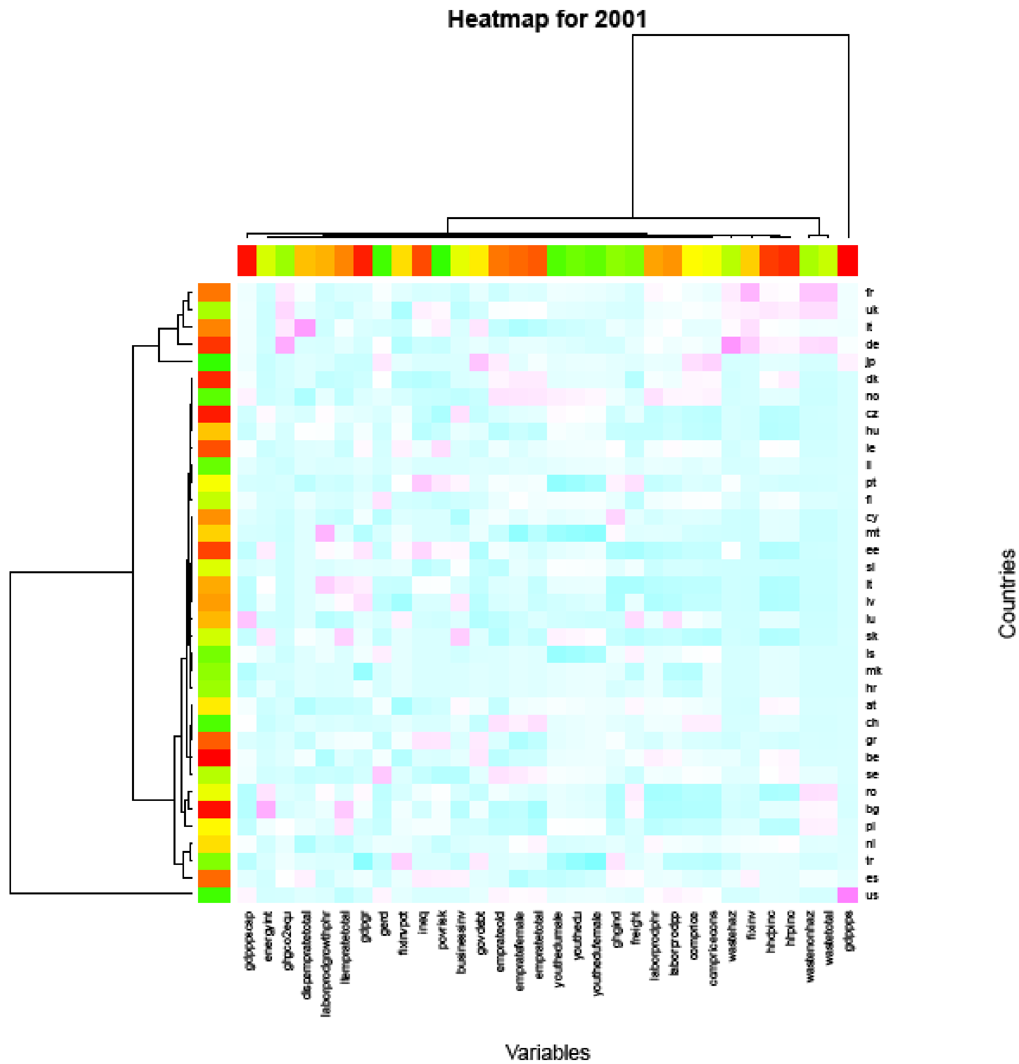

Figure 7-22: Heat map for 2001.

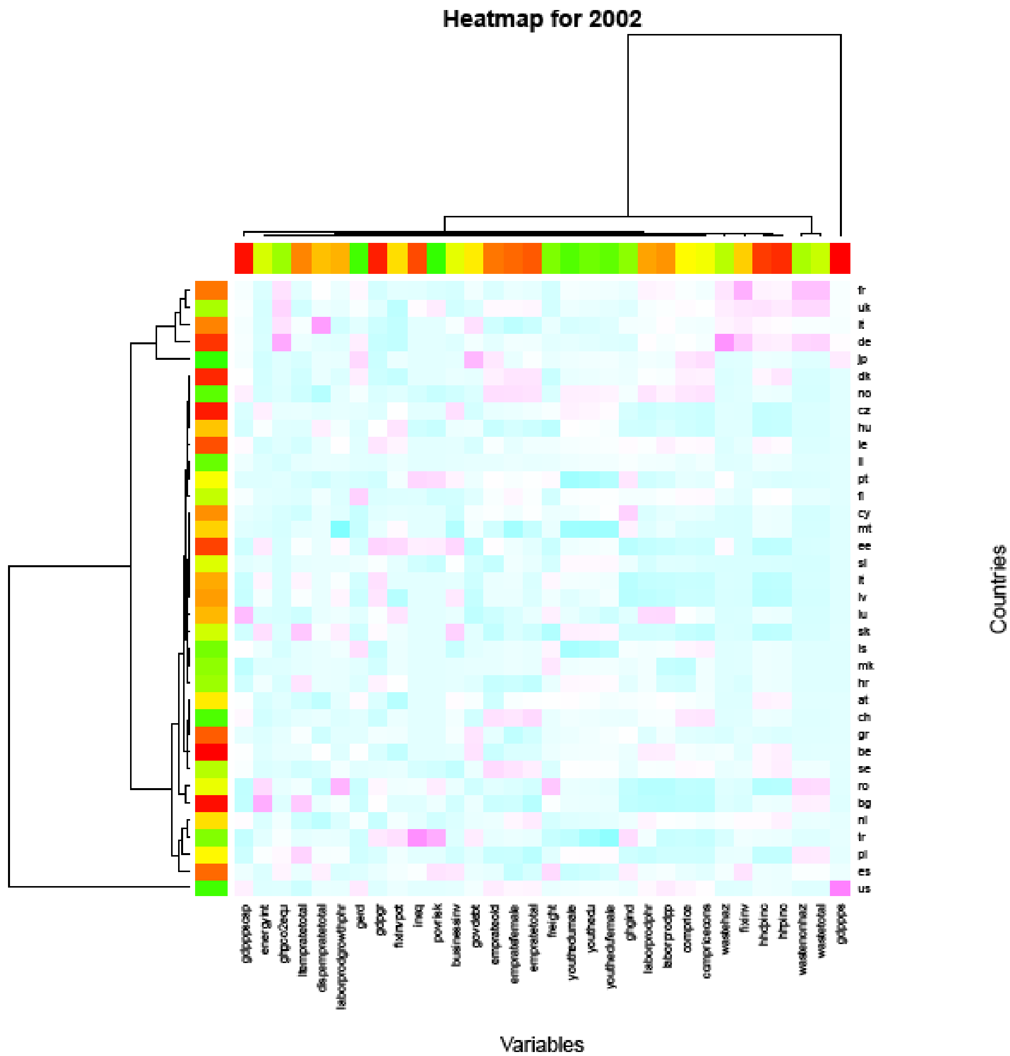

Figure 7-23: Heat map for 2002.

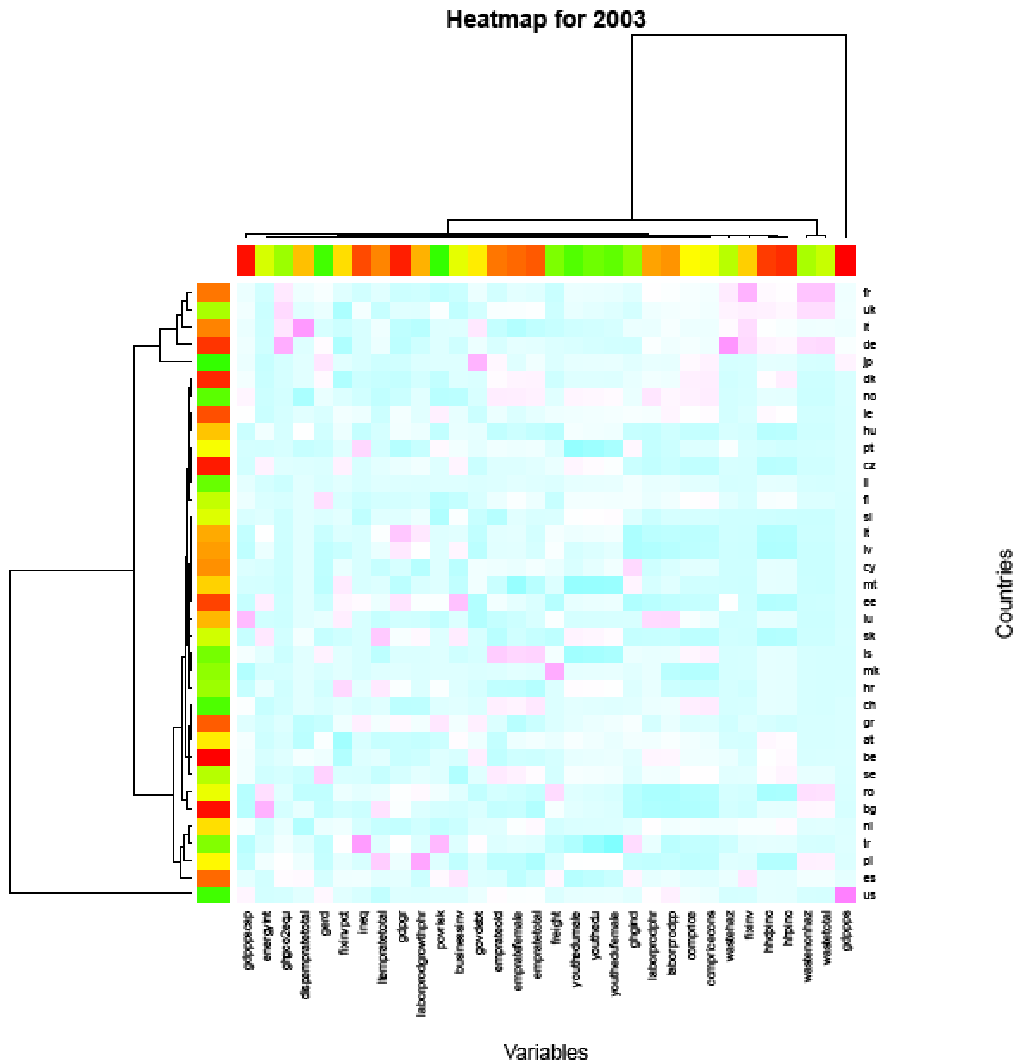

Figure 7-24: Heat map for 2003.

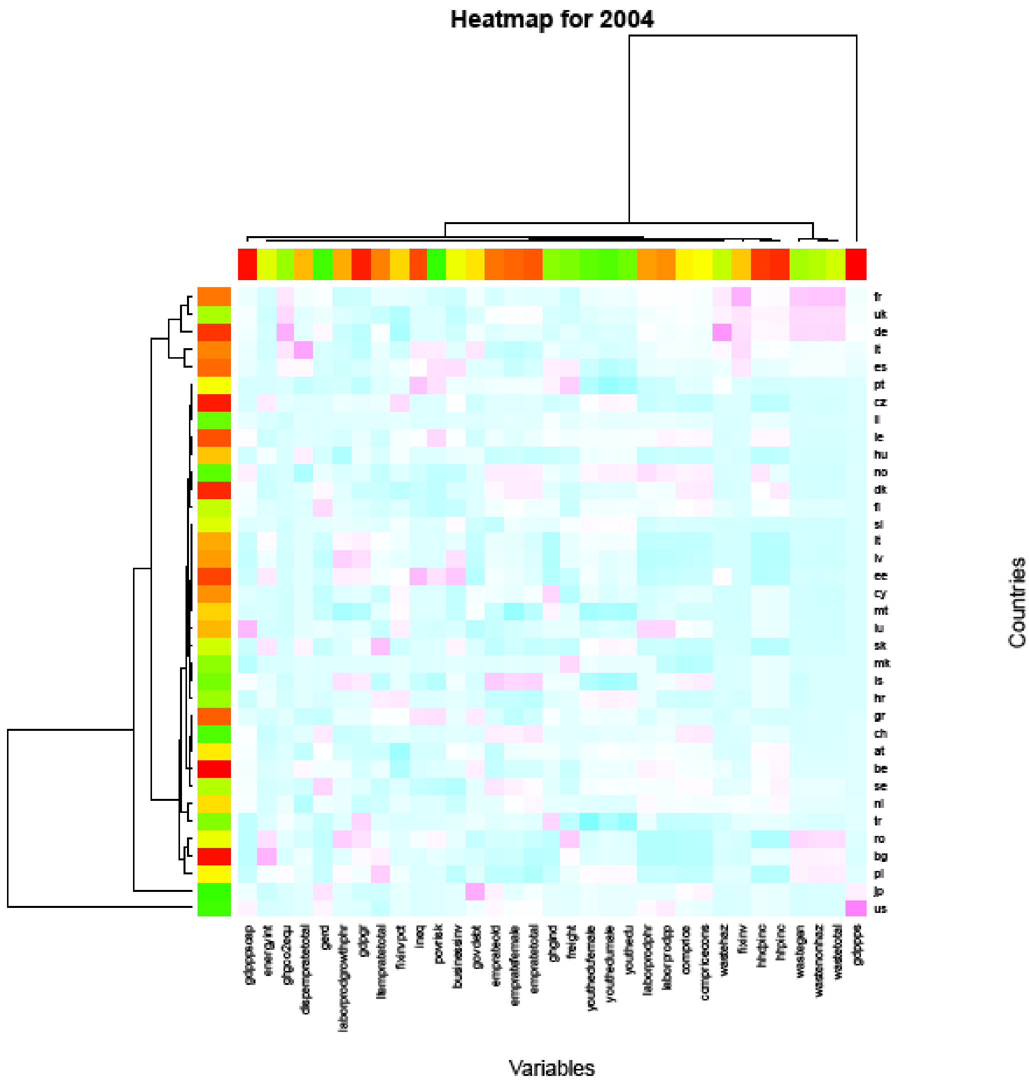

Figure 7-25: Heat map for 2004.

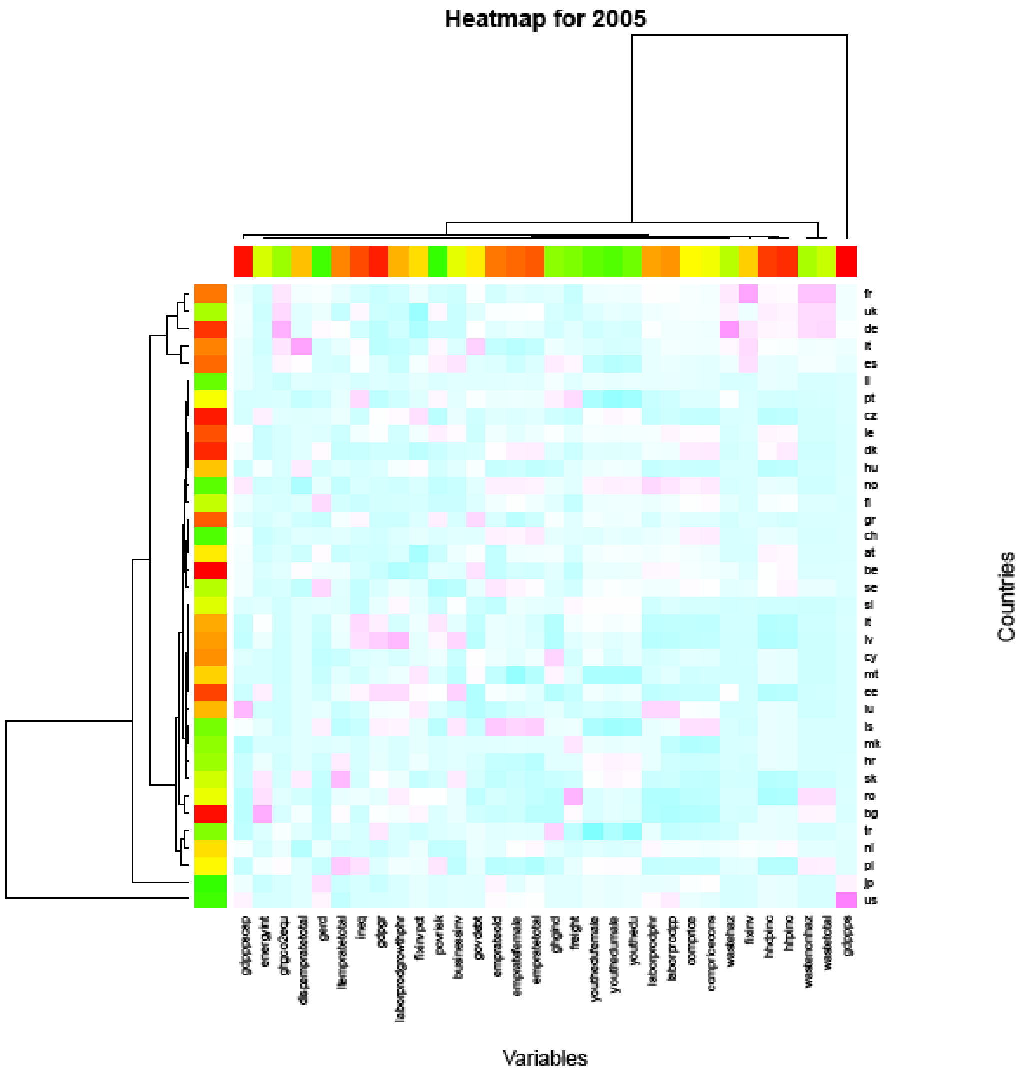

Figure 7-26: Heat map for 2005.

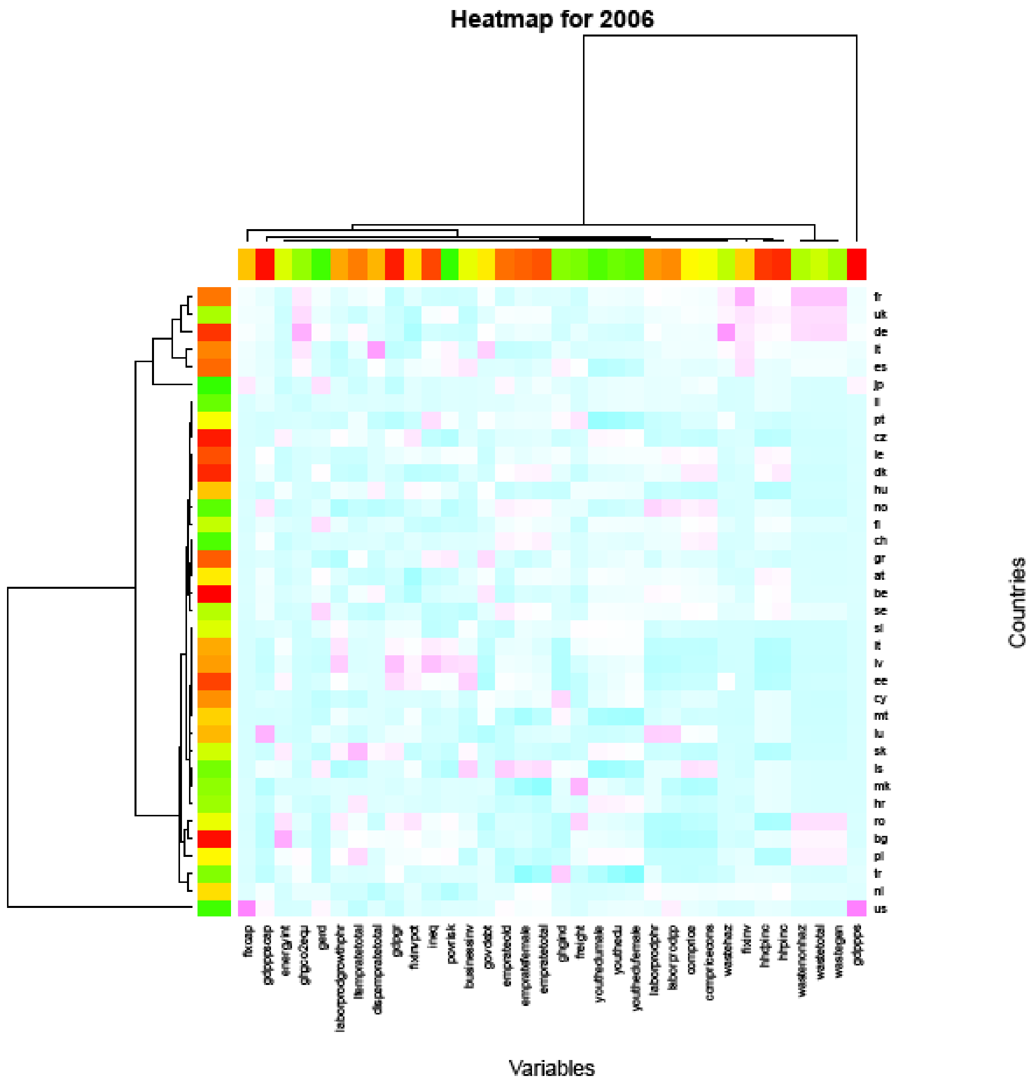

Figure 7-27: Heat map for 2006.

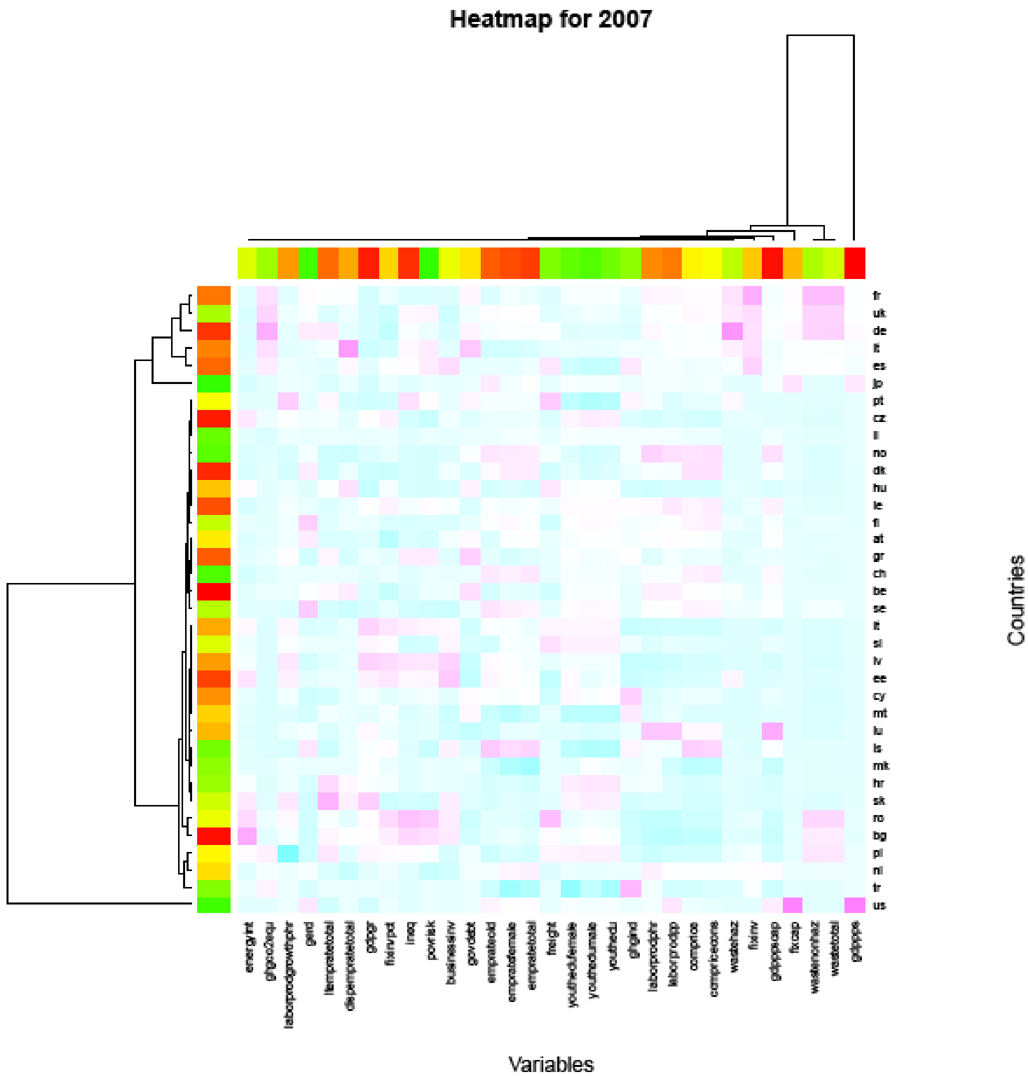

Figure 7-28: Heat map for 2007.

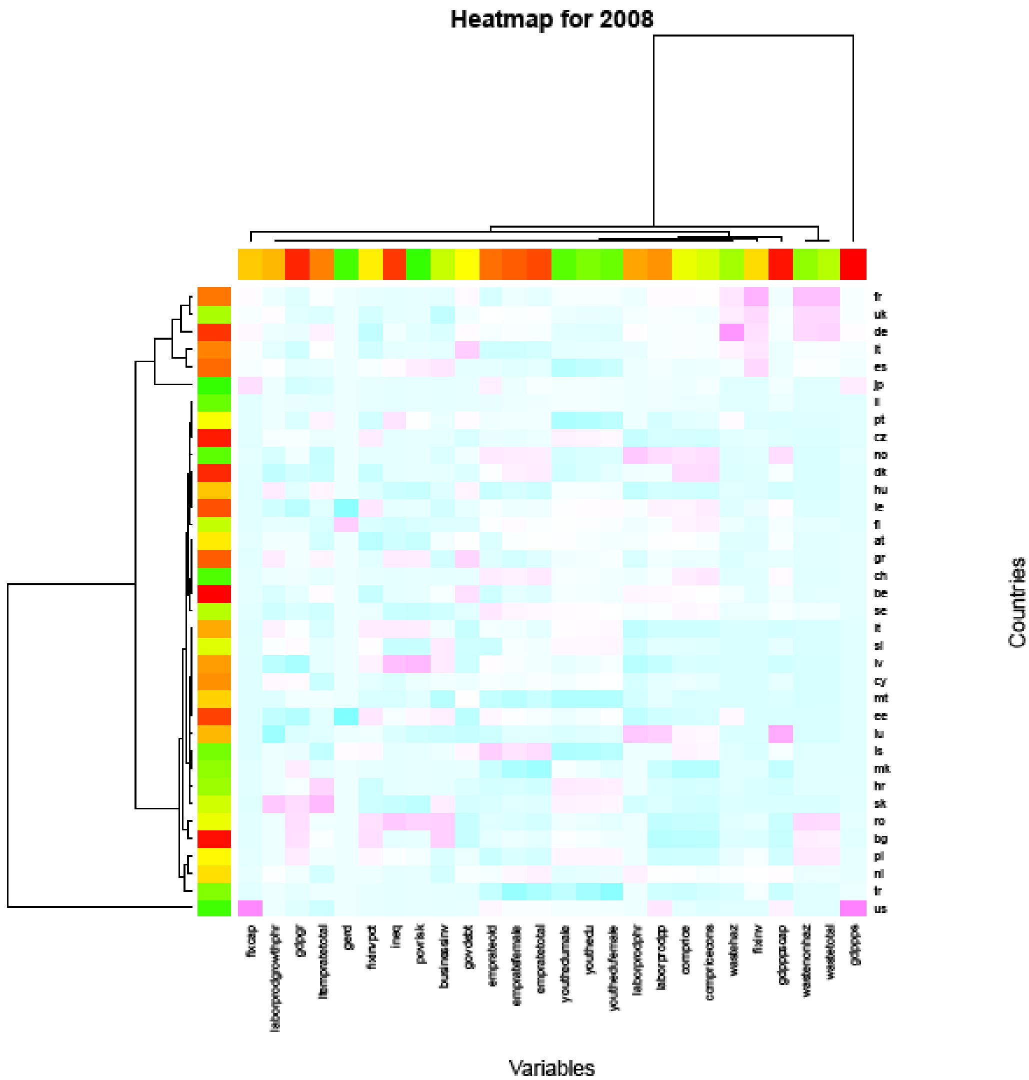

Figure 7-29: Heat map for 2008.

8. Glossary

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

Cluster Analysis:

Cluster analysis, or clustering, is the assignment of a set of observations into subsets (called clusters) so that observations in the same cluster are as similar in some sense as possible and as dissimilar as possible across clusters. Clustering is a method of unsupervised learning, and a common technique for statistical data analysis that is used in many fields, including machine learning, data mining, pattern recognition, image analysis and bioinformatics. Besides the term clustering, there are a number of terms with similar meanings, including automatic classification, numerical taxonomy, botryology and typological analysis. [Source: adjusted from Wikipedia, http://en.wikipedia.org/wiki/Cluster_analysis, (10 December 2010)]

Correlation:

In statistics, correlation and dependence are any of a broad class of statistical relationships between two or more random variables or observed data values. Formally, dependence refers to any situation in which random variables do not satisfy a mathematical condition of probabilistic independence. In general statistical usage, correlation or co-relation can refer to any departure of two or more random variables from independence, but most commonly refers to a more specialized type of relationship between mean values. There are several correlation coefficients, often denoted ρ or r, measuring the degree of correlation. The most common of these is the Pearson correlation coefficient, which is sensitive only to a linear relationship between two variables (which may exist even if one is a nonlinear function of the other). Other correlation coefficients have been developed to be more robust than the Pearson correlation, or more sensitive to nonlinear relationships. [Source: adjusted from Wikipedia, http://en.wikipedia.org/wiki/Correlation_%28statistics%29, (10 December 2010)]

Indicator:

A pointer or index that indicates something; a meter or gauge; the needle or dial on such a meter; (chemistry) any of many substances, such as litmus, used to indicate the concentration of a substance, or the degree of a reaction; (ecology) a plant or animal whose presence is indicative of some specific environment; (economics) a measure, such as unemployment rate, which can be used to predict economic trends [Source: adjusted from Wikipedia, http://en.wiktionary.org/wiki/indicator (10 December 2010)]

Principal Component Analysis:

PCA refers to a mathematical procedure used in statistics, psychometrics, and other fields that transforms a number of possibly correlated variables into a number of uncorrelated variables called principal components, related to the original variables by an orthogonal transformation. This transformation is defined in such a way that the first principal component has as high a variance as possible (that is, accounts for as much of the variability in the data as possible), and each succeeding component in turn has the highest variance possible under the constraint that it be orthogonal to the preceding components. PCA is sensitive to the relative scaling of the original variables. [Source: adjusted from Wikipedia, http://en.wikipedia.org/wiki/Principal_component_analysis, (10 December 2010)]

Purchasing power standard (PPS):

The purchasing power standard, abbreviated as PPS, is an artificial currency unit. Theoretically, one PPS can buy the same amount of goods and services in each country.

Significance:

In statistics, a result is called statistically significant if it is unlikely to have occurred by chance. The phrase ‘test of significance’ was coined by Ronald Fisher. As used in statistics, significant does not mean important or meaningful, as it does in everyday speech. The amount of evidence required to accept that an event is unlikely to have arisen by chance is known as the significance level or critical p-value: in traditional Fisherian statistical hypothesis testing, the p-value is the probability of observing data at least as extreme as that observed, given that the null hypothesis is true. If the obtained p-value is small then it can be said either the null hypothesis is false or an unusual event has occurred. It is worth stressing that p-values do not have any repeat sampling interpretation. An alternative statistical hypothesis testing framework is the Neyman–Pearson frequentist school which requires both a null and an alternative hypothesis to be defined and investigates the repeat sampling properties of the procedure, i.e. the probability that a decision to reject the null hypothesis will be made when it is in fact true and should not have been rejected (this is called a "false positive" or Type I error) and the probability that a decision will be made to accept the null hypothesis when it is in fact false (Type II error). More typically, the significance level of a test is such that the probability of mistakenly rejecting the null hypothesis is no more than the stated probability. This allows the test to be performed using non-significant statistics, which has the advantage of reducing the computational burden while wasting some information. It is worth stressing that Fisherian p-values are philosophically different from Neyman–Pearson Type I errors. This confusion is unfortunately propagated by many statistics textbooks. [Source: adjusted from Wikipedia, http://en.wikipedia.org/wiki/Significance_%28statistics%29, (10 December 2010)]

Time series:

A time series is a sequence of data points, measured typically at successive times spaced at uniform time intervals. [Source: adjusted from Wikipedian, http://en.wikipedia.org/wiki/Time_series, (10 December 2010).