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Consumer's behaviour in assessing environmental impact of consumption

State of the art and challenges for modelling consumer's behaviour in life cycle based indicators

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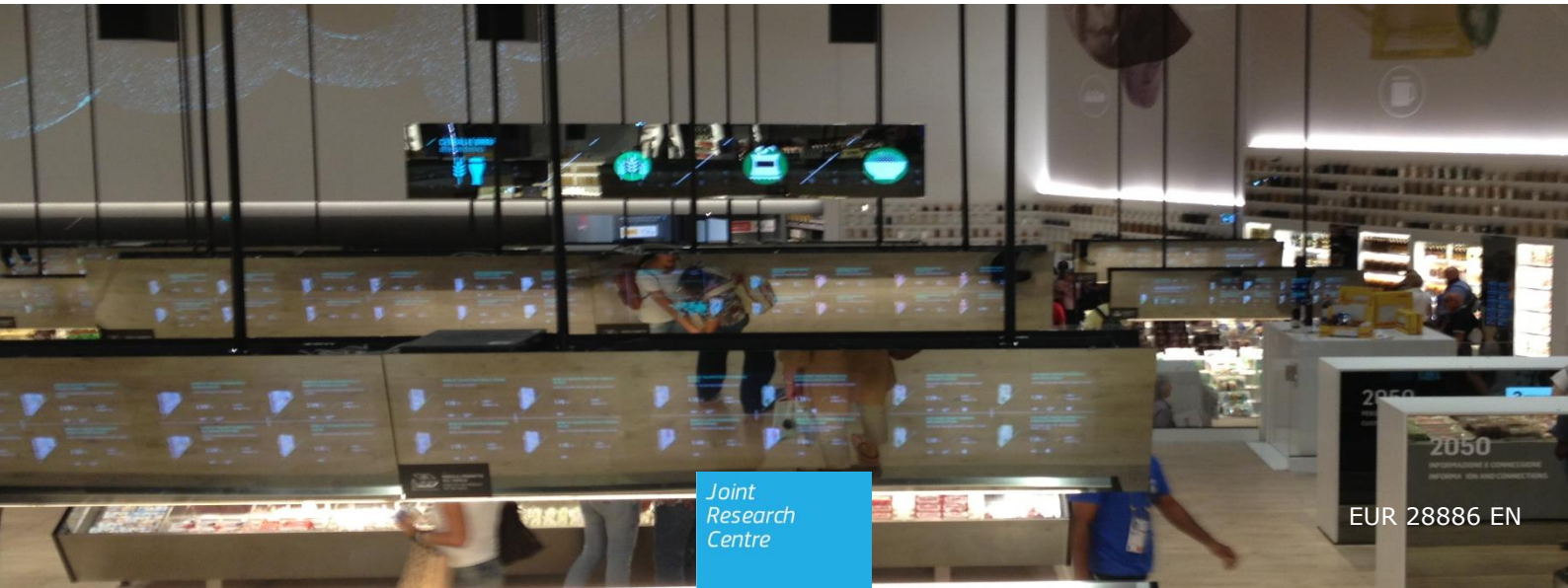

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Abstract

The European Commission (EC) has been developing an assessment framework to monitor the evolution of environmental impact associated to the European Union (EU) consumption. The assessment framework should help to support a wide array of policies, such as those related to resource efficiency, eco-innovation and circular economy. The environmental impact of EU consumption is assessed adopting two sets of life cycle-based indicators: the Consumption footprint and the Consumer footprint, which have a complementary role in assessing those impacts.

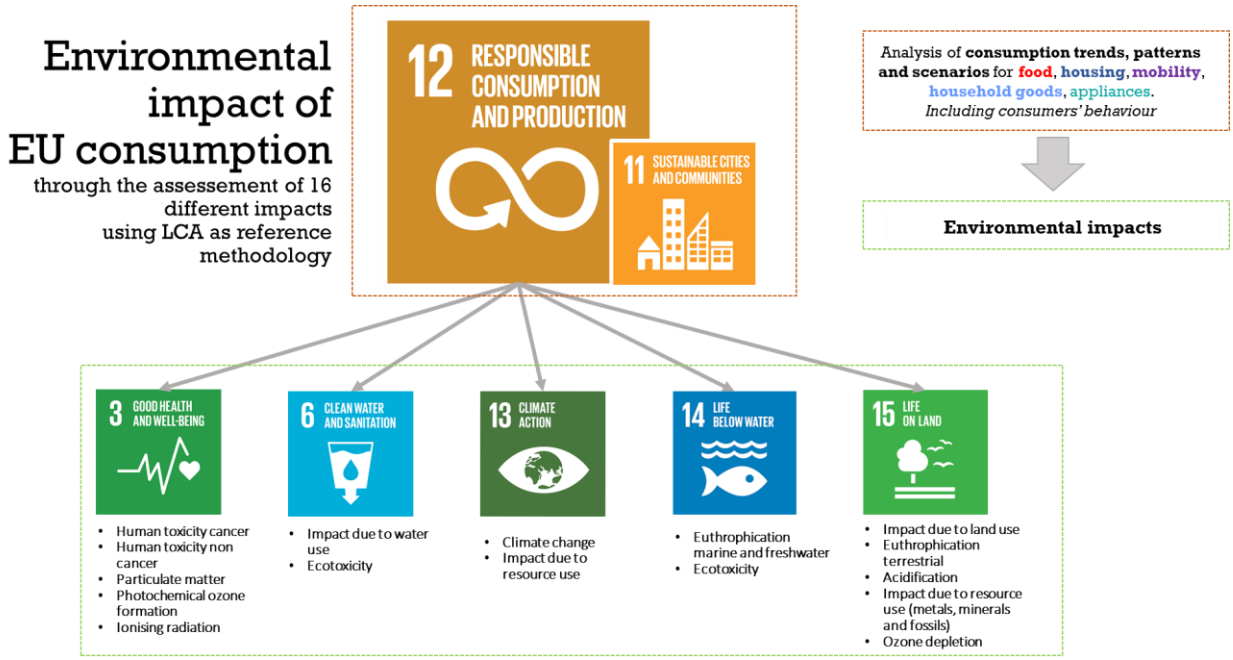
The EU Consumer Footprint is the measurement of the environmental impacts based on the life cycle assessment (LCA) of products (or services) purchased and used in one year by an EU citizen. This is based on the results of LCAs of representative consumed products (and services, where relevant). Within the framework of this project, a dedicated area of research focused on the "Product use phase and consumption scenarios", aiming at the examination of consumer behaviour types in view of further refinement of product use phase modelling and in support to the definition of scenarios on improved environmental behaviours. Whereas the production-based perspective helps in identifying domestic sectors, product groups and products responsible for emissions and resource use, the consumption-based perspective looks at the overall environmental impact induced by the domestic consumption. Each of the two perspectives on environmental impact has its use for policy-makers. This report is addressing variability in the use phase grounded on consumers' actual behaviour patterns, with reference to the aims presented before.

After a brief review of theories and models explaining consumer behaviours, this report discusses the main approaches for measuring the environmental impacts of consumption and the key drivers that influence consumers' shift towards more envrionmentally friendly consumption choices and behaviours. Moreover, the possible link between behavioural sciences and Life Cycle Assessment, through the development of scenarios on consumer behaviour applied to the Basket of Products (BoPs) is discussed, together with the possibility to capture the rebound effects in these scenarios. Current knowledge gaps and related research needs are illustrated in the concluding section, highlighting possible future paths of research for the integration of behavioural economics into environmental assessment (e.g. to capture the rebound effects induced by household expenditure structure shifting, based on Engel's curve), and to complement and further improve the approaches discussed herein.

1 The European Union (EU) Consumer Footprint

Assessing the environmental impact due to consumption of goods and services is a crucial step towards achieving the sustainable development goal related to responsible production and consumption (SDG 12). As part of its commitment towards more sustainable production and consumption, the European Commission has developed an assessment framework to monitor the evolution of environmental impacts associated to the European consumption adopting LCA as reference methodology (EC-JRC, 2012a; EC-JRC, 2012b). The present study is expanding the initial assessment framework to ensure a more complete and robust evaluation of the impacts, addressing SDG 12, partially SDG11 (on sustainable cities and communities) and assessing impact on a number of environmental impact categories related to other SDGs, mainly the ones addressing ecosystems and human health. Assessing environmental impact of consumption is primarily linked with SDG 12, and it implies the evaluation of the level of decoupling of environmental impact from economic growth, and related consumption patterns. However, assessing impact of production and consumption means, as well, understanding to which extent production and consumption may have an impact on other SDGs (Box 1).

Box 1 Overview of the link between SDGs, assessing the environmental impact of consumption and calculating these impacts with Life Cycle Assessment



The assessment framework aims to support a wide array of policies, such as those related to circular economy, resource efficiency and ecoinnovation. The environmental impact of EU consumption is assessed adopting two sets of life cycle-based indicators: the Consumption footprint and the Consumer footprint, which have a complementary role in assessing impacts (Box 2).

The Consumer footprint adopts a bottom-up approach, aiming at assessing the potential environmental impact of EU consumption in relation to the impacts of representative products. In fact, the Consumer footprint is based on the results of the life cycle assessment (LCA) of more than 100 representative products purchased and used in one year by an EU citizen. The Consumer footprint allow assessing environmental impacts along each step of the products life cycle (raw material extraction, production, use phase, re-use/recycling and disposal).

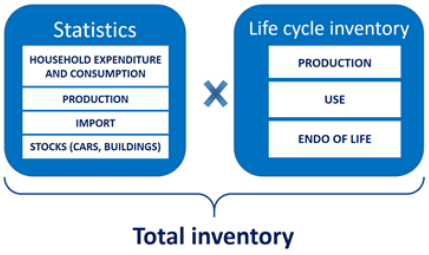
Box 2 Overview of the life cycle-based indicators for assessing the impacts of EU consumption

The life cycle-based indicators for assessing the impact of EU consumption

The Consumer footprint (BOTTOM UP)

LCA of products representative of the consumption of an average EU citizen

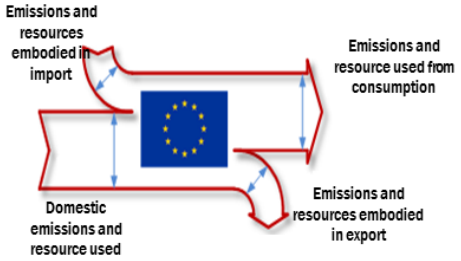
- Focusing on resources used and emissions due to production and consumption during the all life cycle of a product in selected areas of consumption (food, mobility, housing, household products, appliances)
- Combining life cycle data (environmental profiles of products) with consumption statistics



The Consumption footprint (TOP DOWN)

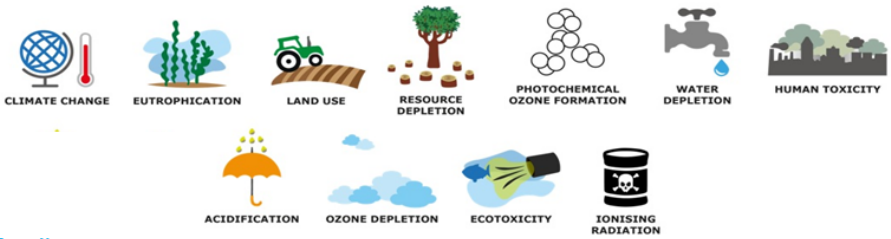
Economy wide assessment of apparent consumption in Europe

- Focusing on resources used and emissions due to production and consumption in one year in all sectors
- Combination of environmental statistics and life cycle inventories of representative products according to trade statistics
- Alternatively though the use of a the Environmentally Extended Input-Output Approach



Life Cycle Impact Assessment

Each emission in the environment and resource used are then characterized in term of potential environmental impacts in the life cycle impact assessment phase, covering the 15 impact categories recommended for the Product Environmental Footprint, including:



Results

Environmental impacts associated to households in Europe. Identification of hotspots in the Life Cycle of the consumed products considering five product categories: Food, Mobility, Housing, Household goods and Appliances. Results could be analysed for different types of consumer behaviours –e.g. average vs pro-environmental.

Each BoP represents a baseline for assessing ecoinnovations scenarios at all life cycle stages, from raw material, production, up to use phase and end of life. This help assessing benefits of sustainable lifestyles.

Environmental impacts of consumption in Europe and for each Member State, including the distinction of impacts in the three categories:

- Direct impacts, that occur because of the use of products and services.
- Indirect domestic impacts, that occur because of the life cycle impacts of products that are produced in the same country where they are consumed .
- Indirect imported impacts that occur because of the life cycle impacts of products that are produced in different countries where they are consumed.

For the calculation of the Consumer footprint, the consumption of European citizens is split into five key areas (food, housing, mobility, household goods and appliances). For each area, a respective Basket of representative Products (BoP) has been built based on statistics on consumption and stock of products. For each of the five BoPs, a baseline scenario has been calculated, taking as reference the consumption of an average EU citizen.

The developed LCAs are in line with the International Life Cycle Data system (ILCD) guidelines and follow, to the extent it is possible and relevant, the environmental footprint methods as published in the Communication "Building the Single Market for Green Products" (EC, 2013). The quality of the models has been ensured by periodical consistency checks and model refinements. In order to allow for periodical updates, the models has been built with a parametric approach. Hence, for example, the amount and structure of consumption could be updated to more recent reference years using data on apparent consumption (i.e. BoP composition and relative relevance of representative products) taken from Eurostat.

The baseline models allow identifying the environmental hotspots along the products lifecycle and within the consumption area of each specific BoP. The results of the hotspot analysis are, then, used as a basis for the selection of actions towards environmental burden reduction, covering shifts in consumption patterns, behavioural changes, implementation of eco-solutions, or a combination of the previous ones. For each of the actions, a scenario has been developed, by acting on the baseline model and simulating the changes associated to the specific intervention. The LCA results of each scenario are then compared to the results of the baseline, to identify potential benefits or impacts coming from the implementation of the solution tested, as well as to unveil possible trade-offs.

Complementary to the Consumer Footprint is also developed by JRC the Consumption footprint indicator. The consumption footprint is basically a top-down approach, aiming at assessing the potential environmental impact of EU apparent consumption, accounting for both domestic impacts (production and consumption at country level with a territorial approach) and trade-related impacts. The impacts are assigned to the country where the final consumer is located.

This report focuses on consumer’s behaviour, which affects the product use phase and consumption scenarios in the consumer footprint assessment, and more generally, the link between consumption and environmental impacts in the consumption footprint.

2 Product use phase and consumption scenarios in the Consumer Footprint and in the Consumption footprint

One of the LC-IND2 project's objectives is to "further develop an LCA-based framework, including modelling, for assessing relevant consumption and eco-innovation policies". Within the framework of this project, a dedicated area of research focused on the "Product use phase and consumption scenarios", aiming at the examination of consumer behaviour types in view of further refinement of product use phase modelling, supporting the definition of scenarios for the Basket of Products (BoP) indicators. Assessing drivers of consumer choices and behaviours is, indeed, a crucial part of the overall assessment framework of LC-IND2 project. This report is addressing variability in the use phase grounded on consumers' actual behaviour patterns, covering these issues:

- Methods for including behaviour when calculating the environmental impact of household consumption, circumscribing the scope of consumption-based perspective and its policy implications.
- Determinants of consumer choices and behaviours, building on a recent review of main theories and models explaining consumption and consumer behaviour (Polizzi di Sorrentino et al. 2016)
- List of pro-environmental behaviours to be further translated into LCA model parameters, including a literature-based analysis of the determinants of and obstacles to pro-environmental behaviour.
- Proposal of specific scenarios for the areas of consumption of the basket of products
- Identification of possible rebound effects1 due to the household expenditure category shifting (at the macro-scale).

Several aspects dealt with in the present report require further research activities, beyond the scope of the present study. However, possible future paths of research in this areas are presented (e.g. for capturing the rebound effects induced by household expenditure structure shifting, based on Engel's curve), to complement and further improve the approaches discussed herein.

2.1 Consumption-based perspective and its policy implications

In a *consumption-based perspective*, economics consider the consumption as the ultimate driver of all production activities. Adopting a social and environmental perspective, sustainable consumption is defined as "the use of services and related products, which respond to basic needs and bring a better quality of life while minimizing the use of natural resources and toxic materials as well as the emissions of waste and pollutants over the life cycle of the service or product, so as not to jeopardize the needs of further generations" (UN, 1994).

According to European Commission (2015), "transition to a more circular economy, where the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste minimised, is an essential contribution to the EU's efforts to develop a sustainable, low carbon, resource efficient and competitive economy. Such transition is the opportunity to transform our economy and generate new and sustainable competitive advantages for Europe". Acknowledging the important role of consumption phase for circular economy, European Commission (2015) highlights that "choices made by millions of consumers can support or hamper the circular economy". Since consumption is a key area of the product life cycle, the development of consumption-based footprint indicators is thus important for monitoring sustainable consumption and transition to a circular economy.

Whereas the *production-based perspective* helps identifying domestic sectors, product groups and products responsible for emissions and resource use, the *consumption-based perspective* focuses on the overall environmental impact induced by the domestic consumption. As pointed out by Scott (2009), each of the two perspectives has its own use for policy-makers.

Taking a sustainable consumption-based approach entails extending the production-based perspective's scope, by accounting for all environmental pressures induced by domestic

[1] Rebound effects are considered even if not quantified.

consumption, i.e. occurring both domestically (stemming both from the domestic production system and final use of goods and services) and from abroad (embedded into the imported goods and services produced in the rest of the world and consumed domestically) (Ivanova et al., 2015; EEA, 2015a). From this perspective, not only the environmentally improved products and production processes but also less environmentally impacting consumption behaviours come into play in reducing the overall environmental impact of goods and services (Table 1). According to this approach, households' overall environmental impact is given by the sum of all emissions and resource uses that households cause *directly*, namely by their purchasing and use of good and services (e.g. shelter-related consumption of services or car use), and *indirectly*, i.e. covering those emissions and resources occurring across different supply chain stages of the production of the goods and services consumed (Hertwich and Ivanova, 2015). In the circular economy context (EC, 2015), what would matter is a consumption that allows products to be used for longer, be reused/refurbished, and new products that contain recycled material etc.).

Table 1. A framework for a comprehensive analysis of the environmental impact of domestic consumption. JRC elaboration, based on Eurostat (2011a)

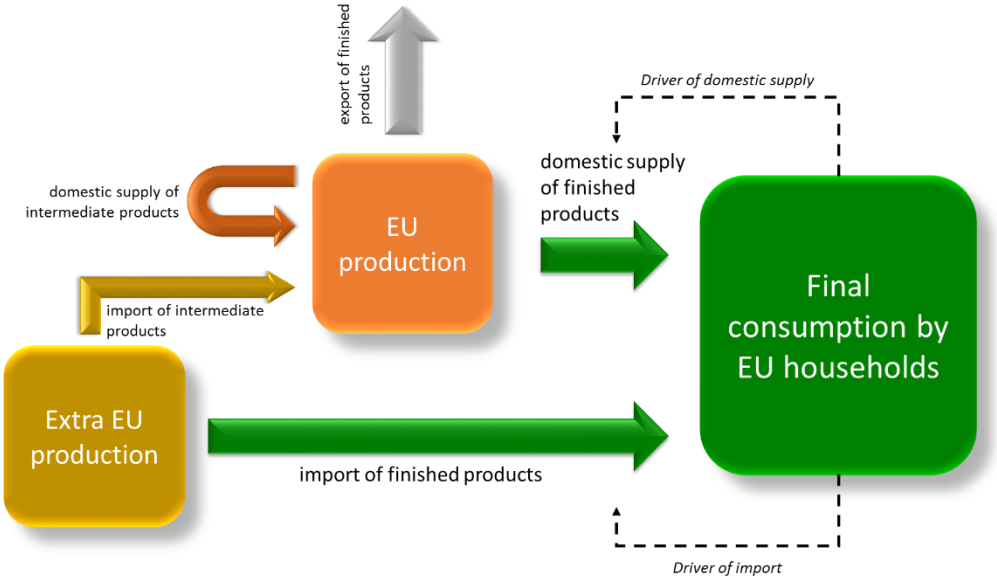
	Domestic final demand (total)	**Domestic final demand categories**			**Household consumption: breakdown by COICOP [2]categories**			
		Government	**Investment/ Gross capital formation (GFC)**	**Household consumption**	**H_1**	**H_2**	**…**	**H_{12}**
Domestic products	Y_d	G_d	I_d	H_d	H_{1d}	H_{2d}	…	H_{12d}
Imported products	Y_m	G_m	I_m	H_m	H_{1m}	H_{2m}	…	H_{12m}
Environmental impact	Y	G	I	H	EDH_1 EIH_1	EH_2 EIH_2	…	EDH_{12} EIH_{12}

Y_d *Domestic final demand from domestic production, by product category*
Y_m *Domestic final demand from imports, by product category*
Y *Direct environmental impact of final demand*
G_d *Government demand from domestic production, by product category*
G_m *Government demand from imports, by product category*
G *Direct environmental impact – government consumption*
I_d *Gross capital formation from domestic production, by product category*
I_m *Gross capital formation from imports, by product category*
I *Direct environmental impact – GFC*
H_d *Household demand total from domestic production, by product category*
H_m *Household demand total from imports, by product category*
H *Total environmental impact – household consumption total (= EH_i +)*
EDHi *Direct/embodied environmental impact – COICOP category*
EIHi *Indirect/Use-related environmental impact – COICOP category*

As an illustration, Figure 1 presents the relationships between imports, production and household consumption in the European production-consumption system. Domestic final consumption of products, through the existing consumption patterns, determines the structure of both domestic production system and imports.

[2] COICOP stands for Classification of Individual Consumption by Purpose, a classification developed by United Nations Statistics Division (please see Annex 2 for its detailed content).

Figure 1. Relationships between imports, production system and household consumption for food



As it can be seen in Figure 1, there are imports flows that go directly into the production system (used as intermediates in production of final goods), and others (final products) that go directly to the final demand, including household consumption.

The consumption-based perspective is able to: i) distinguish the sources of consumed products, i.e. domestic production and imports; ii) shed more light on the extent domestic consumption, driven by the existing consumption patterns, shapes the magnitude and structure of imports and domestic production system.

The resulting policy challenge - as already put forward in the European Commission's Sustainable Consumption and Production and Sustainable Industrial Policy (SCP-SIP) Action Plan (EC, 2008) - is to create a "virtuous circle". This could be done by improving the overall environmental performance of products (e.g. through eco-design, product and process innovations, etc.) and, in parallel, stimulating consumers to make more environmentally beneficial consumption choices (e.g. by better informing the consumer through product labelling) and to demand environmentally better-performing products. If eco-efficiency and eco-innovation measures (on the supply side) are to be effective, they must be supplemented by substantial changes on the demand side (Scott, 2009; UNEP, 2010).

Consumption is concerned by "an array of complex, interrelated factors such as demographics, income and prices, technology, trade, policies and infrastructure, as well as social, cultural and psychological factors" (EEA, 2010). Thus, a better understanding of consumption's drivers and patterns is needed for designing effective sustainable consumption policies (such as the Roadmap to a Resource Efficient Europe, EC 2011). However, as stated in the 7th Environment Action Programme (EAP), the existing knowledge gaps in properly understanding both the consumption structure and its drivers and thus consumption-induced environmental impact, require further research to which this project is contributing.

3 Unfolding consumer's behaviour: brief review of main theories and models

Among the main economic theories addressing consumption and consumer behaviour are Keynes' consumption function (Keynes, 1936), followed by - and also stemming from it - Friedman's permanent income hypothesis (Friedman, 1957) and Duesenberry's theory of relative consumption expenditure (Duesenberry, 1949).

Basically, Keynes' short-term aggregate consumption function is given by equation $C = a + bY$, where a is the autonomous consumption, b is the marginal propensity to consume and Y is the disposable income[3]. By explaining why income is more volatile than consumption on the long term, Friedman emphasized that propensity to consume is driven by the anticipated long-term income. In fact, permanent consumption is given by the equation $c_p = k(r,z)y_p$, where c_p is permanent consumption, $k(r,z)$ is the long-term average propensity to consume and y_p is permanent income (Meghir, 2004).

Further, individual consumption patterns started being explained not only by current income, but also by many other determinants, such as utility maximization, long-term income expectations and other subjective factors (for a detailed discussion on this topic, see D'Orlando and Sanfilippo, 2010). Duesenberry (1949) took into account other consumption factors than absolute income. Expenditure habit formation (given by the previous peak income level) and the role of social interdependencies in actual consumption pattern formation (e.g. social status, relativeness of individual consumption to the average consumption in a society) came also into play in explaining the underlying drivers of individual consumption spending. As far as the social influence on individual consumption tendency is concerned, "the strength of any individual's desire to increase own consumption expenditure is a function of the ratio of his expenditure to some weighted average of the expenditures of others with whom he comes into contact" (Duesenberry, 1948)[4].

Consumption has been thus increasingly seen as depending not only on the past, current or future income (for a review of this debate, see D'Orlando and Sanfilippo, 2010), but also on many other individual (e.g. habit) and social factors (e.g. social status or norms). This emerging strand led to the development of various behaviour-based principles, approaches and models, advanced from different disciplinary strands. As mentioned, D'Orlando and Sanfilippo (2010) provide a comprehensive review of them. A selection of the main contributions from various disciplines to better understanding consumer behaviour is briefly presented below.

In economics, the extended range of consumption drivers has paved the way for behaviour-centred approaches, aiming to develop more empiric, observation-based foundations of consumer decisions. Many empirical results were incorporated into the macroeconomic models for resolving various deficiencies, such as refining the assumptions on real-world economic behaviour of household consumption (for a detailed discussion, Driscoll and Holden, 2014) and for better grounding the aggregate consumption function.

Over time, behavioural economists have used psychology and laboratory experiments developed in the area of experimental economics for explaining the observed economic behaviours of consumers and exploring the social and psychological determinants behind consumption decisions (e.g. habits, routines, conventions, etc.) (D'Orlando and Sanfilippo, 2010; Hosseini, 2003). Tomer (2007) circumscribes the scope of the emerged behavioural economics by defining its specific research methods (e.g. extensive use of survey and experiments) and different research strands (e.g. Carnegie School; Michigan School; psychological and experimental economics; cognitive psychology; behavioural macroeconomics; evolutionary theory). Overall, he describes behavioural economics as "less narrow, rigid, intolerant, mechanical, separate and individualistic than mainstream economics" (Tomer, 2007), thus trying to replace the traditional

[3] Developed in Keynes (1936). A detailed presentation of Keynes's consumption function is provided by S. Guru, Consumption Function: Concept, Keynes's Theory and Important Features, http://www.yourarticlelibrary.com/economics/consumption-function/consumption-function-concept-keyness-theory-and-important-features/37745/

[4] For a detailed review, S. Guru, 3 Important Theories of Consumption (with Diagram), http://www.yourarticlelibrary.com/economics/consumption-function/3-important-theories-of-consumption-with-diagram/37756/

economic assumptions of rational and regular behaviour based on long-established principles such as utility maximization.

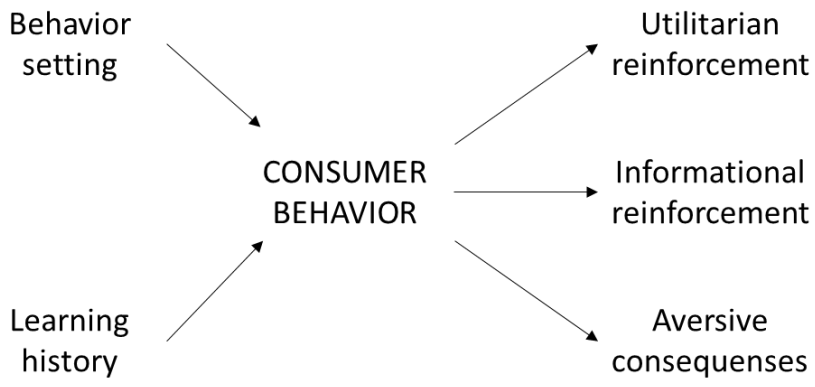
Behavioral principles and theories stemming from marketing and behavioral economics led to the multidisciplinary area of "consumer behavior analysis" (Foxall, 2003), aiming at explaining the drivers of actual consumer's choices and behaviour (Di Clemente and Hantula, 2003 for a detailed review of this evolution). For example, the stream of consumer psychology undertakes longitudinal studies, applying research on actual consumer behaviour in "search for, acquisition and use of, and disposition of goods and services" (Di Clemente and Hantula, 2003), and identification of other indirect variables which consumer behaviour is dependent on (e.g. attitude, intention, etc.).

Pecha and Milan (2009) show that the recent empirical evidence on consumer's behaviour in behavioural sciences (from different strands, such as behavioural and experimental economics) are deeply rooted into Keynes' psychological assumptions on individual consumption motives, such as on the role of mental habits, overconfidence, exaggerated optimism, status quo bias, ambiguity aversion, expectations, etc. In parallel, D'Orlando and Sanfilippo (2010) explored the behavioural literature and found that the new advanced motivation concepts of individual consumption behaviour, such as procrastination, cognitive scarcity, myopia and prodigality, mental budgeting, debt aversion, routine and habits, are all very akin to Keynes's treatment of "subjective factors" such as enjoyment, short-sightedness, miscalculation, etc.

The *most comprehensive and systematic model of consumer behaviour* was proposed by G.R. Foxall in his progressively developed *Behavioural Perspective Model (BPM)* (Foxall, 1990; 1994; 1995; 2003). The model puts into relation consumers' past experience, attitude and situational influences in a stimulus-response-reward framework (Figure 2), in which consumer behaviour is defined as a complex interplay of "structural components of consumer situations" and "affective responses". While behaviour's contextual setting and rewards (i.e. the "informational reinforcement") are "structural components", pleasure and dominance are individual "affective responses" of consumption acts (Foxall and Yani-de-Soriano, 2005). According to Foxall's BPM, there are also different expected consequences of consumer behaviour, namely: i) "hedonic/utilitarian reinforcement" (e.g. purchase's utility or satisfaction effect); ii) "aversive stimuli" (e.g. price to be paid), and iii) "informational reinforcement" (e.g. social feedback).

"Within consumer behaviour analysis, the Behavioural Perspective Model (BPM) interprets consumer behaviour as occurring at the intersection of the individual's learning history and the consumer setting, which signals utilitarian and informational consequences associated with consumption-related responses. Utilitarian consequences are mediated by the product or service and are related to its functional benefits. Informational consequences are social, mediated by other people, and are related to feedback upon consumers' behaviour, such as social status and prestige" (Foxall et al., 2011).

Figure 2. Interplay of consumption behaviour's determinants in the Behavioural Perspective Model (BPM).

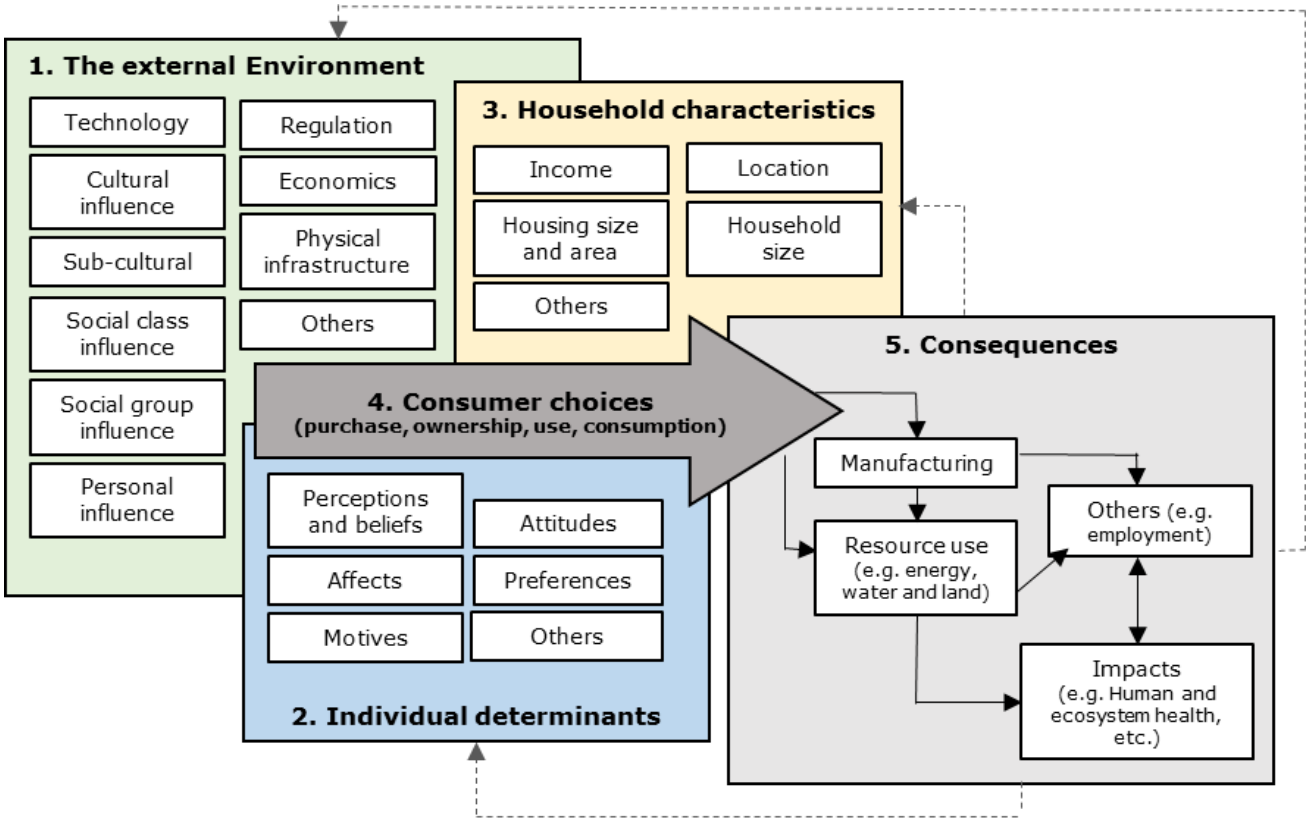


Source: Foxall (2007)

Additionally, the BPM provides *four broad categories of consumer behaviour*, differentiated by purpose (Foxall, 1994): i) maintenance (e.g. by food consumption), ii) accumulation (e.g. house purchase), iii) pleasure (e.g. recreation) and iv) accomplishment (e.g. attainment-showing behaviour).

A similar systemic framework, but with a limited application to housing, was provided by Bin and Dowlatabadi (2003) (Figure 3). It highlights the consumption behaviour intrinsically arising from the interplay of heterogeneous factors such as individual/subjective (choices), socio-demographic (household characteristics), contextual/external, and their environmental consequences (impacts due to energy use and CO_2 emissions).

Figure 3. Representation of the housing system.



(Modified from: Bin and Dowlatabadi, 2005)

Both Foxall's BPM and the housing system framework developed by Bin and Dowlatabadi (2003) show the embeddedness of consumption activities into an interplay of mutually interacting factors. The two frameworks suggest that: i) consumption behaviour cannot be analysed separately from its context, and ii) policy measures aiming at sustainable consumption need to broaden their scope of design and application. Besides properly addressing all the underlying determinants, consumer behaviour analysis needs to be rooted into the specific context in which behaviour acts take place, thus taking into account local factors such as framework conditions, households' socio-economic characteristics, culture-rooted habits, etc. Accordingly, impacting areas of policy intervention seem to be both (based on Stern, 2000) i) individual capabilities (e.g. educational attainment, welfare level, etc.), and ii) contextual determinants such as infrastructure availability and technological readiness, by means of financial, legal and institutional incentives.

3.1 Determinants of environmental behaviour

There are several reasons why identifying consumer behaviour's determinants and capturing its patterns are important for modelling the product use phase and for developing scenarios on consumption-related environmental impact:

- **At macro level:** the analysis of determinants is useful for understanding how final demand shapes the magnitude and structure of supply (see the consumption-based diagram - Figure 1, above);
- **At both macro and meso level:** determinants play an important role in the actual validation of eco-innovations' environmental gains in the use phase (mainly due to the rebound effect); additionally, they help estimate more realistic BoP composition (e.g. based on proxy such as household spending patterns) or consumption dynamics;
- **At meso level:** emerging consumption behavior patterns bring about changes in BoP product composition
- **Product LCA:** Consumer behavior patterns in the use phase greatly influence the overall life cycle environmental performance of some products (e.g. dwelling, appliances, car use, etc.). Therefore, identifying behavior's determinants is useful for refining average use-phase assumptions and parameters and for defining use phase scenarios, based on users' actual consumption patterns.

A widely accepted definition of environmental behaviour is provided by Stern (2000): "*environmentally significant behaviour can reasonably be defined by its impact: the extent to which it changes the availability of materials or energy from the environment or alters the structure and dynamics of ecosystems or the biosphere itself*".

According to Scott (2009), there are three main competing - but in fact interdependent - categories of widely accepted consumer behaviour drivers:

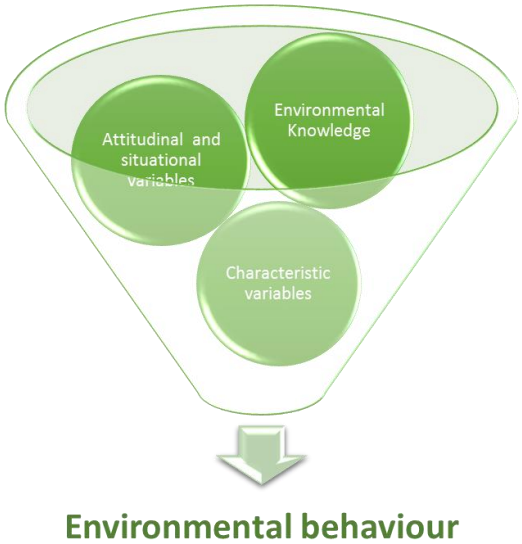
— psychological factors (such as: values, motivations, habits);

— social factors such as norms and existing social practices;

— external (such as: economic and institutional), context-related conditions (e.g. infrastructure, existing institutional and economic contexts).

By reviewing the literature, Sun and Wu (2006) also identify four main interlinked categories of variables (Figure 4) that influence environmental behaviour: attitudinal (including environmental beliefs, values and sensitivity), characteristic (e.g. moral norms), cognitive (e.g. knowledge and skills), situational variables (context-related determinants). The authors designed a conceptual framework for showing their relationships with environmental behaviour.

Figure 4. Broad categories of factors determining environmental behaviour



(Modified from: Sun and Wu, 2006)

Stern (2000) points at an important distinction between *pro-environmental concerns/attitudes* and *actual environmental impact of a behaviour*. In his viewpoint, there are four types of causal variables of environmental behaviour, some of which could be the focus of policy intervention (*in Italic*):

1. attitudinal factors (i.e. norms, beliefs, and values);
2. contextual determinants, which include *political institutional, financial social, (e.g. incentives*), interpersonal and market (e.g. advertising) factors and physical obstacles (e.g. technology and *infrastructure availability*);
3. personal capabilities, which refer to *knowledge and educational level, skills,* income, social status, etc.;
4. habits and routine.

In fact, all these four categories of factors interact with and influence to different extents specific pro-environmental behaviours.

An important source of complication is the difficulty of pinpointing the actual behaviour of individuals in surveying. Since, as Sun and Wu (2006) show, respondents' self-reported environmental attitude is not always translated into similar environmental behaviour, another strand of research focuses on the *gap between self-reported and actual environmental behaviour*. Kormos and Gifford (2014) measured the concordance extent between self-reported and actual environmental behaviour by a meta-analysis of 15 studies. As much of the variance remains unexplained, in spite of strong association between respondents' self-reported and actual behaviour, the authors conclude that, for more accurate prediction of actual environmental behaviour, surveying research based on self-reporting needs to be supplemented by additional methods.

De Groot (2015) also tackled this issue of value-behaviour gap in buying green products (e.g. organic food), finding that, when consumers' pro-environmental values are weak, their purchasing decisions are primarily based on the product's "egoistic attributes" (e.g. low price, quality, health effect) and then on its "green attributes" (e.g. reduced environmental impact). According to the results of two experiments, i) reported values cannot predict purchase type by themselves; ii) reducing the price of green products lead to the increase of green products' purchase and iii) green purchase is highly influenced by pro-environmental values. Trying to overcome the weak correlation between ecological attitude and action/behaviour, Gleim et al. (2013) tested whether environmental attitude (i.e. knowledge, value and intention) is a significant predictor of ecological behaviour, especially when several methodological issues such as situational influences and measurement specificity are properly considered.

Based on empirical research conducted in Australia, Moloney and Strengers (2014) put forward an alternative way to overcome the value-action gap in the quest for changing the current environmentally impacting consumption patterns. The authors highlighted the high significance of "ontological framing of social change" based on social practices (e.g. laundering, food preparation, entertaining, traveling, heating and cooling practices), and shown the limitations of attempting to change the individual consumer's behaviours based exclusively on individual's pro-environmental attitudes. Due to the embeddedness of consumption behaviours into an interplay of mutually interacting factors, both subjective and situational, consumer behaviour analysis needs to be rooted into the specific contexts.

Box 3. Systemic framework for understanding and changing behaviours towards more pro-environmental ones

Steg and Vlek (2009) put forward a systemic framework for understanding and changing behaviours towards more pro-environmental ones, with the general aim of reducing the environmental impact. The four successive methodological steps proposed for designing policy interventions are:

— identification of behaviours to be changed and selection of the most environmentally impacting ones; evaluation of the change feasibility and target groups;

— examination of behaviours determinants, by considering:

• motivational factors (e.g. cost/benefits; norms, values, etc.);

• contextual factors (e.g. increase availability/quality and reduce the price of infrastructure use)

• existing habits;

— elaboration, planning and implementation of policy interventions in response to each specific determinant proven to be an obstacle/area of potential improvement; two types of strategies are proposed: a)

• information strategies, such as better informing, social support, persuasion,

• strategies addressing behaviour's underlying structure (e.g. legal and financial instruments, influencing product availability)

— monitoring and evaluation of intervention effects, in terms of perceived changes in behaviour and behaviour's determinants or the resulting environmental gains.

3.2 Identifying the pro-environmental behaviours

Building upon the distinction between subjective behaviour and its purpose (i.e. environmental consequences), Kaiser et al. (2003) assessed the environmental impacts of 52 presumed, self-reported ecological behaviours, obtained by processing four samples (2 with Swiss, 1 with Swedish and one with participants from US). The environmental performance of the ecological behaviours was tested by employing available data from LCA literature.

Even if, as admitted by the paper's authors, the identified ecological behaviours holds true especially for the surveyed population, we retained several items since considered more generally relevant and added further features (e.g. consumption category, drivers, effects, type of data collection source/method) in Table 2. The list of ecological behaviours will be refined/extended during the process of literature review of environmental impact of each area of consumption covered by the specific BoPs. Depending on their appropriateness, and data availability, some ecological behaviours could, subsequently, be converted into use phase/manufacturing technical parameters as alternatives to the baseline scenario's ones.

Table 2. List of the identified pro-environmental behaviours (starting from Kaiser et al., 2003)

	Decision/ behaviour	Pro-environmental behaviour	Consumption category	Consumption drivers	Effect	Reference	Type of data collection source/method	Regional relevance	Eco-innovation relevance
1	Use of energy-efficient lighting bulbs (e.g. CFL and LED)	Use of energy efficient bulbs.	Housing	Cost, environmental attitude	25-80% less energy use	US Department of Energy[5]	Estimate	yes	Comparative performance. Diffusion rate.
2	Ownership and use of energy-efficient household devices	Purchase and use of energy-efficient household devices	Housing	Cost, consumer decision, habits	Energy saving , to be estimated	Estimate, based on individual adoption rate, energy saving and frequency of use	Estimate	yes	New, more efficient appliances
3	Full-load use of washing machine	Energy-efficient use of washing machine	Housing	Energy cost, attitude, habits	Water and energy saving	To be estimated	Surveys	yes	No
4	No clothes prewashing	Energy-efficient use of washing machine	Housing	Energy cost, attitude, habits	Water and energy saving	To be estimated	Surveys	yes	no
5	Use of clothes dryer	Air drying	Housing	Energy cost, attitude, habits	Energy saving 100%	-		yes	no
6	Use of home solar panel electric systems	Choosing and purchasing solar panels	Housing	Energy cost; Energy self-sufficiency;	100% saving of conventional electricity	Energy Saving Trust, UK[6]	Statistics + surveys	Yes	Technical performance and environmental gains.
7	Use of renewable energy sources	Choice and use of renewable energy sources	Housing	Energy cost; attitude; choice;	Less fossil energy consumption	Estimate, based on use rate	Statistics	-	-
8	Use of Euro6 private car	Choice and use of less-emission car	Mobility	choice; standards	Euro 6 cars emit about 20% less CO_2 (11% for small diesel cars)	Borken-Kleefeld et al., 2013[7]		Yes	Less-fuel-consumption cars
9	Use of airplane for long journey (>6h of driving)	trip length of 500−1000 km, i.e. feasible transport mode choice	Mobility	comparative travel cost	Less fuel/greenhouse gases (GHG) consumption per passenger	Estimates, depending on fuel type, emission standard, engine capacity and occupancy;	Borken-Kleefeld et al., 2013	Yes	NA

[5] http://energy.gov/energysaver/how-energy-efficient-light-bulbs-compare-traditional-incandescents
[6] http://www.energysavingtrust.org.uk/renewable-energy/electricity/solar-panels
[7] Borken-Kleefeld et al. (2013)

	Decision/ behaviour	Pro-environmental behaviour	Consumption category	Consumption drivers	Effect	Reference	Type of data collection source/method	Regional relevance	Eco-innovation relevance
10	Use of public transportation in nearby areas by commuters (<30 km)	Transport mode choice	Mobility	Travel money; convenience; time budget	"Energy and environmental impacts of public transport depend on the type of vehicles used, driving pattern, road conditions, passengers load and other factors."	Tartakovsky et al., 2013	Estimate	Yes	NA
11	Purchase of processed/convenience food	Food choice	Food	Income; convenience; time budget	- global warming and human toxicity: up to 35% lower; - eutrophication, photochemical smog and ozone layer depletion are up to 3 times lower	Schmidt Rivera et al. (2014)[8] Ivanova et al. (2015)	LCA-based paper	yes	yes
12	Consumption of meat and dairy	Food choice	Food	Income / expenditure level	More environmentally impacting	Ivanova et al. (2015)	MRIO-based study	yes	yes
13	Use of rechargeable batteries	Rechargeable battery purchase and use	Housing / Household appliances	Overall cost; Performance	overwhelmingly less environmental impact of the re-chargeable battery	Pearson (2007)	LCA study	yes	yes
14	Buying clothing made from (silk, cotton, wool or linen)	Purchase and use of all-natural fabric clothes	Clothing Housing (laundry)	Performance Health aspects	Mixed: - Biodegradability - Cotton is pesticide intensive - Harmful solvents - PVC toxicity	NRDC[9]	LCA studies	yes	yes
15	Buying meat and meat products with eco-labels	Consumer's informed choice	Food	Egoistic attributes: health and cost; income level Environmental values	More environmentally impacting	Ivanova et al. (2015)	MRIO- and LCA-based studies	yes	yes

[8] Schmidt Rivera et al. (2014)
[9] http://www.nrdc.org/international/cleanbydesign/consumercare.asp

4 Measuring the environmental impact of consumption

Environmental impact of consumption covers both the direct environmental pressures from the actual use of products (e.g. car use) and indirect pressures induced by the production of goods for satisfying the final demand, sourced from both domestically and abroad (i.e. imports) (EEA, 2010 and LC-IND project). The environmental impact of consumption could be assessed with different perspectives, namely: top-down approach (adopting for example Input-Output as in EC-JRC, 2006) or bottom-up approach (as defined in our previous project LC-IND, assessing life cycle impact associated to representative products).

Regarding the top-down perspective, by applying the CEDA EU-25 Products and Environment model, the Environmental Impact of Products (EIPRO) project (Tukker et al., 2006) identified the product groups and categories with the highest environmental impact across their life cycle stages in the EU-25's final consumption, originated from both domestic production and imports. The results show that 22 aggregated product groups account together for more than 50% of each potential impacts (i.e. the eight environmental impact categories considered in the study). The groups are the following: motor vehicles; car repairs and servicing; clothing; domestic heating equipment, including use but excluding electric heating; electric light bulbs and tubes; household laundry equipment; household refrigerators and freezers; household use of pesticides and agricultural chemicals; meat; sausages and other prepared meat products; poultry; milk; cheese; new buildings and conversions; new one-family houses; drugs; services of beauty and hairdressing salons; services of restaurants and bars; telephone, telex and communications services; other edible fats and oils; other household appliances; other leisure and recreation services.

At a more aggregated level, the areas of consumption that generate larger impact are: i) food and drink (in general, between 20% and 30%), ii) transport (from 15% to 35%) and iii) housing (from 20% to 35%). Together, they account for around 60% of consumption spending and 70-80% of the entire life cycle environmental impact of the EU-25's final consumption (i.e. both household's and public sector's consumption).

Mont et al. (2014) summarize the research findings on the main environmental pressures caused by consumption patterns in the EU as follows:

- together, consumption in the areas of food, housing and private mobility are responsible for 70-80% of EU's environmental impacts (EC-JRC, 2006);
- within food category, meat and dairy consumption alone accounts for 24% of all final consumption impacts (Weidema et al., 2008);
- domestic heating, water consumption, appliances and electronics account for 40% of total energy consumption, while space heating accounts for 67% of household energy consumption in the EU-27 (EEA, 2010).
- the number of private cars increased by 35% between 1990 and 2007 in the EU-27 (EEA, 2010).

An overview on the potential contribution of behavioural science to LCA is presented in Table 3.

Table 3. Potential contribution of behavioral science (BS) within steps of LCA and as input to communication

Behavioral science (BS) support to LCA studies in each LCA step		
Goal and scope	**Decision context**	Helping in defining assumptions for the specific decision context, also including cultural-specific or social-context specific aspects
	System boundary	System boundaries may change, e.g. if there is the need of moving from product to functions of the product, meaning that the product is used for answering a need and this need may be fulfilled with product/ services etc. BS may help moving from product orientation to function orientation in assessing the way consumer answer to his need. Moreover, including the assessment of rebound effects (Girod et al 2011, Vivanco and van der Voet 2014) may imply the system expansion. Typically, the boundaries of the product system may also change in consequential LCAs by enlarging to product systems that are indirectly related to the investigated product (co- or by products or competitive products).
	Functional unit	Goedkoop et al. (1998) and Goedkoop (1999) advocated for determining the functional unit based on the observed consumer and producer's behaviour, rather than arbitrarily. By using observed behavioural data, two main outcomes arise: firstly, changes in demand due to the direct rebound effect may be incorporated and, secondly, changes in different ancillary product systems can be assessed, offering a broader picture to potentially assess other causal effects. The functional unit indeed should be based on insight of variability of different behaviour, based on behaviour measuring.
	Scenarios under assessment and assumptions on user behavior	Several scenarios could be run in order to assess variability in the results (as estimate of the uncertainty of the results) as well as exploring and identifying condition which may minimize the impacts. Assumption on life span of a product, typologies of uses etc. should be based on clusters of behaviours. Regarding clustering of use, an example could be the clustering of users' behaviour based on being a "hero", "antihero" or anarchist (Autio et al. 2009) as well as framing different perceptions and associated consumers profiles (e.g. Gatersleben et al. 2002) including ecological behaviours (Kaiser et al. 2003). Additionally, differences in use phase could be linked to variability in behavior due to, e.g.: lifestyle (Heinonen and Junnila, 2011; Bin and Dowlatabadi, 2005), geographical context (Schlegel et al. 2012), income (Girod and de Haan, 2010), age and demographic aspects (Zagheni, 2011) etc BS may equally support definition of future scenarios, helping framing future consumption trends (e.g. Girod et al. 2013; Erikson et al. 2012)
LCI	**Data collecting**	Using BS results to assess how the inventory should be built and be modified under different scenarios of use. This is again linked with availability of information on different possible behaviours. Examples of this are related, e.g, to the emission profile of different driving behaviours (Rangaraju et al. 2015, Girod et al. 2013b)
LCIA	**Impact assessment**	Behaviour-related aspects that may imply higher or lower likelihood to be exposed in the use phase. Indeed, examples exist on for variability in exposure, exposure duration, use of preventive measures e.g. in the impact assessment for indoor exposure is under development within LCA (Jolliet et al. 2015, Goldsteijn et al. 2014)
communuication	**Presentation of LCA results, labelling**	BS may help in identifying the message and most effective ways to deliver communication of LCA results (see for example Waechter et al. 2015). This may also support understanding how the LCA results are perceived (Tobler et al. 2011) and or how LCA-based labelling could be more effective (Röös and Tjärnemo, 2011)
Potential improvement	**Feedback to ecodesign**	BS may support the decision on whether (and how) improving the products (e.g. default options as the greener one, improving users' awareness through feedback). This could be based on evidence of possibilities for behavioural changes (e.g. Tobler et al. 2011, Jones and Kammen 2011) Studies on how the behaviour of a user is affected by the design of a product are increasingly available (see e.g. the list provided by Daae and Boks 2015) and the example of influence of packaging attributes on consumer behaviour (Wikström et al. 2014). Other studies such as those on influencing factors and mitigation prospects (Zhang et al. 2015) as well as of persuasive technology to encourage sustainable behaviour (Midden et al. 2008)

Applying a bottom-up approach in LC-IND project, Benini et al. (2014) calculated the relative change in the environmental impact levels of the EU-27 for the period 2000-2010, for each EU member state and each impact category.
As far as the overall environmental impact occurring domestically is concerned, i.e. emissions of pollutants and extraction of resources taking place within the boundary of the EU-27 countries, it decreased in the referred period for almost all impact categories, excepting land use and water resource depletion. On the other hand, the environmental impact induced by trade (i.e. exports and imports) increased in almost all countries, showing a high variation.
Dewulf et al. (2014) calculated the total environmental impacts of the three environmentally significant broad categories - i.e. food, housing and mobility, as average by EU-27 citizen, for 14 impact categories; and, within each category, of representative products. Main findings are as follows:

- production and use phase overwhelmingly dominate the overall life cycle environmental impacts; at the other end, the least contributing LC phase is End-of-Life.
- The average contribution of BoP-specific production stage is as follows: food - 54.5%; mobility - 34.3%; housing - 11.2%;
- The average contribution of BoP-specific use stage is as follows: food – only 2.2%; mobility - 45.9% (with a highly significant role of passenger car); housing - 51.8%; thus, use phase is a major contributor for housing and transport demand's environmental impact in the EU-27.

4.1 Macro-level calculation of environmental impact of household consumption and the importance of lifestyle

Besides exports, government demand and companies' gross capital formation, household consumption is an important component of final demand in the System of National Accounts (SNA). The System of Environmental Economic Accounting (UN, 2014) provides the SNA-matching framework for capturing interactions between economy and environment.

Environmentally extended input-output framework aims at capturing the environmental impact associated with the product flows coming from the domestic production and imports and going to the final demand. Country-level Environmentally Extended Supply Use Tables (EE SUTs) allow for interrelating the environmental impacts of consumption and environmental impacts of production, however not allowing for the calculation of pollution embodied in trade. Other current drawbacks are related to a limited sector detail and low coverage of environmental extensions.

Tukker et al. (2013) calculated the environmental impacts of EU final consumption by using a Multi-Regional Environmentally Extended Supply and Use Table (MR EE SUT) covering 43 countries, 129 sectors, 80 resources and 40 emissions, developed within the context of the EXIOPOL project (2011)[10]. Through this tool, the author found that a high share of EU consumption in terms of land, water, and material use takes place outside the EU.

Based on World Input-Output Database (WIOD), Arto et al. (2012) calculated indicators linking global (including EU-27) domestic production, consumption, and trade to six environmental impact dimensions, i.e. land use, material extraction, water use and emission of acid substances, greenhouse gases (GHG) and ozone precursors, for the period 1995-2008. Besides indicators on resources used in domestic production (i.e. domestic extraction of materials or land cultivated) and their associated emissions, the authors also provide indicators on the resources/emissions embodied into the household final demand of one country, regardless of their source. Their detailed results per country and the Classification of Individual Consumption by Purpose (COICOP)[11] consumption categories (total and for each MS), for 1) land use, 2) material extraction, 3) water use, 4) acidifying substance emissions, 5) GHG emissions and 6) ozone precursors.

[10] "A New Environmental Accounting Framework Using Externality Data and Input–Output Tools for Policy Analysis".
[11] Annex 1 provides the detailed Eurostat's COICOP classification.

According to the main findings from Arto et al. (2012), the most contributing categories for the EU-27 household consumption environmental pressures in 2008 are highlighted as follows:

1. **Land use**: in descending order of magnitude, i) Food, drinks and tobacco, ii) Recreation and culture, and iii) Restaurants and hotels

2. **Material extraction**: in descending order of magnitude, i) Food, drinks and tobacco, ii) Housing, fuel and power, and iii) Transport and communication activities.

3. **Water use**: in descending order of magnitude, i) Food, drinks and tobacco and ii) Recreation and culture activities, iii) Housing, fuel, and power and iv) Restaurants and hotels.

4**. Acidifying substances:** i) Food, drinks and tobacco, ii) Housing, fuel and power, and iii) Transport and communication were responsible for most of the acid footprint.

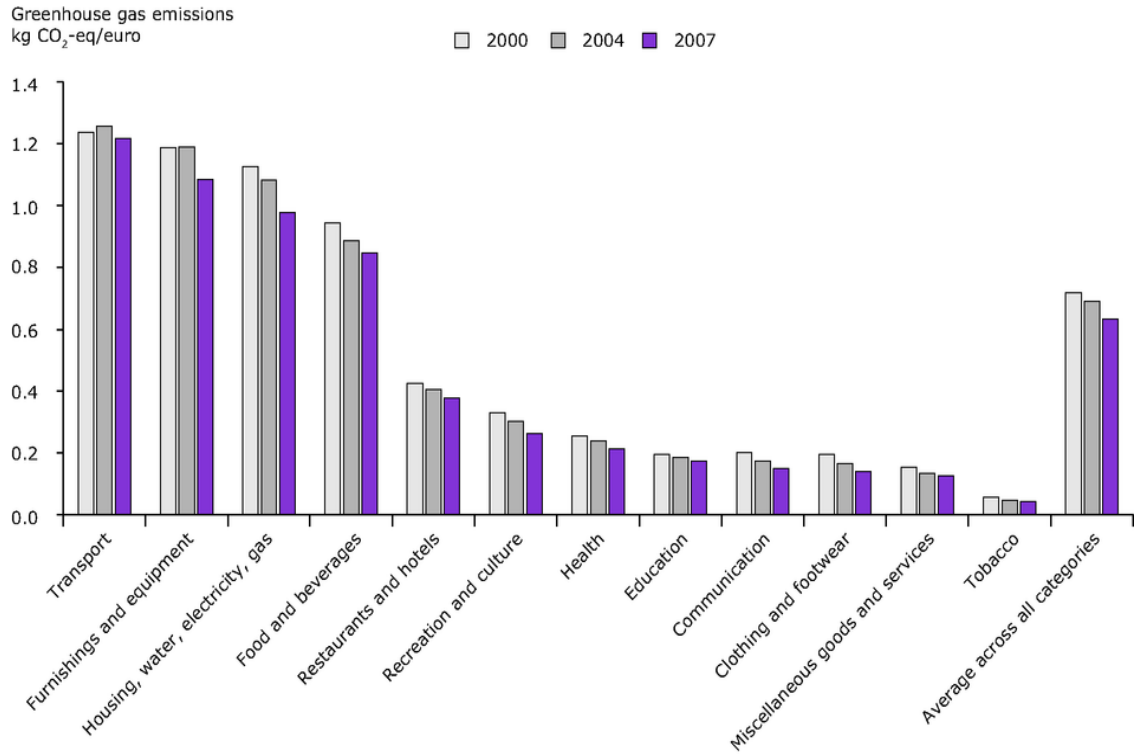
5**. GHG emissions:** i) Housing, fuel and power, ii) Transport and communication, and iii) Food, drinks and tobacco

6. **Ozone precursors emissions:** i) Transport and communication, ii) Housing, fuel and power and iii) Food, drinks and tobacco.

Based on EXIOBASE 2.1, Tukker et al. (2014) calculated the worldwide environmental impacts of trade and final consumption in 43 countries and over 150 smaller countries combined in 5 'Rest of the World' groups by continent in 2007, covering 160 industry sectors and 200 product categories by country, and 40 emitted substances, land use, water use and 80 resources by industry.

Some work on calculating four environmental pressures (GHG, acidifying and tropospheric ozone precursor emissions, and direct material input) induced by the expenditure patterns of the European households in the period 1996-2012 by COICOP consumption category was done by EEA (2013). The GHG impact of European household consumption is presented in Figure 5.

Figure 5. GHG emissions induced by household consumption, per Euro spent of expenditure in the 12 COICOP household consumption categories (2000, 2004, 2007).



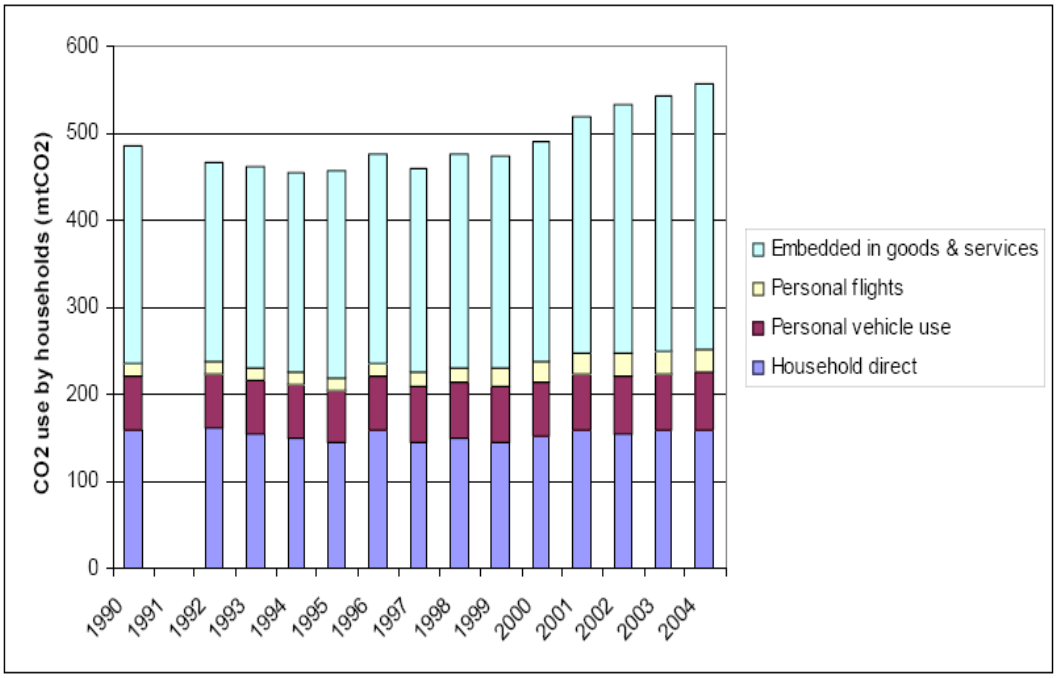
(Source: EEA, 2013)

At country level, Druckman and Jackson (2009) constructed a disaggregated framework for attributing CO_2 emissions from energy incorporated in the products demanded by UK households in the period 1990-2004, by functional uses (i.e. fuel use by households, personal vehicle use and personal flights). They found that:

- a high share of embedded environmental impacts takes place abroad;
- there is a high variation of carbon footprint among consumption categories;
- there is a high variation among different segments of the UK households (Figure 6).

Their findings show that the highest carbon footprints derive from recreation and leisure, food & catering and house heating, which point to the relevance of modern lifestyle drivers and the need of detailed analysis of household consumption.

Figure 6. Trends in CO_2 emissions from UK household demand in the period 1990-2004.



(Source: Druckman and Jackson, 2009)

Hertwich and Peters (2009) calculated country-level GHG emissions induced by final consumption of goods and services for 73 nations and 14 aggregate world regions, divided into 8 product group categories: construction, shelter, food, clothing, mobility, manufactured products, services and trade. Their findings show that:
i) worldwide, the share of household consumption's contribution to the GHG emissions is 72% of the carbon footprint related to the final demand;
ii) household's indirect impacts are more important than direct impacts from direct use;
iii) a strong correlation between consumption expenditure and emissions, with an elasticity of 0.57 for all GHGs;
iv) the contribution of the 8 categories differs according to the development stage of countries.

Using Multi-Regional Input-Output (MRIO) EXIOBASE 2.2 and Global Trade, Assistance, and Production (GTAP) 7 database, Ivanova et al. (2015) assessed four categories of environmental impact (material, water and land use, and GHG) from production (i.e. spread across the supply chains of products consumed by households) and direct use of products consumed by households for 43 countries and five rest-of-the-world regions for 2007.

JRC is currently working on the results of EXIOBASE 3 (Stadler et al., 2018) in the context of the Consumption Footprint in the LCIND2 project (Schmidt and Sala, 2017).

4.2 Developing scenarios for the baskets of products

The development of scenarios on pro-environmental behaviours for the basket of products builds on the results of a literature review about identified pro-environmental behaviours and the related key issues that may drive the change. The scenarios should aim at capturing the effects of either shifting between products or product groups within the same BoP (e.g. transport mode shift within Mobilty BoP; partial replacement of meat and dairy by vegetables and cereals within the Food BoP etc.) or changing behaviour in the use phase of products or services (e.g. by putting in place energy saving measures to reduce energy consumption in the housing sector).

Within the food category, meat and dairy consumption alone accounts for 24% of all final consumption impacts (Weidema et al., 2008). Therefore, dietary change, especially in areas with affluent diet, could play an important role in reaching environmental goals, with up to 50% potential to reduce GHG emissions and land use demand of the current diet (Hallström et al., 2014)

Regarding mobility, Avineri (2012) investigated the potential contribution and limitations of applying behavioural economics to issues, such as: i) understanding and incorporating behavioural notions (e.g. irrational deviations of travel choice from forecasting models) into travel behaviour and demand modelling (e.g. travel choices such as mode, route and time choices; activity-based travel demand modelling), ii) predicting future travelling behaviours and iii) designing policy measures for behaviour change accordingly. Beside widely accepted hedonistic, social, economic and demographic factors of travel choice, there is a variety of behavioural factors potentially involved in explaining travel-related choices, stemming from rational behavioural models due to geographical contextual effects and habits.

Through a review on sustainable consumption in the area of mobility, Hertwich and Katzmayr (2003) found that the distances travelled in the EU are expected to increase, the kilometres travelled per person being expected to double by 2025. Statistics about transports confirm that transport rates are annually growing for both passenger (about +1.8% between 2013 and 2014) and freight transport (+1.1% between 2013 and 2014) (EC, 2016a).

Among the most suitable sustainable consumption measures in the area of mobility, Hertwich and Katzmayr (2003) identified the following:

i) reducing mobility demand increase through measures such as city planning;

ii) influencing the modal split by, for example, ensuring shifting to public transportation by providing the necessary infrastructure;

iii) influencing the choice of environmentally friendly or energy efficient cars by measures such as fuel taxes and differentiated registration fees; iv) increasing the vehicles occupancy rate through establishing public services for mobility centres and for car-pooling.

With reference to mobility and housing, several specific drivers of consumption have been also identified, as follows:

Mobility:

i) **Vehicle's intrinsic attributes**: price; fuel consumption; average speed; engine power; load capacity; safety, comfort, style.
ii) **Individual determinants**: attitudes and values (environmental vs. egoistic, car ownership, etc.); preferences (luxury level; specific travel mode); Travel Time Budget and Travel Money Budget (Zahavi and Talvitie, 1980).
iii) **Contextual factors**: passenger transportation system (e.g. public transports and cycling); travel cost.

Housing:

i) **Building-related determinants**: number, size and types of buildings; age structure of building stock occupancy rate.
ii) **Individual determinants**: disposable income; attitudes and values; habits.

iii) **Contextual factors**: available technology and infrastructure; regulation in force; climatic area; location (rural vs. urban).

4.3 Proposed scenarios on consumer's behaviour and their rationale to be assessed with LCA

A review of literature on consumer behaviour demonstrated that it is very critical to assume specific parameters for LCA directly out of behavioural economic (BE) literature. Table 4 summarises several use-phase-related areas of improvement identified in the literature for three areas of consumption (food, housing and mobility). The BE domain is mainly focused on qualitatively describing the drivers of the behaviour and not quantitatively addressing the specific and product-related parameters which vary with the specific choices and the behaviour.

Table 4. Improvement in the product use phase per consumption area (i.e. BoP food, mobility and housing)

Food	Mobility	Housing
Changes in the shares of consumption of different food (by diet shifts), e.g. country based differences in the diet	Travel patterns	Use of empty instead of new buildings
Consumption-related food waste reduction	Driving style and patterns	Construction of buildings adapted to new functions or changing needs
Reduction (by 25/50%) in animal-based consumption (e.g. beef, pork, poultry, dairy and eggs) by shifting to plant-based diets (Westhoek et al, 2014)	Transport mode structure. E.g., 28-45% vehicle-kilometres reduction in Europe by car sharing (range provided by Shaheen and Cohen, 2008)	Multi-purpose use of buildings
50 less GHG and land use impact from diet shift (Hallström et al., 2014)	Higher average occupancy factors (by carpooling or implementation of high-occupancy vehicle lanes – Girod et al, 2013)	Design of mechanisms for rewarding good users;
Reduction of meat and dairy consumption	Declining medium-distance light-duty vehicle use by higher share of public transport	"Nearly zero-energy buildings"
Eating more plant-based foods or shifting to a pesco-vegetarian diet	Change of luxury-level preference (Girod et al., 2013)	Zero-carbon home electricity use
Beverage choice	Shifting from car and air travel to other lower-impact modes, like public transportation (IEA, 2009)	Zero-increase living area per person
	Energy consumption of vehicle use and rail transportation	Energy-efficiency design for household appliances

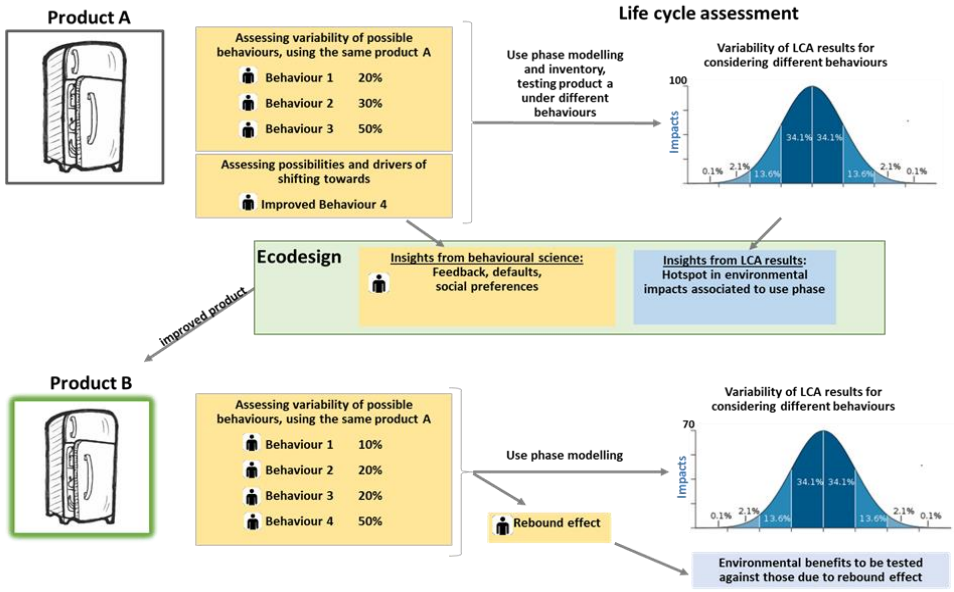
A preliminary methodological framework for coupling BE and LCA has been depicted by Polizzi di Sorrentino et al. 2016, focusing on how to capture the following elements:

- variability in selecting a product;
- variability in how the product is used, including its fate in the end-of-life stage;
- variability in the ownership of the product (e.g a shift from purchase to use of products).

Figure 7 illustrates the basic methodological principles of the integration of BE within LCA and eco-desing. The yellow boxes refer to the contribution of behavioural science to use phase modelling in LCA and improvement definition in eco-design. Behavioural science may help identifying more realistic user scenarios and sets of behaviours (behaviour 1, 2, 3) and their

possible share among a population, as well as exploring drivers of new/improved behaviours (behaviour 4). Behavioural science may also inform eco-design on specific drivers for behaviour change (e.g. setting the environmentally preferred options as default option in a product). Moreover, behavioral science plays a crucial role in order to properly model direct and indirect rebound effects, such as different responses to a marginal increase in income.

Figure 7. Conceptual scheme of the mutual interaction between behavioural science, life cycle assessment and eco-design



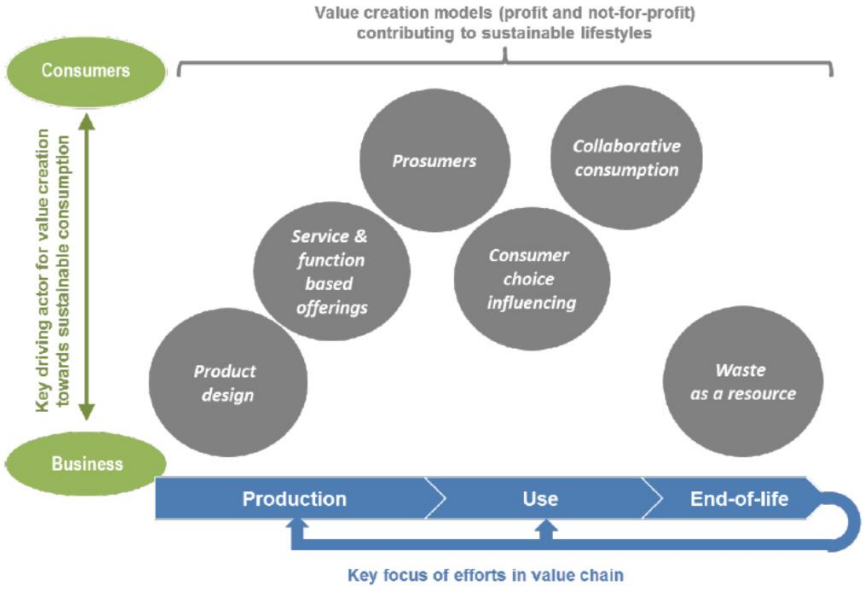
(Source: Polizzi di Sorrentino et al., 2016)

Many drivers could influence the range of variability and are presented in literature, e.g.:

- Different lifestyles can influence variability in consumption (e.g. rural/urban lifestyle Heinonen and Junnila, 2011) or emission profiles (e.g. CO_2 emissions Bin and Dowlatabadi 2005)
- Income (Girod and De Haan, 2010)
- Specific behaviours, e.g. driving behaviour (Girod et al 2013), eating "green" (Tobler et al. 2011)

However, the available literature is often relatively limited to a specific context/case study/survey. Currently, there are few studies on larger scale, usually focusing on market penetration (e.g. a worldwide study on car-sharing based on expert surveying, see Shaheen and Cohen, 2007). Moreover, consumer-related and business-related aspects are intertwined, as the evolution of pro-environmental behaviour is also influenced by evolution of business models and vice versa (new business models try to answer new consumer trends) as illustrated in Figure 8.

Figure 8. Value creation models contributing to sustainable lifestyles



(Source: EEA, 2014)

Given data limitations and the complexity of the production and consumption system, a different approach was needed to identify and then introduce assumptions in the LCA's use phase and consumption pattern, to define parameters and to populate the table of pro-environmental behaviour. Numerous assumptions on behaviours are proposed, based on findings of Eurobarometer surveys. Using Eurobarometer survey allows to identify country-specific patterns, as well as average EU ones, and represents the best proxy for an overview of the EU's trends regarding «stated preferences». Of course, the fact of being stated preference is also a limitation of the approach, because the actions are not related to statistics (no reality check), but to preferences.

In Table 5, we report an illustrative example related to how the results of an Eurobarometer survey (Eurobarometer, 2015) have been linked to the identified pro-environmental behaviour and, then, translated into LCA parameters (affecting the selection of a product or the intensity/modality of use of the product).

Table 5. Example of scenarios based on Eurobarometer surveys to be used for modifying parameters for the BoP indicator

Behaviour	Pro-environmental behaviour	BoP	Drivers	Effect	Ref.	Type of data collection source/ method	Regional relevance	Eco-innovation relevance	Eurobarometer			Action on the BoP	Life cycle phase	Parameter to be changed
									Ref	Question	Results			
Use of energy-efficient lighting bulbs (e.g. CFL and LED)	Use of energy efficient bulbs.	Housing	Cost, environmental attitude	25-80% less energy use	US Department of Energy	Estimate	yes	Comparative performance. Diffusion rate.	Eurobarometer 435, action on climate change 2015	You have bought a low-energy home	5% (increase of 1% compared to 2013)	BoP Housing	Use phase	Electricity use
Ownership and use of energy-efficient household devices	Purchase and use of energy-efficient household devices	Housing	Cost, consumer decision, habits	Energy saving, to be estimated	Estimate, based on individual adoption rate, energy saving and frequency of use	Estimate	yes	New, more efficient appliances	Eurobarometer 435, action on climate change 2015	When buying a new household appliance e.g. washing machine, fridge or TV, you choose it mainly because it is more energy efficient than other models	42% (increase of 8% compared to 2013)	BoP Housing	Use phase	Electricity use
		Appliances										BoP appliances (products)	All	New type of appliances to be included in the model
Full-load use of washing machine	Energy-efficient use of washing machine	Housing	Energy cost, attitude, habits	Water and energy saving	To be estimated	Surveys	yes	No				BoP Housing	Use phase	Electricity and water use
												BoP appliances (products)	Use phase	Electricity and water use
No clothes prewashing	Energy-efficient use of washing machine	Housing	Energy cost, attitude, habits	Water and energy saving	To be estimated	Surveys	yes	no				BoP Housing	Use phase	Electricity and water use
												BoP appliances (products)	Use phase	Electricity and water use
Use of clothes dryer	Air drying	Housing	Energy cost, attitude, habits	Energy saving 100%	-		yes	no				BoP appliances (composition)	All	Reduced share of drying machines
Use of home solar panel electric systems	Choosing and purchasing solar panels	Housing	Energy cost; Energy self-sufficiency ;	100% saving of conventional electricity	Energy Saving Trust, UK	Statistics + surveys	Yes	Technical performance and environmental gains.	Eurobarometer 435, action on climate change 2015	You have installed equipment in your home (e.g. solar panels) to generate renewable electricity.	6% (increase of 1% compared to 2013)			
Use of renewable energy sources	Choice and use of renewable energy sources	Housing	Energy cost; attitude; choice	Less fossil energy consumption	Estimate, based on use rate	Statistics	Yes	-	Eurobarometer 435, action on	You have switched to an energy supplier, which	9% (increase of 2%	BoP Housing	Use phase	Change in the energy mix for the use phase

Behaviour	Pro-environmental behaviour	BoP	Drivers	Effect	Ref.	Type of data collection source/ method	Regional relevance	Eco-innovation relevance	Eurobarometer			Action on the BoP	Life cycle phase	Parameter to be changed
									Ref	Question	Results			
									climate change 2015	offers a greater share of energy from renewable sources than your previous one.	compared to 2013)			
Use of low fuel consumption private car	Choice and use of less-emission car	Mobility	choice; standards	Euro 6 cars emit about 20% less CO2 (11% for small diesel cars)	Borken-Kleefeld et al., 2013		Yes	Less-fuel-consumption cars	Eurobarometer 435, action on climate change 2015	You have bought a new car and its low fuel consumption was an important factor in your choice	13% (increase of 2% compared to 2013)	BoP Mobility (composition of BoP)	All	Increased share of Euro 6 cars
Use of airplane for long journey (>6h of driving)	trip length of 500−1000 km, i.e. feasible transport mode choice	Mobility	comparative travel cost	Less fuel/GHG consumption per passenger	Estimates, depending on fuel type, emission standard, engine capacity and occupancy ;	Borken-Kleefeld et al., 2013	Yes	NA	Eurobarometer 435, action on climate change 2015	Avoid taking short-haul flights	13% (increase of 4% compared to 2013)	BoP Mobility (composition of BoP)	All	Increased share of long-haul flights
Use of public transportation in nearby areas by commuters (<30 km)	Transport mode choice	Mobility	Travel money; convenience; time budget	"Energy and environmental impacts of public transport depend on the type of vehicles used, driving pattern, road conditions, passengers load and other factors."	Tartakovsky et al., 2013	Estimate	Yes	NA	Eurobarometer 435, action on climate change 2015	You regularly use environmentally-friendly alternatives to using your private car such as walking, biking taking public transport or car-sharing.	36% (increase of 8% compared to 2013)	BoP Mobility (composition of BoP)	All	Increased share of trains and buses

Behaviour	Pro-environmental behaviour	BoP	Drivers	Effect	Ref.	Type of data collection source/ method	Regional relevance	Eco-innovation relevance	Eurobarometer			Action on the BoP	Life cycle phase	Parameter to be changed
									Ref	Question	Results			
Purchase of processed/convenience food	Food choice	Food	Income; convenience; time budget	- global warming and human toxicity: up to 35% lower; - eutrophication, photochemical smog and ozone layer depletion are up to 3 times lower	Schmidt Rivera et al. (2014) Ivanova et al. (2015)	LCA-based paper	yes	yes				BoP food (composition of BoP)	All	Reduced share of pre-prepared meals
Consumption of meat and dairy	Food choice	Food	Income / expenditure level	More environmentally impacting	Ivanova et al. (2015)	MRIO-based study	yes	yes				BoP food (composition of BoP)	All	Reduced share of meat and dairy, compensated by other types of food
Use of rechargeable batteries	Rechargeable battery purchase and use	Housing / Household appliances	Overall cost; Performance	overwhelmingly less environmental impact of the re-chargeable battery	Parson (2007)	LCA study	yes	yes						
Buying clothing made from (silk, cotton, wool or linen)	Purchase and use of all-natural fabric clothes	Clothing Housing (laundering)	Performance Health aspects	Mixed: Biodegradability - Cotton is pesticide intensive - Harmful solvents - PVC toxicity	NRDC	LCA studies	yes	yes						
Buying meat and meat products with eco-labels	Consumer's informed choice	Food	Egoistic attributes: health and cost; income level	More environmentally impacting	Ivanova et al. (2015)	MRIO- and LCA-based studies	yes	yes				BoP food (products)	All	More environmentally friendly food production and supply

Behaviour	Pro-environmental behaviour	BoP	Drivers	Effect	Ref.	Type of data collection source/ method	Regional relevance	Eco-innovation relevance	Eurobarometer			Action on the BoP	Life cycle phase	Parameter to be changed
									Ref	Question	Results			
			Environmental values											chain (e.g. less pesticides, less energy intensive production process, less transport, etc.)
Reduce packaging		Food/ Housing							Eurobarometer 435, action on climate change 2015	You try to cut down on your consumption of disposable items whenever possible, e.g. plastic bags from the supermarket, excessive packaging.	57% (increase of 6% compared to 2013)	BoP food (products)	Packaging	Reduced amount of packaging per unit of product
Locally and seasonal food consumption		Food							Eurobarometer 435, action on climate change 2015	You buy locally produced and seasonal food whenever possible	49% (increase of 13% compared to 2013)	BoP food (products)	Logistics	Reduced distance travelled
Reduce waste		Food/ Housing							Eurobarometer 435, action on climate change 2015	You try to reduce your waste and you regularly separate it for recycling	74% (increase of 5% compared to 2013)	BoP food (products/composition)	EoL/All	Reduced amount of food to waste treatment/lower amount of food bought
Insulation		Housing							Eurobarometer 435, action on climate change 2015	You have insulated your home better to reduce your energy consumption	23% (increase of 2% compared to 2013)	BoP Housing	Raw material and use phase	Addition of raw materials for insulation + reduced energy consumption in the use phase

5 Rebound effect: definition and possible methodologies towards its assessment in LCA

The study of the so-called "rebound effect" has traditionally pertained to the domain of neoclassical energy economics. In recent years, other disciplines have applied this concept in the context of the environmental assessment of products and policies: among these, the environmental rebound effect perspective, focused on efficiency changes and indicators that go beyond energy to multiple environmental issues, has remained relatively unnoticed (Vivanco et al., 2016a). One of the first studies addressing rebound effect and LCA has been done by Hertwich (2005), who pointed out that:

"any given efficiency measure has several types of environmental impacts. Changes in the various impact indicators are not necessarily in the same direction. Both co-benefits and negative side effects of measures directed to solve one type of problem could be identified. Environment is often a free input, so that a price-based rebound effect is not expected, but other indirect effects not connected to the price, such as spillover of environmental behaviour, also occur".

Based on an extensive literature review of LCA studies addressing it, Vivanco and van der Voet (2014) provided the following definition of rebound effect:

"The rebound effect is the change in overall consumption and production due to the behavioral or other systemic response to changes in economic variables (income, price and financial gains or costs of product and material substitution) induced by a change in the technical efficiency of providing an energy service."

The authors identified different types of rebound effect: direct, indirect, economy-wide/structural effect, and transformational effects. Further, they analyzed the way in which in LCA studies this aspect has been addressed. The different types of rebound effect can be summarized as follows:

- **direct effect**: change in the consumption or production of a product as a behavioral response to a change in economic variables induced by a change in the provision of the same product
- **indirect effect**: change in the consumption or production of other products as a behavioral response to a change in economic variables induced by a change in the provision of a product
- **economy-wide/structural effect**: change in the overall consumption and production as a systemic market in response to changes in aggregated total demand induced by a change in the provision of a product/service (e.g. by linking the LCA process tree to a CGE model)
- **transformational effect**: change in the overall consumption and production as a systemic societal response to changes in consumers' preferences, social institutions or the organization of production induced by a change in the provision of a product/service

The main elements of interest in rebound analysis are: the economic context, the infrastructure, the existing regulations, the consumer preferences and the established practices.

Based on their review of 42 LCA studies in which rebound was included, Vivanco and van der Voet (2014) were able to identify the advantages of the life cycle perspective, as well as to define the main inconsistencies and uninformed claims present in literature. Three main advantages have been identified and discussed, namely: (1) the representation of the rebound effect as a multi-dimensional, life-cycle estimate, (2) the improvement of the technology explicitness and (3) the broadening of the consumption and production factors leading to the rebound effect. However, some inconsistencies on the definition and classification of the rebound effect have been found among studies.

This concept is particularly relevant when assessing the diffusion ad adoption of innovation and emerging technologies through LCA. Sharp and Miller (2016) assessed the integration

between techniques for modelling diffusion and LCA of emerging technology for providing estimates for the extent of market penetration, the displacement of existing systems and the rate of adoption. Beyond the general perspectives of the macro-level diffusion models - which use a function of time to represent adoption -, they introduce a micro-level diffusion models that simulate adoption through interactions of individuals.

For the specific cases related to the BoP indicators, beyond the well-established studies that refer to rebound effects due to energy efficiency, several studies have been recently published in the field of mobility (e.g. for electric vehicle, Vivanco et al. 2014; on general mobility shift over time, Vivanco et al. 2015).

Focusing on the energy efficiency domain, Vivanco et al. (2016b) examined the extent to and ways in which the rebound effect is considered in policy documents, assessing 13 policy pathways for rebound mitigation. The authors concluded that an appropriate policy design and policy mix are key issues to avoiding undesired outcomes, such as the creation of additional rebound effects and environmental trade-offs. From their study, economy-wide cap-and-trade systems as well as energy and carbon taxes emerged as the most effective policies in setting a ceiling for emissions and addressing energy use across the economy.

However, due to an inconsistent incorporation of rebound effect into LCA up to now, rebound analysis requires the use of market information when building the life cycle inventory, as well as the further elaboration of the functional units (e.g. "average food consumption per person", "average consumption related to housing per person", "average use of cars"), based on data on the observed market behavior (e.g. income groups, household size clusters). Indeed, actual environmental gains of an eco-innovation become validated in the use phase by comparing alternative macro-level scenarios; however, in available studies it results that only few eco-innovations have been validated (i.e. eventually resulting in environmental pressure reduction) in their actual economic functioning (see e.g. Vivanco et al,2015)

Hence, based on the available literature, *it is clear that there is the need of identifying empirical regularities in household consumption expenditure dynamics induced by different variables (e.g. income, HDI) and their resulting environmental impacts*. The following section is devoted to the presentation of a methodology for the identification of rebound effect, focusing on an illustrative analysis of the expenditure in the food sector.

5.1 A methodological proposal for capturing rebound effects induced by household expenditure structure shifting, based on Engel's curve

As shown by EEA (2013b), European (i.e. EU-28 plus Iceland and Norway) trends of household spending patterns between 1996 and 2012 were mixed across countries. For getting a clearer picture of the existing and emerging household expenditure trends and for capturing the rebound effects due to the household expenditure structure shifting, the EU-27 aggregates need, in a first step, to be detailed at country-level, and then to be put into relationship with the country-specific variables, such as income level or Human Development Index (HDI) score. Mapping macro-level trends in the household demand structure can: i) provide important insights into the broad drivers of indirect rebound effects occurring in a certain country/region and ii) help in identifying empirical regularities in household consumption expenditure dynamics induced by various variables (e.g. income, HDI). Further, the environmental impact induced by these country-specific dynamics or by shifting between consumption categories or products groups can be calculated.

In an input-output framework for capturing the environmental impact changes induced by changes in the households' consumption expenditure (in monetary units), Ivanova et al. (2015) used *expenditure elasticity* as measure of *direct change of environmental impact* (%) due to a 1% increase in the total household demand (Table 6).

Table 6. Elasticity of environmental impact to household expenditure, by consumption and environmental impact category.

	Carbon footprint		Land footprint		Material footprint		Water footprint	
	ε	**R^2**	**ε**	**R^2**	**ε**	**R^2**	**ε**	**R^2**
Total	0.66***	0.83	0.56**	0.49	0.54***	0.85	0.40***	0.54
Direct impact								
Shelter	0.70*	0.08	-	-	-	-	0.20*	0.07
Mobility	0.80***	0.83	-	-	-	-	-	-
Indirect impact								
Shelter	0.58***	0.44	0.45**	0.20	0.73***	0.54	0.75***	0.60
Food	0.41***	0.62	0.49***	0.41	0.29***	0.46	0.30***	0.35
Clothing	0.58***	0.63	0.76***	0.65	0.63***	0.62	0.67***	0.62
Mobility	0.77***	0.79	0.80***	0.68	0.76***	0.81	0.54***	0.38
Manufactured products	0.75***	0.86	0.88***	0.69	0.75***	0.87	0.72***	0.77
Services	0.75***	0.81	0.91***	0.69	0.71***	0.81	0.69***	0.51

Note: Expenditure elasticity of consumption measures the effect of changes in per capita expenditure on the environmental footprints. The "Total" row shows the estimated coefficients when using the total per capita footprints as dependent variables that are regressed on household expenditure per capita. To compare coefficients across consumption categories, additional regressions are run separately where dependent variables are the environmental footprints of the different categories. The land and material footprints are associated with no direct impacts by households. The symbols *, ** and *** denote significance levels, α, of 10%, 5% and 1%, respectively.

(Source: Ivanova et al., 2015)

At country level, shifts between food expenditure share and shares of other consumption spending categories (e.g. clothing; recreation and culture) lead to changes in the overall demand structure and thus of its overall environmental impact. These potential shifts can take place between different expenditure categories, such as "Food and non-alcoholic beverages" (CP01 in COICOP) and "Restaurants and hotels" (CP11 in COICOP) within the same BoP – in this case Food; or to the same product group, for instance, through a shift between, for example, fish and pork meat, or between beer and wine consumption.

Beside the direct and indirect environmental impacts caused by changes in the amount of household expenditure, *dynamic structural shifts between consumption categories* may take place. Once captured, the effects of these shifts need to be tested in order to determine whether i) indirect rebound effects are brought about by these shift in consumption spending, and ii) there are structural dynamics patterns specific to a certain development level of a country (e.g., measured by HDI or a certain average income level). The hypothesis of an existing correlation between expenditure structure and country's development level was supported by Deaton and Case (1987), who point out that:

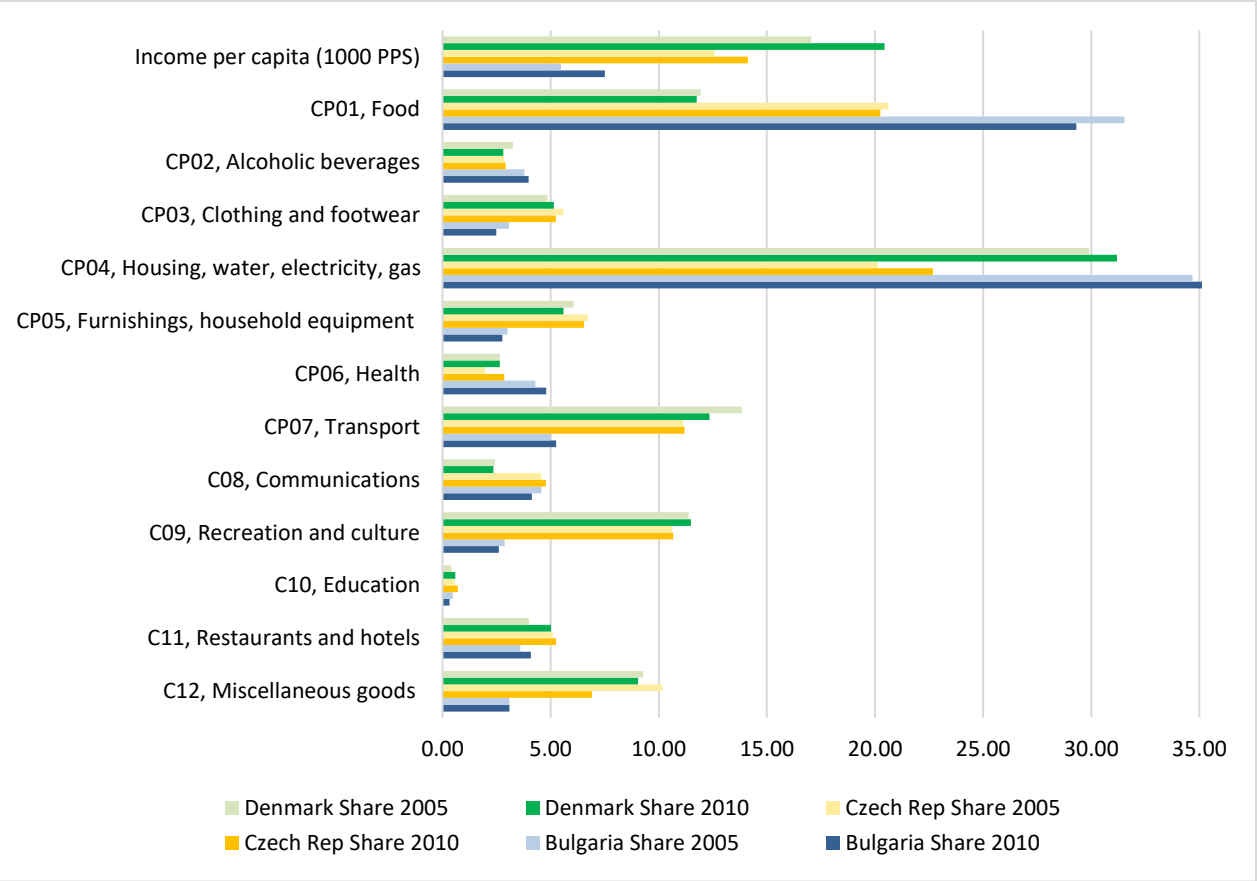
"*the pattern of demand, as represented by the shares of each expenditure in the total, can be compared both across countries and across time and, since we know a great deal about how these patterns change historically and with economic development, any given set of shares provides useful indicators of development*."

The correlation between country-level HDI and Real adjusted gross disposable income of households per capita, on the one hand, and the share of food expenditure, on the other hand, turns out to be highly negative. This is shown in the illustrative test in Figure 9, which presents income per capita and shares of COICOP 2-digit expenditure categories in 2005 and 2010 for: a) Denmark (high-level income country), b) Czech Republic (medium-level income country) and c) Bulgaria (lower-level income country). The three examples

show varying distribution of the shares according to the consumption expenditure category at different levels of disposable income per capita in Purchasing Power Parity (PPS).

As far as food expenditure share is concerned, one can notice that increasing levels of income per capita correspond to decreasing food expenditure shares. Thus, it may be inferred that additional income share is freed up for other expenditure categories (i.e. the other COICOP categories). In order to identify another potential empirical regularity, this kind of cross-country comparison needs to be further made for other consumption expenditure categories.

Figure 9. Income per capita and shares of COICOP 2-digit expenditure categories in 1) Denmark (high-level income country), 2) Czech Republic (medium-level income country) and Bulgaria (lower-level income country) in 2005 and 2010. (JRC calculations based on Eurostat, 2016c)[12]



For exploring in detail a single country, Table 7 presents a time comparison of private households' consumption expenditure in Germany, including the evolution of Real adjusted gross disposable income of households per capita (in PPS) and food expenditure shares.

[12] Eurostat (2016a) Real adjusted gross disposable income of households per capita in PPS, http://ec.europa.eu/eurostat/tgm/table.do?tab=table&language=en&pcode=tec00113
Eurostat (2016b), Household Budget Survey, Consumption expenditure of private households, http://ec.europa.eu/eurostat/web/household-budget-surveys/database
Eurostat (2016c) Household Budget Surveys, Mean consumption expenditure by detailed COICOP level (in PPS), http://ec.europa.eu/eurostat/web/household-budget-surveys/database

Table 7. Comparison of private households' consumption expenditure in Germany in the period 2003-2014[13]

Expenditure	2003		2009		2010		2011		2012		2014	
	EUR	%	EUR	%	EUR	%	EUR	%	EUR	%	EUR	%
	Average per household and month											
Real adjusted gross disposable income of households per capita (PPS)	**19,905**		**22,882**		**24,437**		**25,375**		**26,165**		**27,191**	
Private consumption expenditure	2,177	100	2,156	100	2,168	100	2,252	100	2,310	100	2,375	100
Food, beverages and tobacco	303	**13.9**	302	**14.0**	305	**14.1**	312	**13.9**	321	**13.9**	326	**13.7**
Clothing and footwear	112	5.1	98	4.6	100	4.6	104	4.6	106	4.6	107	4.5
Housing, energy, maintenance of the dwelling	**697**	**32.0**	**724**	**33.6**	**738**	**34.1**	**775**	**34.4**	**796**	**34.5**	**856**	**36.0**
Furnishings, equip-ment and house-hold maintenance	127	5.8	116	5.4	118	5.4	125	5.5	128	5.5	132	5.6
Health	84	3.9	91	4.2	91	4.2	93	4.1	96	4.2	92	3.9
Transport	305	14.0	326	15.1	305	14.1	319	14.2	329	14.2	325	13.7
Postal communication and telecommunication	68	3.1	57	2.6	56	2.6	57	2.5	57	2.5	61	2,6
Recreation and culture	261	12.0	231	10.7	236	10.9	244	10.8	245	10.6	248	10.4
Education	11	0.5	17	0.8	16	0.8	16	0.7	16	0.7	17	0.7
Restaurants and hotels	**101**	**4.9**	**113**	**5.2**	**113**	**5.2**	**119**	**5.3**	**127**	**5.5**	**129**	**5.5**
Miscellaneous goods and services	89	4.3	83	3.8	88	4.1	88	3.9	90	3.9	82	3.5

As the results of European Central Bank (ECB) Eurosystem's 2013 Household Finance and Consumption Survey[14] show, food consumption is positively correlated with income and wealth. Moreover, according to the results of 2015 survey, the cross-country heterogeneity in median food consumption is difficult to interpret without further data on e.g. household composition, purchasing standards, market structure, etc.

As it refers to food share of a geographically defined population, the applicability of Ernst Engel's law (Engel, 1857) for the EU countries needs to be tested. Basically, Engel law claims that the share of household expenditure spent on food (or, more generally, on nourishment) varies with household income level as follows: as income level increases, the

[13] Germany's Federal Statistical Office (Destatis), Consumption expenditure, https://www.destatis.de/EN/FactsFigures/SocietyState/IncomeConsumptionLivingConditions/ConsumptionExpenditure/Tables/PrivateConsumption_D.html

[14] https://www.ecb.europa.eu/pub/pdf/scpsps/ecbsp2.en.pdf

income share spent on food decreases, i.e. the income elasticity of demand of food is between 0 and 1. Chai and Moneta (2010) discuss in detail the context, both reasoning and findings of the Engel's empirical generalization.

The correlation between "Real adjusted gross disposable income of households per capita" (2010; Eurostat data) and the "share of food expenditure" is negative, with a Pearson correlation coefficient R^2 = -0.62 (Figure 10). In addition, when the EU countries' shares of food expenditure is correlated with Human Development Index (HDI 2010), the results also show a high negative linear correlation (Pearson correlation coefficient R^2 = -0.81).

Figure 10. Correlation between EU-27 real adjusted gross disposable income of households per capita and the share of food expenditure (year 2010; based on Eurostat 2016 c-e data). A colour code allow to distinguish country based on the HDI score

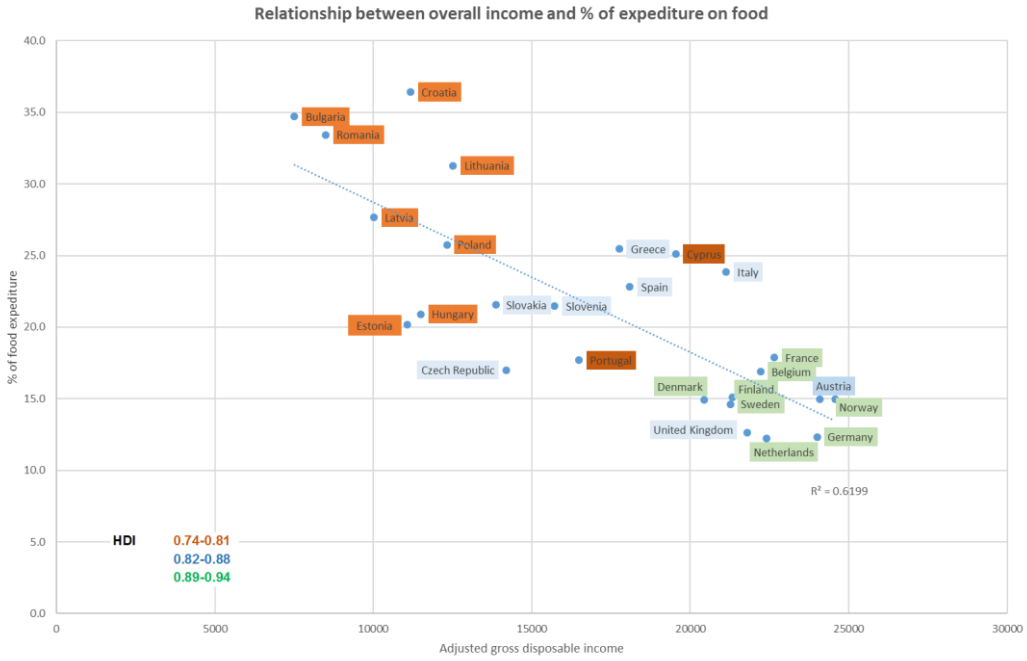
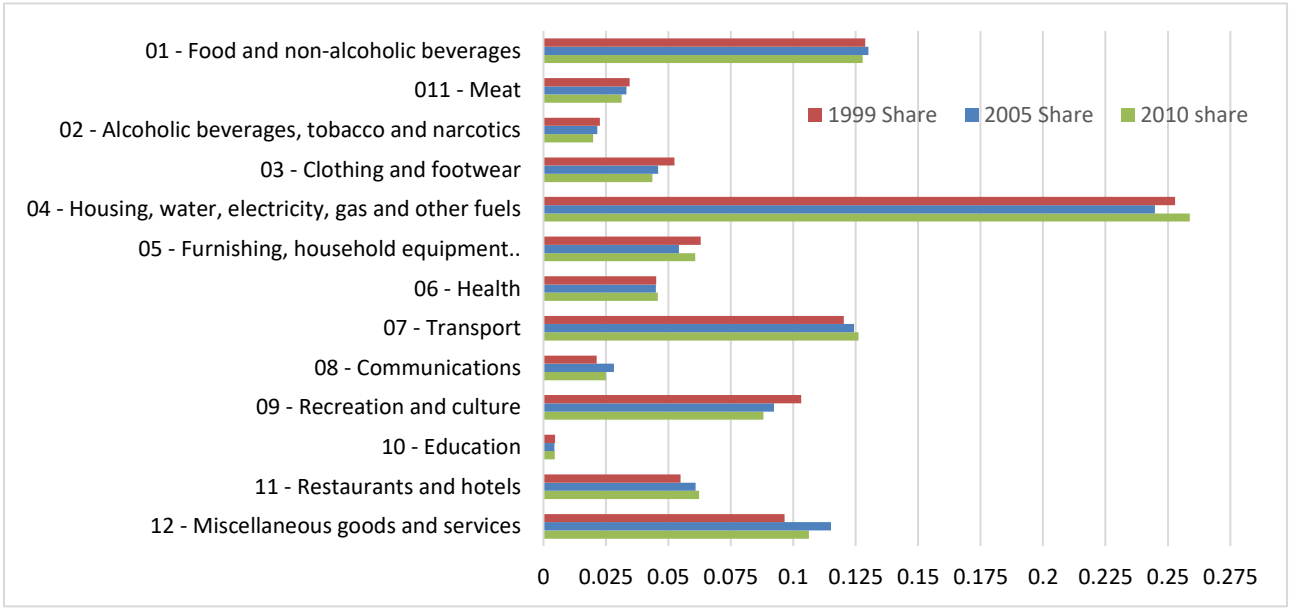


Figure 11. Example of Belgium's structure of consumption: shares of the 12 COICOP categories in the total consumption expenditure in 2010.



(Modified from: Eurostat, 2016b)

The examination of country-level food expenditure share evolution and of expenditure share shifts between food and the other consumption expenditure categories is thus ***a way of capturing country-level indirect rebound*** **effects**. Herring (2008) already noticed the importance of the expenditure shifts, pointing out that "this question of what the monetary saving is spent on is crucial to the concept of 'sustainable consumption' on what they will spend this 'discretionary income' depends on their current income levels: those on low incomes will use it for 'basic' goods; those on higher incomes on 'luxury' services".

Lower and medium-level income countries experience higher shares of food expenditure (and thus more reduced expenditure shares for the other consumption categories) and progressively decreasing shares of food expenditure. More developed countries are characterized by increasing expenditure shares allocated to other consumption categories, due to income freeing-up effect, and occurrence of "differences in satiation patterns" (Kaus, 2013).

The conclusiveness and empirical application of these consumption-related regularities need to be further investigated, especially because, so far "evidence on systematic changes in other expenditure categories is hardly available. Both theoretical conjectures and empirical evidence on other systematic changes in the decomposition of consumer expenditures remain scarce" (Kaus, 2013).

Building upon the assumption that, as less income is devoted to food by more reduced food share expenditure, more income is freed up for other expenditure categories (i.e. the other 11 COICOP categories), **further modelling-based research on expenditure share shifts between food and the other consumption expenditure categories can be carried out**. For example, as done by Kaus (2013), for identifying empirical regularities in consumption expenditure, country-specific income elasticities of the remaining 11 COICOP categories and their response to evolution of food shares needs to be determined.

6 Proposed structure for building country-specific consumption-environment profiles

Consumption patterns mirror both human development and quality of life. The amount of consumption can be expressed as $qi = gi(y, z)$, where qi is the quantity consumed of good i, y is income, wealth, or total expenditures on goods and services, and z is a vector of other characteristics of the consumer, such as household composition, socioeconomic group, etc. (Lewbel, 2006). In addition, the structure of consumption expenditure is driven by "non-economic factors" such as lifestyles and behaviours (Chitnis and Hunt, 2012), but their identification needs narrowing down the research scope, by "analysing differences in the behaviour of households within a single community or country" (EEA, 2010).

Even if annual food supply per capita is used as a proxy for actual per capita consumption, in order to map the food consumer behaviour patterns, further food supply breakdown and additional data and information about monetary/quantitative consumption characteristics in different regions, socioeconomic groups, households and individuals need to be gathered (e.g. Hallström & Börjesson, 2013).

Table 8. Methods of analysing consumption patterns at different scales

Method	**Source**	**Scale**	**Outcome**
Input-output; EE-MRIO	European system of national and regional accounts (ESA 1995)	Country level	EU-27 final demand and actual household consumption, by category (government, household, NHPS)
Household consumer expenditure survey	Classification of individual consumption by purpose (COICOP), based on Household budget survey (HBS); National accounts; Harmonised index of consumer prices.	Country level	Average consumption expenditures of households as individual consumption in euros per capita
Other household surveys	Eurostat's database on Income and Living Conditions; Various national surveys, e.g. German SOEP - Socio-Economic Panel (DIW)	Country level	socio-economic indicators (household composition, employment, income, health) and other contextual factors underlying consumption
Questionnaire-based surveys on individual consumption	Individual food consumption surveys, e.g. Dutch National Food Consumption Survey	National, sub-national and individual-level consumption	e.g. national food consumption databases; tables of food composition by the selected individuals over a specific period

6.1 Successive steps for bridging country-level consumption patterns at different levels: example of Food BoP

This section presents an illustrative example of the steps needed for capturing country-level consumption patterns. The exercise is related to food consumption, namely it could be applicable to the BoP food.

6.1.1 National-level analysis of consumption patterns

Step 1. FAO's Food Balance Sheets (FBS) provide physical data on annual per capita supply of food (kg/year/person) available for use within a country, which allows cross-country and over-time analysis of food consumption (FAOSTAT, 2016) [15]. In fact, FAO FBS provide data on food supply available for human consumption in a certain country, with no description of actual consumption patterns breakdown. In addition, nutrition data of food supply (kcal/capita/day) by product and country are provided.

Table 9. Food supply quantity (kg/capita/year) of several selected product groups and relatedproducts in Bulgaria and Denmark.

1. Bulgaria	**2005**	**2010**
Real disposable income per capita	5484	7512
Alcoholic beverages, out of which:	71.98	89.86
Wine	11.29	14.17
Beer	54.14	68.27
Meat, out of which:	50.63	53.46
Poultry meat	17.32	18.77
Pigmeat	17.84	26.6
Fish, Seafood	4.17	6.5
Bovine meat	12.59	4.97
Vegetables	63.39	77.95
2. Denmark		
Real disposable income per capita	17046	20446
Alcoholic beverages	120.71	101.42
Wine	27.95	29.19
Beer	87.49	67.56
Meat, out of which:	92.65	76.02
Poultry meat	19.67	21.99
Pigmeat	44.04	22.78
Fish, Seafood	24.36	23.06
Bovine meat	26.97	29.31
Vegetables	97.64	120.52

(Source: FAOSTAT (2016) and Eurostat (2016a) for data on real disposable income per capita)

Step 2. Further, product-level consumption data (in kg/capita/year) can be put into relationship with real disposable income or human development level (HDI). In this way, similar consumption trends, common to countries at similar development level/income level[16], could be identified, such as (source: FAO's Food Balance Sheets):

[15] For methodological details, http://faostat3.fao.org/download/FB/*/E

[16] Based on the 2013 HDI scores, the three categories are: Very high: HDI > 0.900; High: 0.850< HDI < 0.900; Medium: 0.850 > HDI > 0.800) (see Annex 2).

- beer (and alcoholic beverages): decreasing consumption in high-level income countries, simultaneous with sharp increase in consumption in low-level income countries;
- vegetables: increasing consumption, regardless of the income level;
- pig meat: decreasing consumption in high-level income countries and increasing consumption in low-level income countries;
- bovine meat: increasing consumption in high-level income countries, simultaneous with decrease/stagnation of consumption in low-level income countries.

Step 3. For identifying sound country-level food consumption patterns at product/product group level, additional research is needed – e.g. calculation of expenditure elasticity of specific food items in order to determine if they are necessity, normal or inferior goods.

6.1.2 Household-level analysis

The household expenditure survey is a statistical tool for measuring the material welfare of individuals, households and socio-economic groups. Household Budget Surveys are conducted by all EU member states' national statistical offices for identifying consumption patterns of private households, including their food intake habits, by food category (Eurostat, 2003). Currently, data on average consumption expenditure of private households are published by Eurostat, based on the COICOP categories (Annex 1).

A more in-depth analysis can be further carried out for the 3- and 4-digit COICOP categories, e.g. CP011 – Food, and its 4-digit COICOP group, Meat.

Then, based on Eurostat's Household Budget Surveys[17], the COICOP categories can be further broken down by socio-economic characteristics of private households, such as:
- household type/demographic composition (e.g. single person, two adults, two adults with dependent children, etc.);
- socio-economic group (e.g. workers, unemployed and retired persons, etc.);
- number of active persons in a household;
- urbanisation degree (i.e. cities, towns and suburbs and rural areas).

Other variables of interest are age and gender of a household reference person or other members.

6.1.3 Individual consumption

As far as **individual consumption** is concerned, data from Eurostat's Household Budget Survey can be supplemented by family/individual consumption surveys conducted in several EU countries, such as: The ECB Eurosystem's Household Finance and Consumption Survey[18], Nationale Verzehrstudie in Germany; Individuelle Nationale des Consomations Alimentaires 2 (INCA 2) in France[19]; Family Spending[20] by the Office for National Statistics (ONS) in UK. In US, the Department of Agriculture (USDA) monitors the individual consumption of food and beverages and nutrient intakes in US – "What we eat in America"[21].

These surveys can serve as a basis for further exploration of individual consumption patterns, based on characteristics such as income, gender, age, employment status, food choice, product intake frequency, etc. For example, UK's Family Spending 2015 survey shows that the largest expenditure categories of UK households in 2014 were transport, housing (excluding mortgages), fuel and power, and recreation and culture. Detailed results for COICOP01, Food and non-alcoholic drinks are presented in Annex 3.

[17] http://ec.europa.eu/eurostat/web/household-budget-surveys/overview
[18] https://www.ecb.europa.eu/pub/economic-research/research-networks/html/researcher_hfcn.en.html
[19] https://www.data.gouv.fr/fr/datasets/donnees-de-consommations-et-habitudes-alimentaires-de-letude-inca-2-3/
[20] http://www.ons.gov.uk/ons/rel/family-spending/family-spending/2015-edition/index.html
[21] http://www.ars.usda.gov/Services/docs.htm?docid=13793

7 Conclusion on consumption behaviours: knowledge gaps and future research needs

The research carried out in the areas of consumer's choice and behaviour, within the framework of the LC-IND2 project , has shown that there is a huge potential related to the use of life cycle based indicators for supporting policies in different stage of policy development (from policy identification to policy monitoring), as well as in other fields of application.

The peculiarity of the set of indicators is the clear focus towards consumption-oriented assessment, highlighting the relative importance and contribution of consumption to the overall assessment of the impacts. Wherever possible, they can be supplemented by incorporating the findings from other fields of consumption- and consumption-behaviour research.

- Household expenditure by consumption category can be used as proxy for existing consumption patterns and lifestyle drivers.
- Due to the integration of consumer behaviours into an interplay of mutually interacting factors, consumer behaviour analysis needs to be carefully carried out and context-specific.
- Consequently, policy measures aiming at sustainable consumption need to be well confined and targeted determinant-specific policy measures need to be designed.
- Empirical regularities (e.g. Engel curve) and further model-based analysis of household spending patterns shifting among various consumption categories can provide important insights into the consumption-structure changes and their resulting environmental impact in a certain region.

In order to overcome the current knowledge gaps and limitations, the various-scale methods for capturing consumption patterns reviewed or developed in this work document can serve as a basis for further research. For example, since the identification of individual consumer behaviours is context-based and thus does not apply to the "average European citizen" at EU-28 scale, thorough analysis of consumption patterns at differing scales, including country level, is needed.

Furthermore, understanding consumption entails developing a comprehensive framework covering structural and contextual aspects, individual factors (e.g. values, believes, habits and moral norms) and "structural constraints" (e.g. Phipps et al., 2013). For this purpose, disciplinary fragmentation should be overcome by deploying otherwise competing and complementary theories[22], models and research methods from various disciplines such as economics, sociology, psychology and consumer behaviour literature, and "bridging the gap between techno-economic and social science research by using a challenge-based approach that will bring together resources and knowledge across different fields, disciplines and technologies" (Mont et al., 2014).

The increasing levels of environmental pressures induced by European consumption vary significantly across and within countries by consumption category, whose contextual features and consumption pattern's determinants need to be further investigated.

Indicators for monitoring the evolution of the environmental impact of EU consumption are important guidelines for the transition to a resource-efficient and circular economy, especially in the key consumption sectors such as food, housing and mobility, which account together for almost 80 % of the environmental impacts of the EU consumption. As also recognized in one of the project's outcomes of the recently completed DESIRE research project (DESIRE, 2015), there is still an "insufficiency of indicator disaggregation by economic sectors and household consumption area". Furthermore, detailed consumption patterns need to be put in relation to their corresponding environmental pressures.

[22] See Hertwich and Katzmayr (2003) for a detailed discussion on various theoretical frameworks and models used in explaining consumer behaviour.

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List of abbreviations and definitions

BE	Behavioural Economics
BoP	Basket of Products
BPM	Behavioural Perspective Model
OICOP	Classification of Individual Consumption by Purpose
EAP	Environmental Action Programme
ECB	European Central Bank
EDH	Direct/embodied environmental impact
EE SUT	Environmentally Extended Supply Use Tables
EIH	Indirect/Use-related environmental impact
EIPRO	Environmental Impact of Products
ERE	Environmental Rebound Effect
FBS	Food Balance Sheets
GEB	General Ecological Behaviour
GHG	Greenhouse Gases
GTAP	Global Trade, Assistance, and Production
HDI	Human Development Index
ILCD	International Life Cycle Data System
INCA	Individuelle Nationale des Consomations Alimentaires
LCA	Life Cycle Assessment
MRIO	Multi-Regional Input-Output
MS	Member State
ONS	Office for National Statistics
PPS	Purchasing Power Parity
SCP-SIP	Sustainable Consumption and Production and Sustainable Industrial Policy
USDA	United States Department of Agriculture
WIOD	World Input-Output Database

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Annexes

Annex 1. Eurostat's Classification of Individual Consumption by Purpose (COICOP)

CP01	**Food and non-alcoholic beverages**
CP011	**Food**
CP0111	Bread and cereals
CP0112	Meat
CP0113	Fish and seafood
CP0114	Milk, cheese and eggs
CP0115	Oils and fats
CP0116	Fruit
CP0117	Vegetables
CP0118	Sugar, jam, honey, chocolate and confectionery
CP0119	Food products n.e.c.
CP012	**Non-alcoholic beverages**
CP0121	Coffee, tea and cocoa
CP0122	Mineral waters, soft drinks, fruit and vegetable juices
CP02	**Alcoholic beverages, tobacco and narcotics**
CP021	**Alcoholic beverages**
CP0211	Spirits
CP0212	Wine
CP0213	Beer
CP022	**Tobacco**
CP0220	Tobacco
CP023	**Narcotics**
CP0230	Narcotics
CP03	**Clothing and footwear**
CP031	**Clothing**
CP0311	Clothing materials
CP0312	Garments
CP0313	Other articles of clothing and clothing accessories
CP0314	Cleaning, repair and hire of clothing
CP032	**Footwear**
CP0321	Shoes and other footwear
CP0322	Repair and hire of footwear
CP04	**Housing, water, electricity, gas and other fuels**
CP041	**Actual rentals for housing**
CP0411	Actual rentals paid by tenants
CP0412	Other actual rentals
CP042	**Imputed rentals for housing**
CP0421	Imputed rentals of owner-occupiers
CP0422	Other imputed rentals
CP043	**Maintenance and repair of the dwelling**
CP0431	Materials for the maintenance and repair of the dwelling
CP0432	Services for the maintenance and repair of the dwelling
CP044	**Water supply and miscellaneous services relating to the dwelling**
CP0441	Water supply
CP0442	Refuse collection
CP0443	Sewerage collection
CP0444	Other services relating to the dwelling n.e.c.
CP045	**Electricity, gas and other fuels**

CP0451	Electricity
CP0452	Gas
CP0453	Liquid fuels
CP0454	Solid fuels
CP0455	Heat energy
CP05	**Furnishings, household equipment and routine household maintenance**
CP051	**Furniture and furnishings, carpets and other floor coverings**
CP0511	Furniture and furnishings
CP0512	Carpets and other floor coverings
CP0513	Repair of furniture, furnishings and floor coverings
CP052	**Household textiles**
CP0520	Household textiles
CP053	**Household appliances**
CP0531	Major household appliances whether electric or not
CP0532	Small electric household appliances
CP0533	Repair of household appliances
CP054	**Glassware, tableware and household utensils**
CP0540	Glassware, tableware and household utensils
CP055	**Tools and equipment for house and garden**
CP0551	Major tools and equipment
CP0552	Small tools and miscellaneous accessories
CP056	**Goods and services for routine household maintenance**
CP0561	Non-durable household goods
CP0562	Domestic services and household services
CP06	**Health**
CP061	**Medical products, appliances and equipment**
CP0611	Pharmaceutical products
CP0612	Other medical products
CP0613	Therapeutic appliances and equipment
CP062	**Out-patient services**
CP0621	Medical services
CP0622	Dental services
CP0623	Paramedical services
CP063	**Hospital services**
CP07	**Transport**
CP071	**Purchase of vehicles**
CP0711	Motor cars
CP0712	Motor cycles
CP0713	Bicycles
CP0714	Animal drawn vehicles
CP072	**Operation of personal transport equipment**
CP0721	Spare parts and accessories for personal transport equipment
CP0722	Fuels and lubricants for personal transport equipment
CP0723	Maintenance and repair of personal transport equipment
CP0724	Other services in respect of personal transport equipment
CP073	**Transport services**
CP0731	Passenger transport by railway
CP0732	Passenger transport by road
CP0733	Passenger transport by air
CP0734	Passenger transport by sea and inland waterway
CP0735	Combined passenger transport
CP0736	Other purchased transport services

CP08	**Communications**
CP081	**Postal services**
CP0810	Postal services
CP082	**Telephone and telefax equipment**
CP0820	Telephone and telefax equipment
CP083	**Telephone and telefax services**
CP0830	Telephone and telefax services
CP09	**Recreation and culture**
CP091	**Audio-visual, photographic and information processing equipment**
CP0911	Equipment for the reception, recording and reproduction of sound and picture
CP0912	Photographic and cinematographic equipment and optical instruments
CP0913	Information processing equipment
CP0914	Recording media
CP0915	Repair of audio-visual, photographic and information processing equipment
CP092	**Other major durables for recreation and culture**
CP0921	Major durables for outdoor recreation
CP0922	Musical instruments and major durables for indoor recreation
CP0923	Maintenance and repair of other major durables for recreation and culture
CP093	**Other recreational items and equipment, gardens and pets**
CP0931	Games, toys and hobbies
CP0932	Equipment for sport, camping and open-air recreation
CP0933	Gardens, plants and flowers
CP0934	Pets and related products
CP0935	Veterinary and other services for pets
CP094	**Recreational and cultural services**
CP0941	Recreational and sporting services
CP0942	Cultural services
CP0943	Games of chance
CP095	**Newspapers, books and stationery**
CP0951	Books
CP0952	Newspapers and periodicals
CP0953	Miscellaneous printed matter
CP0954	Stationery and drawing materials
CP096	**Package holidays**
CP10	**Education**
CP101	**Pre-primary and primary education**
CP1010	Pre-primary and primary education
CP102	**Secondary education**
CP1020	Secondary education
CP103	**Post-secondary non-tertiary education**
CP1030	Post-secondary non-tertiary education
CP104	**Tertiary education**
CP1040	Tertiary education
CP105	**Education not definable by level**
CP1050	Education not definable by level
CP11	**Restaurants and hotels**
CP111	**Catering services**
CP1111	Restaurants, cafés and the like
CP1112	Canteens
CP112	**Accommodation services**
CP1120	Accommodation services
CP12	**Miscellaneous goods and services**
CP121	**Personal care**

CP1211	Hairdressing salons and personal grooming establishments
CP1212	Electrical appliances for personal care
CP1213	Other appliances, articles and products for personal care
CP122	**Prostitution**
CP1220	Prostitution
CP123	**Personal effects n.e.c.**
CP1231	Jewellery, clocks and watches
CP1232	Other personal effects
CP124	**Social protection**
CP1240	Social protection
CP125	**Insurance**
CP1252	Insurance connected with the dwelling
CP1253	Insurance connected with health
CP1254	Insurance connected with transport
CP1255	Other insurance
CP126	Financial services n.e.c.
CP1262	Other financial services n.e.c.
CP127	Other services n.e.c.
CP1270	Other services n.e.c.

Source: Eurostat, http://ec.europa.eu/eurostat/ramon/nomenclatures/index.cfm?TargetUrl=LST_NOM_DTL&StrNom=COICOP_99&StrLanguageCode=EN&IntPcKey=&StrLayoutCode=HIERARCHIC

Annex 2. Grouping of the EU countries according to the 2013 HDI

Group I. Very high human development: HDI > 0.900

1. Netherlands
2. Germany
3. Denmark

Group II. Very high human development: 0.850< HDI < 0.900

1. Ireland
2. Sweden
3. United Kingdom
4. France
5. Austria
6. Belgium
7. Luxembourg
8. Finland
9. Slovenia
10. Italy
11. Spain
12. Czech Republic
13. Greece

Group III. Very high human development: 0.850 > HDI > 0.800

1. Cyprus
2. Estonia
3. Lithuania
4. Poland
5. Slovakia
6. Malta
7. Portugal
8. Hungary
9. Croatia
10. Latvia

Group IV. High human development: HDI< 0.800

1. Romania
2. Bulgaria

Annex 3. Breakdown of UK households' expenditure on food in 2014

				Average weekly expenditure all house-holds (£)	Total weekly expenditure (£ million)	Recording house-holds in sample	Percentage standard error (full method)
Total number of households						5,130	
1	Food and non-alcoholic drinks			58.80	1,563	5,100	*0.9*
1.1	Food			54.00	1,436	5,100	*0.9*
	1.1.1	Bread, rice and cereals		5.40	145	5,000	*1.1*
		1.1.1.1	Rice	0.40	12	1,380	*4.3*
		1.1.1.2	Bread	2.60	69	4,810	*1.3*
		1.1.1.3	Other breads and cereals	2.40	64	4,200	*1.5*
	1.1.2	Pasta products		0.40	11	2,030	*2.6*
	1.1.3	Buns, cakes, biscuits etc		3.70	98	4,570	*1.4*
		1.1.3.1	Buns, crispbread and biscuits	2.20	59	4,240	*1.6*
		1.1.3.2	Cakes and puddings	1.50	39	3,320	*2.1*
	1.1.4	Pastry (savoury)		0.80	21	1,950	*2.6*
	1.1.5	Beef (fresh, chilled or frozen)		2.00	53	2,230	*2.9*
	1.1.6	Pork (fresh, chilled or frozen)		0.70	19	1,220	*4.0*
	1.1.7	Lamb (fresh, chilled or frozen)		0.70	18	780	*5.8*
	1.1.8	Poultry (fresh, chilled or frozen)		2.40	65	2,730	*2.1*
	1.1.9	Bacon and ham		1.00	27	2,270	*2.8*
	1.1.10	Other meats and meat preparations		6.30	168	4,560	*1.4*
		1.1.10.1	Sausages	0.90	24	2,320	*2.5*
		1.1.10.2	Offal, pate etc	0.10	3	690	*5.6*
		1.1.10.3	Other preserved or processed meat and meat preparations	5.20	140	4,380	*1.5*
		1.1.10.4	Other fresh, chilled or frozen edible meat	0.00	1	40	*19.7*
	1.1.11	Fish and fish products		2.70	71	3,310	*2.0*
		1.1.11.1	Fish (fresh, chilled or frozen)	0.90	23	1,230	*3.5*
		1.1.11.2	Seafood, dried, smoked or salted fish	0.60	17	1,120	*3.9*
		1.1.11.3	Other preserved or processed fish and seafood	1.20	31	2,600	*2.3*
	1.1.12	Milk		2.30	62	4,750	*1.5*
		1.1.12.1	Whole milk	0.40	10	1,120	*4.8*
		1.1.12.2	Low fat milk	1.70	46	4,200	*1.6*
		1.1.12.3	Preserved milk	0.20	6	350	*8.7*
	1.1.13	Cheese and curd		1.90	52	3,730	*1.7*
	1.1.14	Eggs		0.70	19	2,990	*1.9*
	1.1.15	Other milk products		2.10	56	3,970	*1.7*
		1.1.15.1	Other milk products	1.00	26	3,010	*2.2*
		1.1.15.2	Yoghurt	1.10	30	2,880	*2.2*
	1.1.16	Butter		0.50	13	1,660	*2.8*
	1.1.17	Margarine, other vegetable fats and peanut butter		0.50	13	2,150	*2.2*
	1.1.18	Cooking oils and fats		0.30	8	1,150	*4.1*
		1.1.18.1	Olive oil	0.10	4	460	*6.0*
		1.1.18.2	Edible oils and other edible animal fats	0.20	5	780	*4.9*
	1.1.19	Fresh fruit		3.50	93	4,350	*1.6*
		1.1.19.1	Citrus fruits (fresh)	0.60	15	2,370	*2.6*
		1.1.19.2	Bananas (fresh)	0.50	13	3,200	*1.9*
		1.1.19.3	Apples (fresh)	0.60	15	2,320	*2.4*
		1.1.19.4	Pears (fresh)	0.20	4	930	*4.1*
		1.1.19.5	Stone fruits (fresh)	0.50	12	1,550	*3.6*
		1.1.19.6	Berries (fresh)	1.20	33	2,630	*2.2*
	1.1.20	Other fresh, chilled or frozen fruits		0.40	10	1,460	*3.2*
	1.1.21	Dried fruit and nuts		0.70	20	1,900	*2.9*
	1.1.22	Preserved fruit and fruit based products		0.10	4	870	*4.1*

	1.1.23	Fresh vegetables		4.20	113	4,660	*1.5*
		1.1.23.1	Leaf and stem vegetables (fresh or chilled)	0.90	24	3,240	*2.2*
		1.1.23.2	Cabbages (fresh or chilled)	0.40	10	2,390	*2.4*
		1.1.23.3	Vegetables grown for their fruit (fresh, chilled or frozen)	1.50	39	3,900	*1.8*
		1.1.23.4	Root crops, non-starchy bulbs and mushrooms (fresh, chilled or frozen)	1.50	39	4,090	*2.0*
	1.1.24	Dried vegetables		0.00	1	210	*12.1*
	1.1.25	Other preserved or processed vegetables		1.40	38	3,760	*2.2*
	1.1.26	Potatoes		0.90	24	3,270	*1.7*
	1.1.27	Other tubers and products of tuber vegetables		1.60	43	3,600	*1.6*
	1.1.28	Sugar and sugar products		0.40	11	1,910	*3.2*
		1.1.28.1	Sugar	0.30	7	1,560	*3.3*
		1.1.28.2	Other sugar products	0.20	4	600	*6.0*
	1.1.29	Jams, marmalades		0.30	8	1,450	*4.3*
	1.1.30	Chocolate		1.90	51	3,380	*2.4*
	1.1.31	Confectionery products		0.70	19	2,450	*2.8*
	1.1.32	Edible ices and ice cream		0.60	16	1,700	*2.9*
	1.1.33	Other food products		2.50	68	4,230	*1.9*
		1.1.33.1	Sauces, condiments	1.30	34	3,420	*1.8*
		1.1.33.2	Baker's yeast, dessert preparations, soups	1.00	26	2,680	*3.5*
		1.1.33.3	Salt, spices, culinary herbs and other food products	0.30	8	1,220	*5.9*
1.2	Non-alcoholic drinks			4.80	127	4,610	*1.5*
	1.2.1	Coffee		0.80	21	1,670	*3.5*
	1.2.2	Tea		0.50	13	1,640	*2.6*
	1.2.3	Cocoa and powdered chocolate		0.10	3	430	*5.7*
	1.2.4	Fruit and vegetable juices		1.10	30	2,780	*2.3*
	1.2.5	Mineral or spring waters		0.30	9	1,220	*4.1*
	1.2.6	Soft drinks (inc. fizzy and ready to drink fruit drinks)		1.90	52	3,280	*2.3*

Source: UK Family Spending, 2015 Edition, http://www.ons.gov.uk/ons/rel/family-spending/family-spending/2015-edition/index.html

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