International household emissions: Identifying the necessary and the needless

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1. Introduction – the importance of the demand-side perspective

Supply-side solutions to greenhouse gas (GHG) emission reduction are central to achieving a stabilisation in the levels of carbon dioxide and other greenhouse gases at levels that are likely to avert catastrophic rates of climate change. Increasingly however, there are a growing number of indications that supply side measures, such as technological innovation and shifts in the sectoral makeup of our economies, may not be able to deliver the rapid transformation of the world's economy that is required.

At the macro level, the plausibility of supply side measures being able to achieve sufficient levels of emissions reductions can be assessed using the IPAT framework developed by Paul Ehrlich and others in the 1970s (Ehrlich, P; J. Holden. 1971). Victor (2011) presents a straight forwards application of this framework to calculate a table of the rates of reduction in the carbon intensity of economic activity required to achieve various levels of reduction in GHG emissions after a 40 year period given certain rates of economic growth. *Table1*, below, presents a simple adaptation of this in which carbon emissions are substituted in place of GHGs.

		Rate of economic growth					
		– 1%	**0%**	**1%**	**2%**	**3%**	**4%**
Emissions reduction after 40 years	**50%**	0.73%	1.75%	2.77%	3.78%	4.80%	5.82%
	60%	1.29%	2.32%	3.34%	4.36%	5.39%	6.41%
	70%	2.03%	3.06%	4.09%	5.12%	6.15%	7.18%
	80%	3.06%	4.11%	5.15%	6.19%	7.23%	8.27%
	90%	4.87%	5.93%	6.98%	8.04%	9.10%	10.16%

Table1: The rates of decoupling of GDP and emissions required to achieve different levels of emissions reductions in economies growing at different rates

In order to stabilise CO_2 concentrations at about 450ppm by 2050, it is estimated by Jackson (2009) that global emissions would have to decline by 50% by 2050, with reduction requirements in industrialized countries reaching as high as 80%. From table 1, it can be seen that growth rate of 3% requires reduction in GHG intensity by 4.8% per year in order to achieve a 50% reduction in carbon emissions in 40 years' time.

By contrast, the rate of reduction of carbon intensity achieved throughout the 1990-2010 period was roughly, and fairly consistently, a more modest figure of 1.5% per year[1]. If this rate of reduction in carbon intensity is to be used as a guide for the coming decades, then it becomes clear that demand-side measures need be considered in order to achieve adequate an reductions in emissions by 2050.

[1] Based on the average annual reduction in global GHG intensity of global economy presented by the CAIT Climate Data Explorer (https://sites.google.com/site/climateanalysisindicatorstool/cait-international-8-0/ghg-intensity-of-economy-1)

While stepping away from the imperative of economic growth may be a necessary step in climate change mitigation, this the same in not necessarily true for continuing progress towards international development goals. Where many GHG emissions scenarios take economic growth projections as a basis for their calculation, the aim of this research is to instead consider the future emissions pathways necessary for providing the material requirements for universal human wellbeing.

Through combining data on consumer expenditure patterns with emissions data from environmentally extended input-output analysis, the research project aims to build a quantitative model capable of producing a comparison between household economic inequality and the resulting emissions inequality.

These comparisons are similar to those considered in recent publications from Piketty and Chancel (2015), which combines data on historical trends in per capita country-level CO2e emissions, consumption-based CO2e emissions data, within-country income inequality and a simple income-CO2e elasticity model; showing how global emissions inequalities had risen in throughout the 1998-2013 period. It is intended that this research build upon the success of this work by using more a detailed array of elasticity values that take into account how elasticity values vary by product.

Section 2 of this document describes work that has been completed so far in the analysis of consumer expenditure survey data and section 3 covers the usage of EEIO analysis that is intended to be used in the analysis. Section 4 of the document describes plans for how outputs of the model will be applied to find relevant conclusions for policy makers.

2. Diamonds and Water – the wellbeing impact of goods

The paradox of water and diamonds, also referred to as the paradox of value, examines the contradiction of how some of the goods with the greatest utility to mankind are frequency valued at just a fraction of the price as some of those with the least practical purpose (Smith, 1776; Blaug, 1962). The wellbeing implications of a product in the life of a person are not well described by their market value and this creates a challenge when designing policies that look at the demand side issues that influence our economies.

In the context of climate change, the implementation of policies that either reduces or stymies the growth in demand for emissions intensive products is a common feature within both national and international markets, examples include fuel taxes and emissions trading schemes. The impact of an increasing the cost of a good on its demand can be assessed using an estimate of that good’s price elasticity of demand.

Taking this assessment alone however provides no assessment of the redistributive impacts of the policy. This can be taken into account by looking at the income elasticity of demand for each good. Policies that change the prices of goods will, inevitably have implications on inequality within a country. For example, a policy that charges an environmental levy on air travel will have a greater financial impact on the higher income groups of a society as they are likely to direct a greater proportion of their expenditure towards this kind of product. A policy that levies a flat price onto domestic energy bills will, vis-à-vis, have a greater impact on lower income groups, for the same reasons.

Goods which have low income elasticities of demand, such as food and public transportation, make up larger proportions of expenditure in lower income groups. These products are the 'water' of an economy as opposed to the 'diamonds' which have high elasticities. By acting under the assumption that goods are purchased by an individual in an order or margin utility, looking at the values of the income elasticity of demand can provide insight into the wellbeing implications of each product.

This research uses consumer expenditure surveys (CES) as a basis for estimating the distribution of the consumption of goods between annual income-level groups within a population. CES are typically performed at a national level and there is no standard format which unites the surveys between different countries. In order for the surveys to be compared, the data first must be harmonised to correct for methodological differences between surveys. Within the EU, CES that have been undertaken by individual countries have been harmonised by EUROSTAT into a single database[2].

The database currently contains entries for five years between 1988 and 2010, covering up to 32 countries within the EU. A total of 47 consumption categories are available for national datasets, each containing details of expenditure patterns for each income quintile within each country. Expenditures are presented not in absolute terms in the dataset and are instead given as parts per 1000 units of annual individual/household expenditure. The absolute values of per capita/household expenditure can be calculated by multiplying the data by values for annual average per capita/household income quintiles provided in a separate EUROSTAT dataset.

Figure 1 displays elasticity values of each consumption category and country available within the dataset for the year 2010. The majority of consumption categories show a large range of elasticity values. Exceptions to this trend are typically seen in goods that have elasticity values that are close to one. *Figure 2* displays a simplified candle plot showing the full and interquartile range of the of the data presented in *Figure 1*; consumption categories including food (CP011) and Electricity, Gas and Other Fuels (CP045) have elasticity values that are consistently near to unity.

The majority of consumption categories, particularly those with higher median elasticity values, have large range and inter-quartile ranges. There are a number of possible explanations for why these differences may exist include different levels of state provision of certain services such as health and education and different levels of income inequality within the countries themselves. Another reason for the large ranges of results may be due to the different methodologies used to perform the surveys by each country.

Figure 3 displays a comparison of EUROSTAT CES data for the UK in 2005 and 2010 with equivalent CES data collected by the UK's Office of National Statistics (ONS). The categories plotted on this chart (known as divisions) are aggregations of the categories plotted in figures 1 and 2 (known as levels). This chart allows an examination of the outcomes of the harmonisation process performed by

[2] http://ec.europa.eu/eurostat/web/products-datasets/-/hbs_exp_t133

EUROSTAT on the UK's data. Over the 10 of the 12 divisions, ONS values are a clear match to with those provided by EUROSTAT. The most notable differences in the data sets can be seen in the 2005 data for housing, electricity, water and gas (CP03).

CES data is available from the national statistical offices of many countries in addition to those within EU, such as datasets available from the US and Australian Bureau of National Statistics. The process of harmonising data from each of these statistical offices will require individual attention to the kinds of expenditures covered in each category in addition to harmonising currency values and demographic groups. To expand the analysis to cover countries for which CES data is not available within a format compatible with those seen in the EUROSTAT CES data, it may be possible to generate synthetic datasets based on information from other expenditure surveys such as those held by the world bank[3].

3. Matching expenditure to emissions

In order to link the trends in expenditure seen in the CES data with climate mitigation policy, it is necessary to be able to estimate the amount of emissions that are occur as a result of an amount of expenditure on any particular product category within the CES dataset. For some products, such as fuels that are used in homes or in private transportation, emissions associated with the consumption of the product occur directly from the households themselves. These emissions, which are typically referred to as 'direct emissions', can be calculated by dividing the expenditure on those products by the price per physical unit of that good and then multiplying by the emissions factor of the fuel in question.

Direct emissions make up only a fraction of emissions that occur as a result of the expenditure of a typical household. In order to capture the full level of environmental impact of a household's annual purchases, it is also necessary to consider the indirect emissions. These include emissions occur during the production process of any goods purchased by the household. In the case of household expenditure on gas for domestic heating, the direct emissions would cover the quantity of GHG gases release when the fuel was burnt in the house, while indirect emission would cover the emissions that had occurred when the natural gas was extracted, processed, transported and otherwise prepared before it reached the household.

One method for calculating the indirect emissions of products would be to use Life Cycle Analysis (LCA). This technique can estimate the emissions that occur throughout the supply chain of a specific product and delivers precise information and detailed information on the environmental impacts of products. The main limitation of LCA is the amount of data and resources are required to apply the technique. For this reason, LCA is better suited to studies performed at the individual or similar scales.

A second possible method for estimating indirect emissions is the application of Environmentally Extended Multi-Regional Input Output (EEMRIO) analysis. This approach, developed by Wassily Leontief (1941, 1970), provides a tool to analyse the inter-industry relationships and inter-

[3] http://data.worldbank.org/indicator/NE.CON.PETC.ZS

dependencies. Through its application with the appropriate environmental extensions, it allows estimations of the life cycle environmental impacts of product groups (e.g. cars, meat, houses, etc.) to be made. While the outputs of the approach are not as detailed as those obtainable via LCA, this is not a disadvantage for this research as the disaggregation of product groups is already limited by the availability of CES data.

The application of EEMRIO analysis requires the use of an input-output (IO) database. The ideal database for this research will disaggregate economies to at least the number of categories available within the CES data but ideally more as it is likely that some product categories will require input from multiple industries to produce. Additionally, it is important that the database is able to provide data in years that are near to that of the CES data and that the database covers the largest number of countries possible.

A number of IO databases exist that could be applied to this research, these include EORA (Lenzen at al., 2012) EXIOBASE (Tukker et al., 2013), GTAP (Andrew, R. & G. Peters, 2013) and WIOD (Genty at al., 2012). EXIOBASE has been chosen for this research project as it has a large disaggregation of sectors (163), covers forty three different countries and is available for the year 2007.

Once both CES and EEMRIO datasets have been prepared, it will be necessary to match the product categories within the CES data to the industry sectors present in the IO database. This will be done by assigning ranges to how much each product category might draw from each sectors and then using Monte Carlo simulation to find a final outcome for this step in the research. Once this has been completed, final demand within the IO database will be split up to be representative of consumption trends found in the CES data for each income group.

4. Directions for the future

The ultimate goal of this research project is to produce a framework for evaluating the equality impacts and human wellbeing impacts of proposals to deal with climate change. Achieving this goal will require the application of data as on human development to model and establishing a suitable framework for defining human wellbeing within the boundaries of the project.

Connecting the models outputs with GHG emissions budgets, such as those given in the AR5 IPPC report will allow the project to comment on the feasibility of achieving international development goals whilst also addressing climate change and how important international equality will be in determining this relationship.

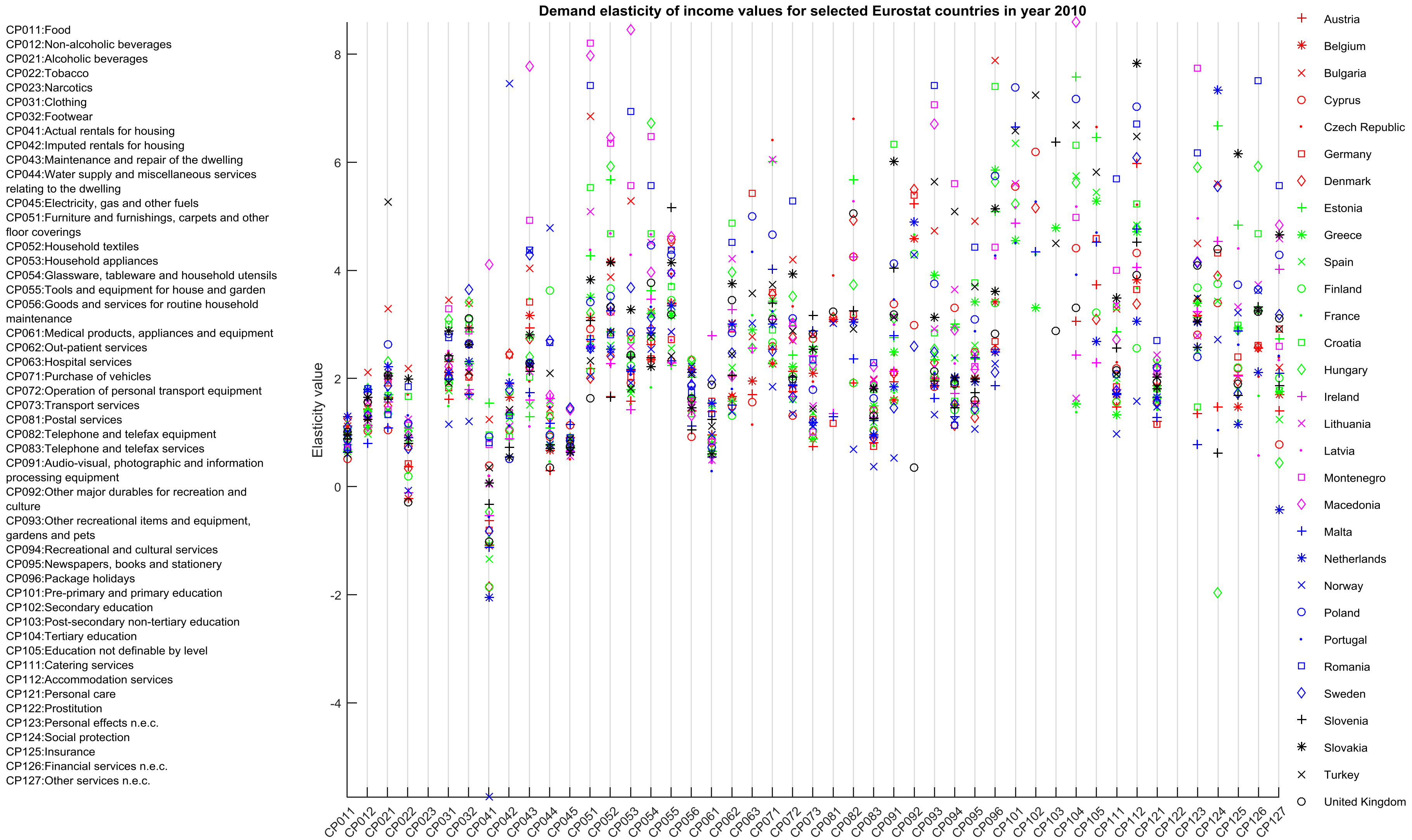

Figure 1: Demand elasticity of income data for the EU in 2010. Italy and Luxemburg are not present within the EUROSTAT for this year and are not displayed on the chart.

CP011:Food
CP012:Non-alcoholic beverages
CP021:Alcoholic beverages
CP022:Tobacco
CP023:Narcotics
CP031:Clothing
CP032:Footwear
CP041:Actual rentals for housing
CP042:Imputed rentals for housing
CP043:Maintenance and repair of the dwelling
CP044:Water supply and miscellaneous services relating to the dwelling
CP045:Electricity, gas and other fuels
CP051:Furniture and furnishings, carpets and other floor coverings
CP052:Household textiles
CP053:Household appliances
CP054:Glassware, tableware and household utensils
CP055:Tools and equipment for house and garden
CP056:Goods and services for routine household maintenance
CP061:Medical products, appliances and equipment
CP062:Out-patient services
CP063:Hospital services
CP071:Purchase of vehicles
CP072:Operation of personal transport equipment
CP073:Transport services
CP081:Postal services
CP082:Telephone and telefax equipment
CP083:Telephone and telefax services
CP091:Audio-visual, photographic and information processing equipment
CP092:Other major durables for recreation and culture
CP093:Other recreational items and equipment, gardens and pets
CP094:Recreational and cultural services
CP095:Newspapers, books and stationery
CP096:Package holidays
CP101:Pre-primary and primary education
CP102:Secondary education
CP103:Post-secondary non-tertiary education
CP104:Tertiary education
CP105:Education not definable by level
CP111:Catering services
CP112:Accommodation services
CP121:Personal care
CP122:Prostitution
CP123:Personal effects n.e.c.
CP124:Social protection
CP125:Insurance
CP126:Financial services n.e.c.
CP127:Other services n.e.c.

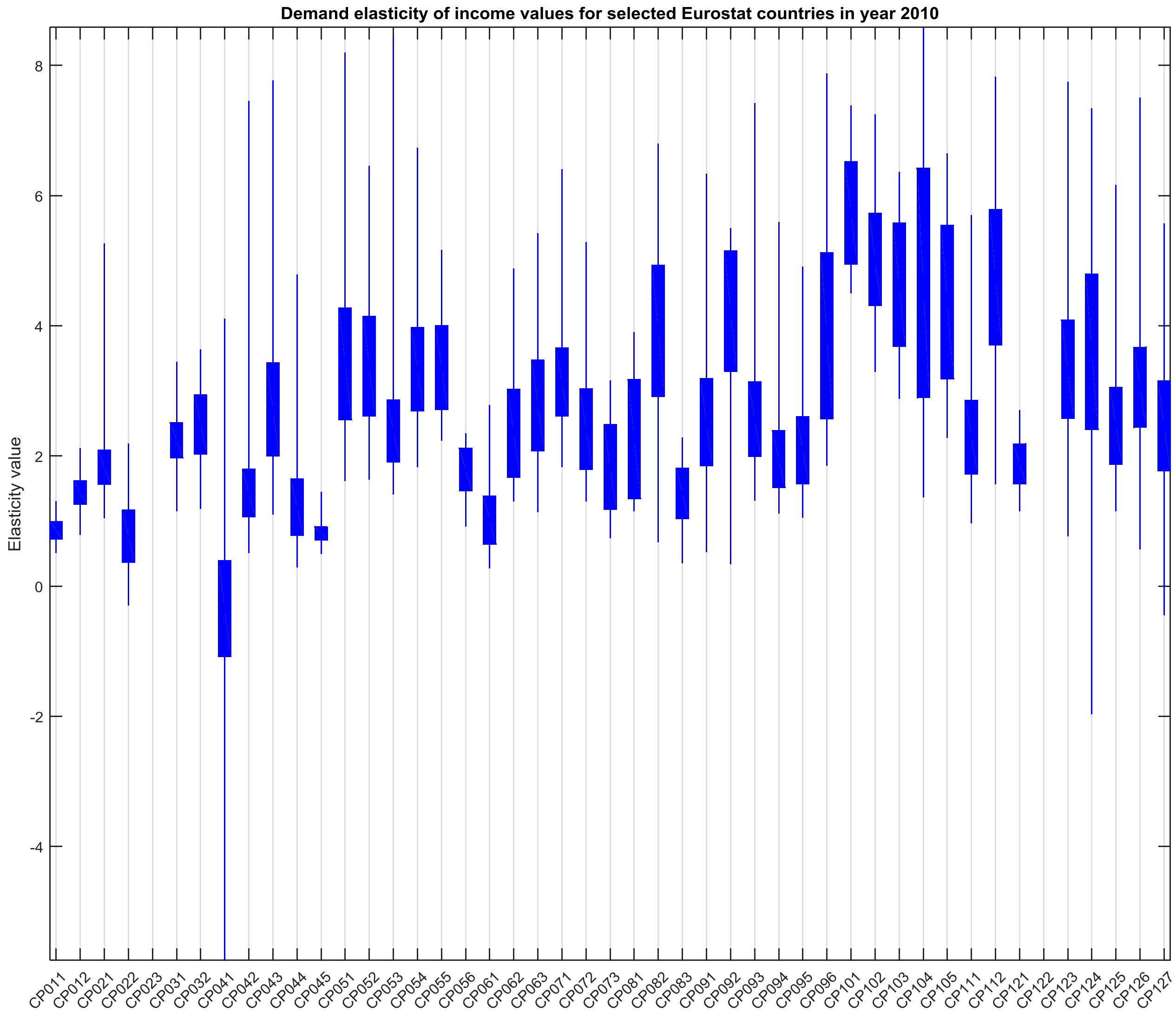

Figure 2: Demand elasticity of income data for the EU in 2010. Italy and Luxemburg are not present within the EUROSTAT for this year and are not displayed on the chart. This candlestick plot provides a simplified version of data presented in figure 1. The shaded bars represent the interquartile range of the elasticities.

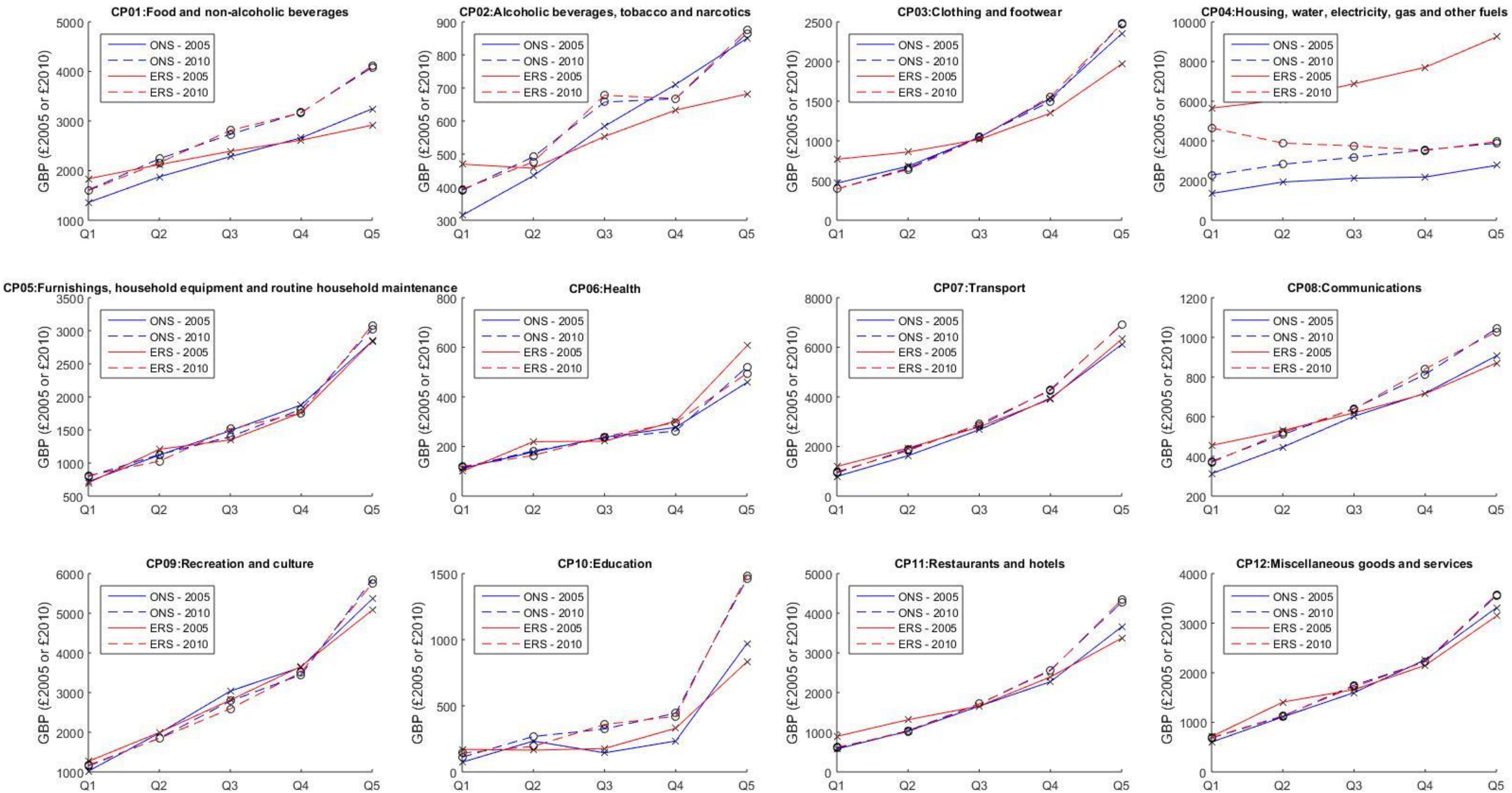

Figure 3: Annual household expenditure across 12 COICOP division in the UK in 2005 and 2010 according to EUROSTAT (ERS) and the UK Office of National Statistics (ONS).

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