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An introduction to product essentiality: conceptualisation and measurement

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ABSTRACT

Moments of crisis such as pandemics, hyperinflation, or natural disasters cause societies, governments, companies, and individuals to reflect on their priorities and essential needs. However, there is no concept or theory that links human needs to the consumption of goods and services. With this in mind, we introduce the product essentiality concept and a method to measure the essentiality level of a group of products. We used a survey questionnaire and quantitative methodology to illustrate the concept and propose that it can be reasonably approximated by a measure of perceived essentiality. Our analysis examined the influence of location, gender, and family income on the perceived essentiality of general goods and services. For this, a sample of Business and Management students in Brazil and the UK classified 81 products as 'essential' or 'superfluous'. Our findings and analyses show that applying the essentiality concept and its measurement can be consistent and useful for reflecting on what is essential and what is not. This study provides preliminary insights on product portfolio essentiality measurements suggesting it is significantly affected by location rather than gender and income. The results can help organisations to rethink their product portfolios, designs, and assist sustainable development policies.

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Introduction

Pursuing GDP growth has been the predominant economic policy in most nations (Jackson 2019). Despite this predominance, the logic, purpose, and consequences of GDP growth are still subject of debate (Jackson 2019; Lomborg 2020). There are concerns about socio-ecological crises because of the limitations of GPD growth policies to consider social issues and their disregard for environmental degradation. Opposing views have called for a redefinition of economic value and production boundaries (Mazzucato 2018), and even considering degrowth as an alternative economic policy (Raworth 2017; Hickel et al, 2022; Nature 2022). In fact, the concept of sustainable development was proposed to make a clear distinction between simply growing an economy instead of developing or improving it. Thus, the sustainable development debate has considered new measures such as natural and social capital (Managi and Kumar 2018). The United Nations 'Sustainable Development Goals' (UNSDGs) were seen to facilitate implementing and monitoring sustainable development initiatives or even guidance for businesses to create higher sustainable value.

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For this purpose, a sense of priority and awareness of human needs and environmental limits are needed. Nunes et al. (2016) propose that the sustainability of a social-ecological system should be measured by two macro-variables: essentiality (representing human needs) and environmental impact (as the respect of environmental limits when consuming natural resources). These variables are at the core of the sustainable development concept: a development that meets the needs of the present without compromising the needs of future generations and their right to access natural resources. Meeting societal needs and respecting environmental limits would avoid ecological and socio-economic crises (Alamino and Nunes 2023).

Although such discussions often occur in ecological economics, there is limited discussion on their influence or implications at the business and product levels. For instance, in considering the 'Theory of value', Méndez-León et al (2022) explain the different interpretations the word *value* can have, which in turn may have led, in studies in the business models area, to a lack of conceptualisation and misunderstandings around the term *sustainable value*. The literature about human needs (e.g. Maslow 1943; Max-Neef 1991) in the field of psychology has influenced topics of sustainable business management, including sustainable innovation (Singh, Maiyar, and Bhowmick 2020), and sustainable production and consumption (Seyfang and Longhurst 2016). However, a structured approach to embed human needs in product design and portfolio management is still missing (Nunes et al. 2022).

At the product level, the analysis of product features and under-featuring issues are discussed (Marzi 2022). However, literature has yet to identify an approach to evaluate how essential products are. Traditionally, the understanding of consumers' and users' (market) needs is a step that instructs product strategy (e.g. order-winners/qualifiers), product features and functionality, and finally, the choice of both product and process technologies (Nunes et al. 2022). Here, constraint-based thinking can serve as a starting point for assessing essentiality (Agarwal, Oehler, and Brem 2021). Nevertheless, this has predominantly been done based on market demand which differs from the basic societal need. Even well-intended strategies such as Bottom-of-the-pyramid (Prahalad 2012) and approaches such as Frugal or Reverse Innovation (Rosca, Arnold, and Bendul 2017; Albert 2019) have been criticised for leading to 'unsustainability', i.e. negative unintended consequences (Hall et al. 2012).

In short, despite the progress in academic literature, researchers, organizations, and policymakers have neither an approach to assess the essentiality of good and services nor a method to measure the essentiality balance of a group of products. This research problem leads to the following research question:

- How can the concept of essentiality be applied to products?
- How can essentiality level be measured in a group of products?

Hence, this paper's contribution to knowledge comprises the novel concept of product essentiality, and it also provides a method for measuring essentiality for an individual product or a group of products. By using the concept and method suggested in this paper, the essentiality level of a given group of products for a group of people can be calculated for a particular location. The concept also allows a more robust evaluation of the sustainability performance of product portfolios by combining essentiality level with data on product environmental impact.

The next section presents the literature related to the concept of essentiality. The structure of the remainder of the paper is as follows. We introduce product essentiality as a concept, as well as the related measurement method. A presentation of our methodology is followed by an overview of key findings. The final discussion is divided into implications for theory and practice.

Literature review on essentiality

Nunes et al. (2016) suggests the following definition of essentiality for socio-ecological systems:

> '(…) a measure of how the consumption of resources meets a system's needs. In societal terms, essentiality is a value given to a unit of consumption relative to its ability to meet a societal need. It can be measured either as the need of an individual, a population or a sub-system (e.g. communities). Through essentiality we conceptualise how available resources can sustain survival.' (p.34)

The critical aspect of essentiality is its direct link to the notion of 'human need' (Maslow 1943; Max-Neef 1991). Maslow's hierarchy of needs has at the bottom levels the physiological, safety and social needs. These are basic or essential needs that support the biological survival of beings. Social and psychological factors which depend on esteem and self-actualization needs are more subjective to assess. Physiological and safety needs may be much the same for all. However, consumption to meet social and psychological needs can differ across cultures, time, and geographic regions.

Max-Neef's Human Scale Development (HsD) methodology classifies the fundamental universal needs (e.g. protection, affection, etc) and the means or satisfiers (e.g. food, shelter, etc).

The method and choices of satisfying a need will impact on the use of resources because every production system is primarily a consumption system transforming resources into products and services to meet the needs or wants of society. The essentiality of processes must be differentiated from the essentiality of the products resulting from using these processes. For instance, producing a superfluous good still creates jobs essential for survival of a community or another social-ecological system (see Figure 1).

Therefore, when studying essentiality, the level of assessment matters. Figure 2 shows the key aspects of essentiality relating to different assessment levels. For example, the food supply chain (socio-technical essentiality level) is largely related to physiological needs, but not all products from that sector meet essential nutritional requirements (product essentiality level). At the firm level, essentiality is related to contributions to addressing local and global needs. At the design level, products can carry essential or non-essential features. A product with a large number of non-essential features may lead to commercial failure, excessive material waste, or lack of affordability to widen its societal value (Marzi 2022).

This paper focuses primarily on product and product portfolio levels. The next subsection presents the relevant supporting literature on product essentiality.

Product essentiality

Product essentiality has both objective and subjective perspectives. Physiological needs are mostly objective (e.g. water, food), social and esteem needs (or aspirations) are predominantly subjective. Two different fields of study have most considered the 'need' for a product as an important variable: marketing (including consumer behaviour) and product development. The former usually relates

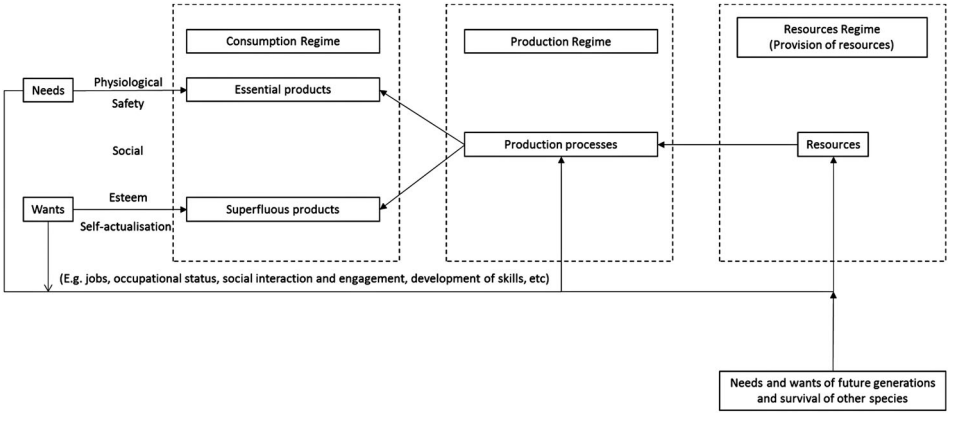

Figure 1. The needs and wants connection to consumption, production, and resources regimes.

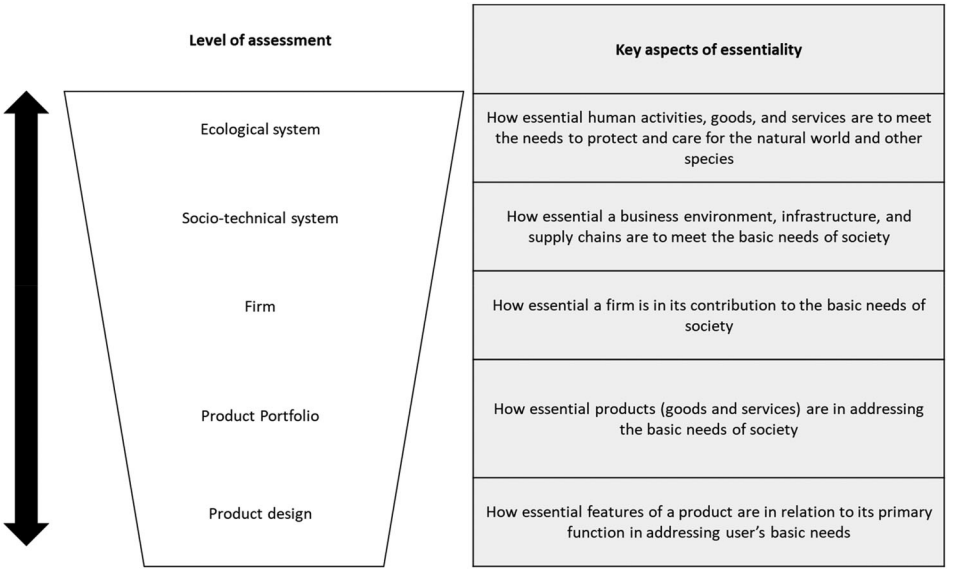

Figure 2. Levels of assessment and key aspects of essentiality (authors' elaboration).

primarily to the intentions of an individual to acquire or purchase a particular product. The latter involves multidisciplinary teams, including business, design, and engineering, among other disciplines. Their focus resides in transforming market (consumer) requirements into product specifications or features when developing a product.

While sustainable or environmentally responsible consumption has various interpretations (Sestino, Amatulli, and Guido 2021), they still need to be linked to needs and wants (McMeekin and Southerton 2012). This can be translated as a focus on product essentials and be linked to what Albert (2019) refers to as sustainable frugal innovation, or to what is called grassroots innovations (Brem and Wolfram 2014).

Gabor and Granger (1972) were among the first to discuss the priority of acquisition and ownership of products but focused on durable goods. Other studies (Corfman, Lehmann, and Narayanan 1991; Pickering 1981) addressed the reasons, patterns, and structures behind consumers' choices to acquire products in a heterogeneous range of products, i.e. before purchasing a particular brand. However, the priority order of acquisition or ownership is not necessarily linked with the level of essentiality as several other factors play a role in the purchasing decision. While the reasons to buy a product include the satisfaction of a need, no study in this field proposed a measurable construct to consider the level of essentiality of a product in the market. For instance, some authors (Kim et al. 2002) select three types of 'needs': functional, social, and experiential, and investigate how the apparel industry satisfies them in China and South Korea. However, this is not ranked within the spectrum of 'essential needs' and wants/aspirations.

Product development studies have been linked to the satisfaction of 'needs and wants' by a product's function or feature. For instance, the Total Product Design Concept (TPDC) consists of three main elements: functionality, aesthetics, and meaning (Srinivasan et al. 2012). In TPDC, functionality arises from the product's features that deliver the specific benefits that customers realise from using the product. Aesthetics arise from the product's sensorial characteristics, including its appearance, sound, touch, smell, and feel. Meaning refers to the significance and memorial associations about a product that is shared by its customers. As one will note, TPDC makes no distinction between a 'perceived benefit' and an essential need.

Similarly, the definitions of product essentiality are useful from a business and innovation perspective but with little link to the social sustainability dimension, i.e. addressing the essential

needs of society. Consideration of the latter must be integrated within business strategy (Porter and Kramer 2011), and consequently within companies' product portfolio.

New product development (NPD) research incorporates the needs of consumers for both conventional and non-conventional uses of the product. Also, the vast literature on the bottom-of-the-pyramid strategy (Hart and Milstein 2003; Prahalad 2012) and on associated products reveals the importance of considering basic needs within business models (Bocken and Short 2016). Nevertheless, there is still a research gap with respect to how strategic essential products are in the portfolio of R&D teams, companies, etc, when measuring sustainability performance.

This is particularly important for sustainability and strategic management scholars who will take 'market needs' as input to formulate theories. Clearly, it is also a key aspect of sustainable business strategy and related functional strategies such as sustainable operations strategy (Nunes et al. 2022); sustainable (frugal) innovation (Albert 2019), and related topics (e.g. design for sustainability, Bottom of Pyramid, Rao 2017). Additionally, life-cycle assessments would benefit from the essentiality concept as instruments to enhance the total sustainability of products. Finally, connecting the concept with both time and space dimensions is important. This will reflect the fact that the essentiality of products will change over time, e.g. as public transport improves, personal car essentiality may fall.

Product essentiality: concept & measurement method

Product essentiality differs fundamentally from the economic concept of utility. *Essentiality* has at its core the notion of 'need' while *utility* is based on 'desire to consume' (De Fraja 2009). However, both concepts use the logic of units of consumptions and diminishing returns of additional consumption units. Thus, the same essential good may have its marginal essentiality value reduced when the system's need has already been met. Consider the need for water to drink or wash. There is a fairly acceptable range of the volume of water required to meet those needs (e.g. around 2 L per day for drinking water and between 50 and 120 litres of water for an average shower or bath). So, the litres of water (unit of consumptions) below the lower threshold are all of high essentiality value. Then, the additional units of consumption will potentially have diminishing values between the lower and upper limits. Beyond the upper limit, all units of consumption would be considered to have zero essentiality (e.g. simply a waste of resources). Figure 3 illustrates a system where, in each period of time, a particular 'need' requires 8 units of consumption to be fulfilled. Note that all units below the lower threshold are given the highest essentiality value (1). Then, the next

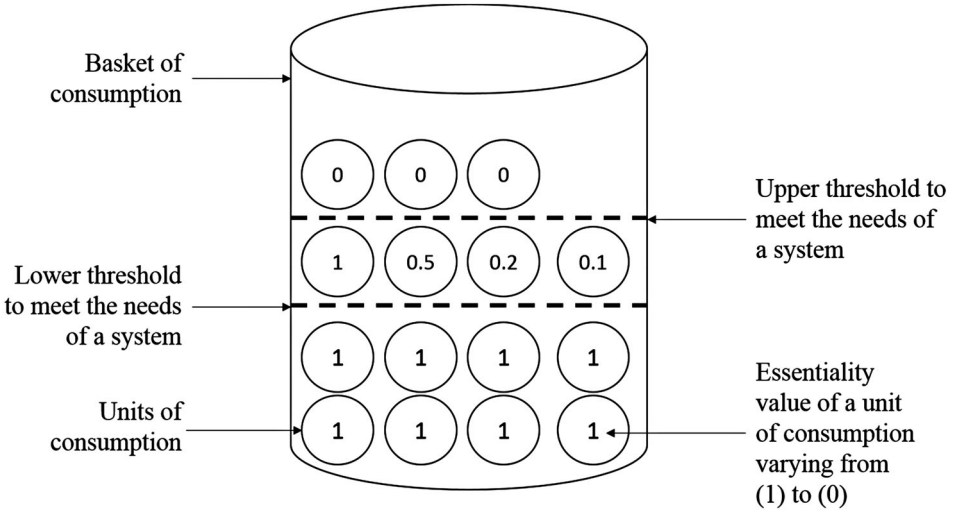

Figure 3. Essentiality values and diminishing returns of various units of consumption where (1) is essential and (0) is superfluous.

additional four units of consumption are still beneficial or at least bring no harm or dysfunction to the system. However, depending on when consumed, they may have different and diminishing essentiality values. Finally, above the upper limit, the consumption does not address any need in the system and may still create harm. In the illustration, three additional units of consumption above the upper threshold represent 'superfluous' consumption with an essentiality value of (0).

The concept of product essentiality is difficult to measure. Although there is an objective component to essentiality, in the sense that it might be possible to evaluate the necessity of certain products for biological and psychological sustenance, there is also a component that depends on cultural, temporal, and even personal influences. One solution to this complexity is to use the idea of *perceived essentiality* as a proxy. It seems reasonable to assume that people have, on average, a reasonable idea of what is essential to them based on personal experience.

Thus, our measure of *perceived essentiality corresponds to an empirical estimation of the probability that a randomly chosen individual from the sample group will classify a product as essential.*

By associating the value 1 to the answer 'essential' and 0 to 'superfluous', we can estimate the value of a product's essentiality by the average of all responses for each product, i.e. the total amount of times it was classified as 'essential' divided by the total number of persons classifying it (see Appendix 2 for a formal justification). In this way, the value e_i of the perceived essentiality of the i-th product is always in the closed interval $0 \leq e_i \leq 1$.

Methodology for this study

Design of data collection instrument

This study used an online survey questionnaire in which participants were asked to perform a binary classification of products as either 'essential' or 'superfluous'. Products and services were adapted from a list of 'essential things in life' used by the BBC (The British Broadcasting Corporation) (BBC 2004) to conduct a public survey in the UK in 2004. In our questionnaire's introductory page, it was made clear that the survey was NOT about intention to consume; it was instead about respondents' views about whether the product was essential or not. Data collection via an online survey has benefits and limitations, while cost and speed are the main benefits over traditional paper questionnaires.

The final list was compared against categories in the sustainable consumption literature (Spangenberg and Lorek 2002) and lastly validated by experts. The binary style of the survey benefited the breadth of the product and the speed in responding to the questionnaire (See Appendix 1 for a sample page of the survey questionnaire).

As a result, 81 products in both Brazil and UK were selected to compose survey questionnaire (see Table 1). The selected products belonged to four categories: consumables, comfort, social, and household appliances (electronics). The classification details are in Table 1 together with the total number of products in each category.

This research and its data collection instruments followed the Research Ethics procedures of the main authors' institution.

Context, population, and sample size

The cities of Porto Alegre (Brazil) and Birmingham (UK) were chosen due to their demographic similarities. For instance, when considering number of inhabitants, Porto Alegre has 1.4 million and Birmingham, 1.1 million. Birmingham has a slightly higher population density (4,262/Km2) of that in Porto Alegre (3,030/km2). Extreme weather events are rare in both cities; but they differ in their seasonal climates as Birmingham has a mild summer and Porto Alegre has a mild winter. Both are also considered culturally similar in the sense that they are direct elective democracies, although the UK is a post-industrial economy and Brazil is an emerging economy. The Human Development Index (HDI)

Table 1. Baskets of products.

Product or Service	
Consumables (22)	Social (18)
• Two meals a day • Fresh fruit daily or every other day • Vegetables daily or every other day • Medicines prescribed by doctor • Beef, chicken, fish or equivalent daily or every other day • Potato, rice, spaghetti or another source of starch equivalent daily or every other day • Bread daily or every other day • Milk daily or every other day • Fruit juices daily or every other day • Soft drinks daily or every other day • Alcoholic drinks such as beer, wine or spirits on the weekends • Coffee or tea daily or every other day • Eggs every daily or every other day • Beans daily or every other day • Yogurt every other day • Cigarettes every other day • Cigars on special occasions • Chocolates every other day • Mineral water (NOT tap water) daily • Sparkling water every other day • Muffins, custards, pudding, and other types of sweets every other day • Microwaveable/ready meals every other day	• Two pairs of all-weather shoes • Appropriate clothes for job interviews • Roast joint/vegetarian equivalent in a restaurant once a week • Presents for friends/family once a year • A holiday away from home once a year not with relatives • Replace worn-out furniture • Dictionary • Hardcopy of university text books • Hardcopy science fiction, thrillers, novels books • E-books • New, not second-hand, clothes for social occasions • Attending place of worship • Coach/train fares to visit friends/family quarterly • An evening out once a fortnight • Gown or suit for weddings, work, and other occasions • Having a daily newspaper • Going to a bar/pub once a fortnight • Holidays abroad once a year
Comfort (19)	**Household appliances (electronics) (22)**
• Beds and bedding for everyone • Reclined chairs to watch TV, read a book, play video games, etc • Bedside tables • Heating to warm living areas of the home • Air conditioner • Safe and damp-free home • Visiting friends or family in hospital • Warm, waterproof coat • Celebrations on special occasions such as Christmas • Ornaments to keep home in a decent state of decoration • Visits to school, e.g. sports day • Attending weddings, funerals • Insurance of contents of dwelling • Hobby or leisure activity • Collect children from school Carpet floors in living rooms and bedrooms • TV stand • Curtains / Blinds • Rugs, mats or similar in the house	Oven/stove Barbecue Grill Toaster Refrigerator Replace or repair broken electrical goods Washing machine Car Conventional landline Telephone Deep freezer/fridge freezer Television Microwave oven Video cassette recorder Tumble dryer CD player Home PC computer Laptop computer Dishwasher Mobile phone / Smart Phone Daily access to the Internet Satellite television Tablets computers Video game console

in Porto Alegre is 0.805 and 0.845 in Birmingham. Relevant differences include years of education and personal income. Annual average personal income in Porto Alegre was much lower than in Birmingham – £7,857 and £22,519, respectively. The number years in (formal) education was also higher in Birmingham (17.2) than in Porto Alegre (11.5). We chose to exercise some control in two variables (age and 'years of formal education') by surveying university business students only, which may have also reduced the variability of socio-economic status and personal income – which could theoretically impact the perception of essentiality.

The participation request was sent to undergraduate business students in Brazil and UK in March 2015. A large second-year module with 1,000 students enrolled was selected to participate in the UK

survey. This specific module was chosen because it is the largest Business school module, compulsory, and with one of the highest levels of engagement. The approach in Brazil was slightly different because class sizes are very small. Therefore, the online survey link was made available in the Business School newsletter and other internal communication to all 400 students registered in the Business Administration programme. A total of 147 students answered the survey in Brazil and 397 in the UK before it was closed in early June 2015. The response rate was 39.7% and 36.75%, respectively. In Appendix 2, we show that, under the assumptions of our model, such population sizes imply an acceptable precision level for our data analysis.

Method of data analysis

To check for the consistency and usefulness of perceived essentiality, we explored our dataset to find whether it could provide any insights within the sub-populations that answered the survey, which we grouped primarily by country and, within each of them, secondarily by gender and income levels. Each of the analysed sub-population was divided in two subgroups – UK vs Brazil for country, male vs female for gender and upper vs lower range for income.

The obtained values of perceived essentiality were compared within sub-populations using two methods. First, a linear regression, which provided the slope and the intercept of the adjusted straight lines, was used to visualise the difference between classifications, in particular the spread around a perfect correlation. The plot also allowed to compare how the classifications deviate from what would be a perfect match between the groups within subpopulations.

It is worth clarifying that we are not assuming any causal relationship between the two variables in each plot, only how well they fit a linear relation. While the linear regression provides good insight, a more precise characterisation of the correlation between the classifications is obtained by further calculating the Pearson correlation coefficient (PCC).

$$\Delta_i = e_i^{BR} - e_i^{UK}.$$

The order in the difference is a question of convention, and, although we chose the above order in our study, it should be stated clearly every time.

Findings

This section describes the analysis of the responses to our survey on perceived essentiality in Brazil and UK. As explained in the previous section, we estimate the *perceived essentiality* of a product as the percentage of persons classifying it as *essential*.

Figure 4 shows how perceived essentiality differs between the two countries. We plotted each product as a point on a graph for which the horizontal axis corresponds to the perceived essentiality in Brazil and the vertical axis to the perceived essentiality in the UK. The thick-dashed line is an adjusted straight line, and the thin dashed-dotted line represents how this line would be if the values were equal for both countries.

For each country, the data were broken down into two subgroups – male vs. female and high vs. low income. The plots of Figure 5 compare the obtained values per country for each of the two subgroups.

Table 2 contains the coefficients of the adjusted lines (2nd and 3rd columns) for each case named in the first column. It also shows the results for their PCC calculated for each dataset (last column).

According to the answers to the survey, there is no significant overall difference in perception concerning *gender* or, even more strikingly, concerning *income* within each country. We can see that in each, the slopes are close to the value 1, which would mean an equal classification by both groups. The intercept is also close to 0, showing that the values of perceived essentiality are indeed almost identical. The values of the PCC are very high, and the spread around the

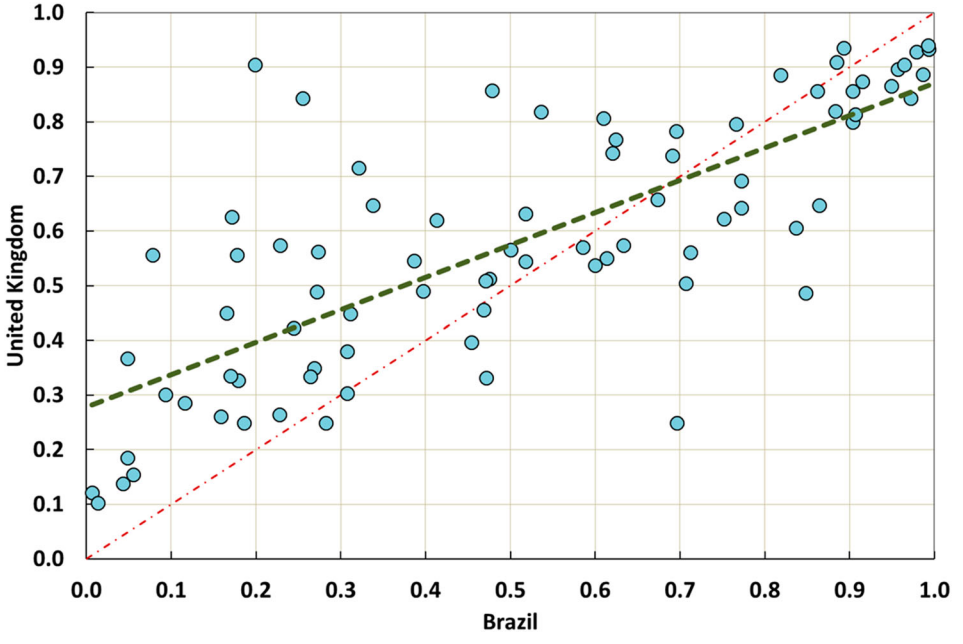

Figure 4. Online survey on perceived essentiality. Values correspond to levels of perceived essentiality in Brazil (horizontal) and UK (vertical). The thick dashed line is an adjusted straight line to the data and the thin dash-dotted line represents what it would look like if both countries exactly agreed on the perceived essentiality for all products.

regression results, measured here by the root mean square error (RMSE), is only about 10% of the maximum possible difference – which is simply 1 – between the predicted values and the measured ones.

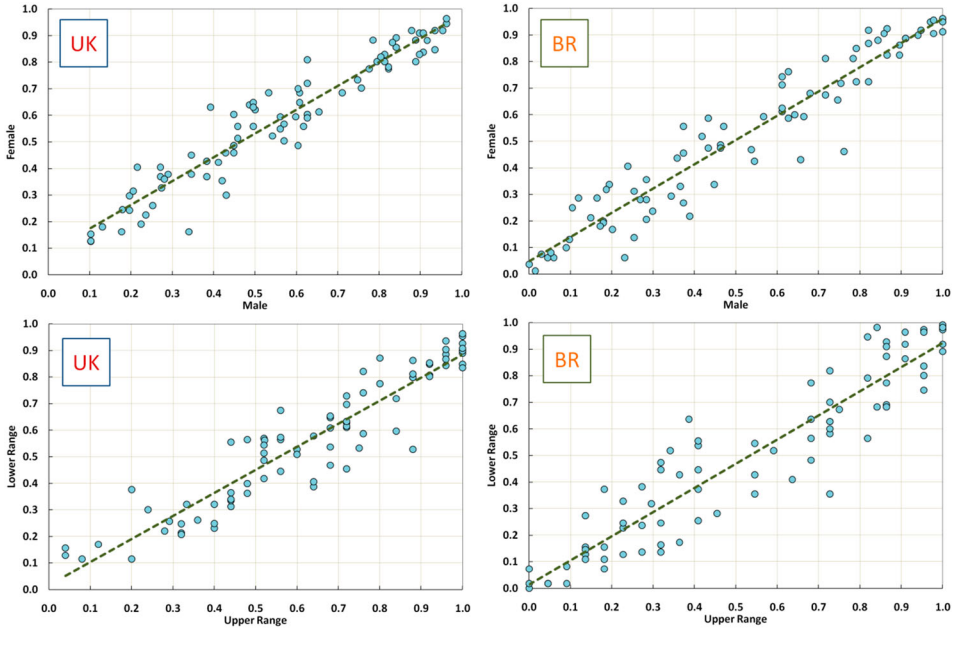

Figure 5. Data from our essentiality perception survey separated by country and subgroup. Dashed lines are once again adjusted straight lines.

Table 2. Coefficients of the adjusted lines from Figure 5.

	Slope	Intercept	PCC	RMSE
Brazil vs UK	0.5921	0.2784	0.77	0.1495
Male vs Female (UK)	0.8958	0.0840	0.95	0.0706
Male vs Female (Brazil)	0.9138	0.0478	0.96	0.0856
Lower vs Upper (UK)	0.8622	0.0238	0.94	0.0854
Lower vs Upper (Brazil)	0.9093	0.0144	0.93	0.1097

When compared against gender and income, the difference between countries is much more noticeable. The slope and intersection for the Brazil-UK comparison are very far from a perfectly matched classification. Although still high, the PCC is much lower than in the other cases. The RMSE is not too high and is close to all other calculated values.

The similarity in perception across gender might be because most products in the survey are not usually attributed to the particular culture of any of them. Some products, however, present such a high difference in their perceived essentiality that it is interesting to list some of them. For instance, the greatest disagreement in Brazil concerns 'drinking fruit juices daily'. It has an essentiality of 0.76 to men and only 0.46 to women. The same product in the UK is rated 0.45 by men and 0.60 by women, showing the opposite behaviour in the two countries. This demonstrates that macroscopic and microscopic data related to essentiality perception are important to understand different aspects of consumption and should be used appropriately according to the sought result.

The comparison between the upper and lower incomes in both countries suggests that a higher-income person perceives more products to be essential. It would be reasonable to expect a smaller correlation between the two ranges, but this is not observed. A possible explanation might be on the profile of those who answered the survey. A large amount of data came from students who, although they might be part of similar economic classes, would allocate their income range within what they earn, even if most of their money comes from their parents. In addition, their consumer habits were mostly acquired from living with their parents, which again might have a different income from their current one.

The above-presented data describes a scenario in which the perception of what is essential is strongly shaped by each country's culture and therefore influences the groups within it in much the same way, a fact that is reflected by the difference in the PCCs of the Brazil vs UK full data.

Our data also shows that UK based respondents are much more inclined to classify products as essential than Brazilians. This might be because many of those products might be more affordable in Europe, making them more widely used and creating a buying habit that would make the product perceived as essential. The higher income per capita may have also had an influence on this finding.

Figure 6 shows a comparison chart depicting the values of the essentialities perceived in Brazil *minus* the values in the UK with the products organised according to the four main categories described before. It clarifies that many products are considered more essential in the UK than in Brazil. The only category in which essentialities are greater in Brazil is consumables, most of which are food and drink products.

The essentiality profile

The tendency of attributing more (or less) essentiality to products, in general, can be compared between two parties by using what we now call their *essentiality profile*. To obtain that, we sort the products in ascending order of perceived essentiality and plot the points in that order. Figure 7 shows the resulting plot.

We divided the essentiality range into three equal bands of width 1/3 and indicated the centre of each band by a (green) dashed line for reference. A uniformly random attribution of essentialities would lie on a straight line increasing from 0 to 1 on this plot, meaning

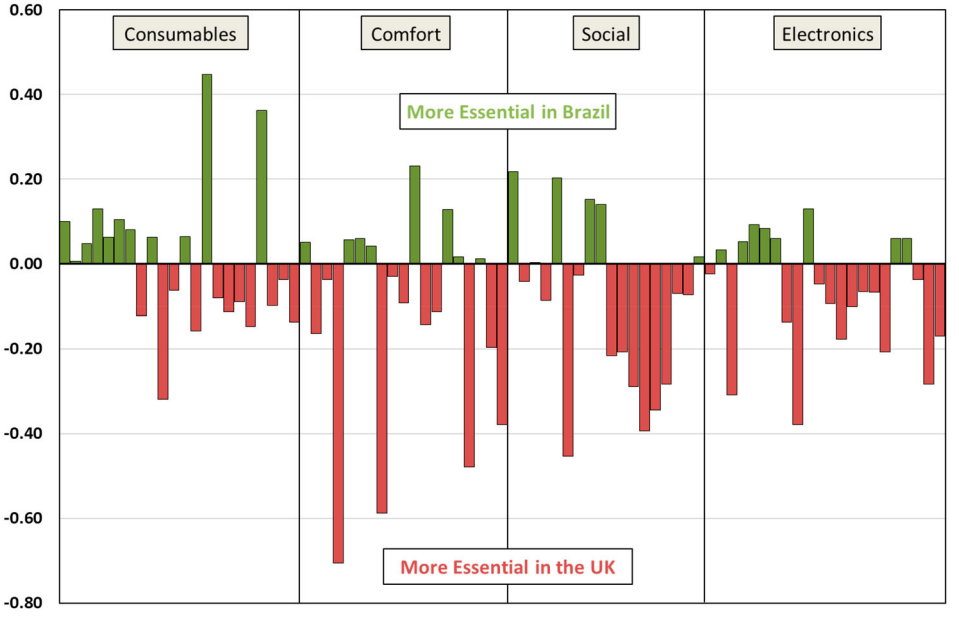

Figure 6. Difference in perceived essentiality (Difference = Brazil – UK) for all products in the survey. The data is grouped in four categories by vertical lines, labelled by the grey text boxes on the top of each band.

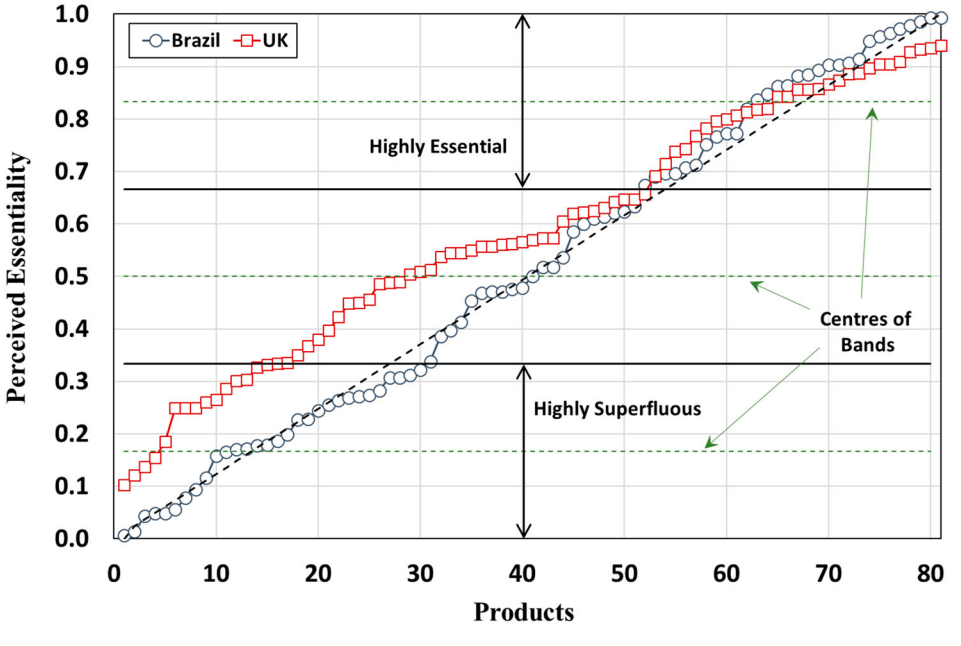

Figure 7. Comparison between the essentiality profile of UK (squares) and Brazil (circles). Products are organised according to order of increasing perceived essentiality. They were subdivided in three bands and dashed horizontal lines mark the centre of each band. The dashed diagonal straight line marks the place where a uniformly random classification of products would fall.

that each band would contain approximately 1/3 of the products. One can see that the UK respondents attributed higher essentiality values to the products not in the highly essential band than the Brazilian respondents.

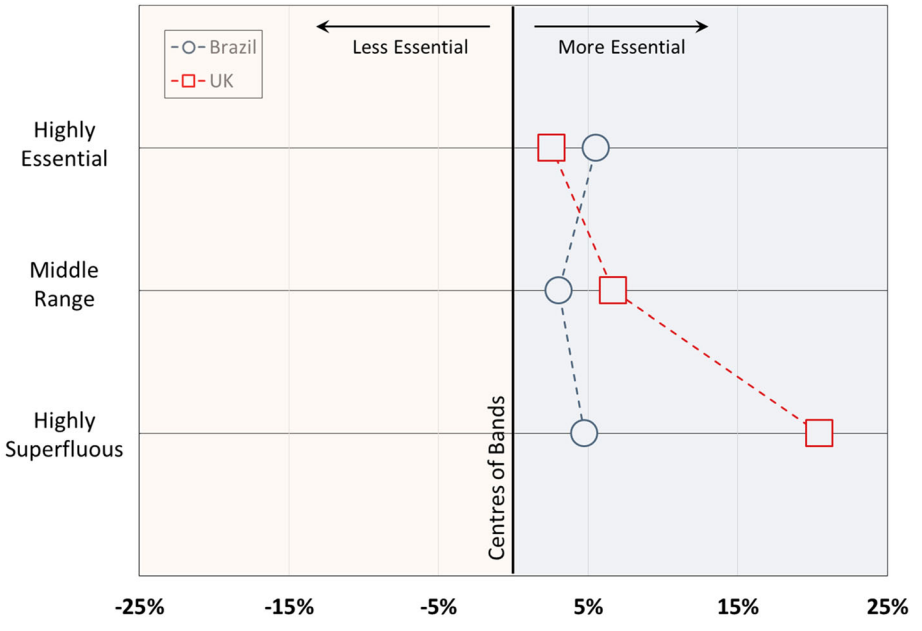

Figure 8. The distance between the centre of each band and the average value of the essentiality inside of it is plotted as a percentage of the size of the band. The negative side is represented only to highlight that it would be possible that the classifications would attribute less essentiality than the centre of the bands to the products.

To visualise it better, we calculated the average of the perceived essentiality inside each band and then plotted the distance between these values and the centre of the corresponding bands as a percentage of the size of the band (which is 1/3), which amounts to the quantity.

$$\frac{\left(\sum_i e_i - c\right)}{1/3},$$

where c is 1/6 for the highly superfluous band, 1/2 for the middle one and 5/6 for the highly essential. The index i is restricted to run only through the products belonging to the corresponding band. The results can be seen in Figure 8. Random values would lie exactly at the centre of the plot with a value of 0%. The effect described previously becomes clear. The greatest difference is for superfluous products. Also, it can be noted that essentiality perceptions in the UK are farther away from random values.

Discussion

Societies constantly reflect on their priorities, key economic sectors, and value of natural capital. Crisis makes those reflections more prominent, often increasing a sense of urgency or accelerating the pace of change. For example, the 2020 COVID-19 global pandemic has brought various countries to impose economic lockdown measures or to encourage a limitation on normal lifestyles. A large part of the challenge of implementing such policies has been to classify economic activities (product and service consumption) into 'essential' and 'non-essential'.

In any given crisis (e.g. political, economic, social, or ecological), socio-ecological systems, including supply chains, tend to reflect on the essential activities (Cohen 2020; Brem, Viardot, and Nylund 2021; Alamino and Nunes 2023). With more and more crises, even in parallel, these so-called polycrises lead to even more continuous reflections on what the essential activities, goods and services really are.

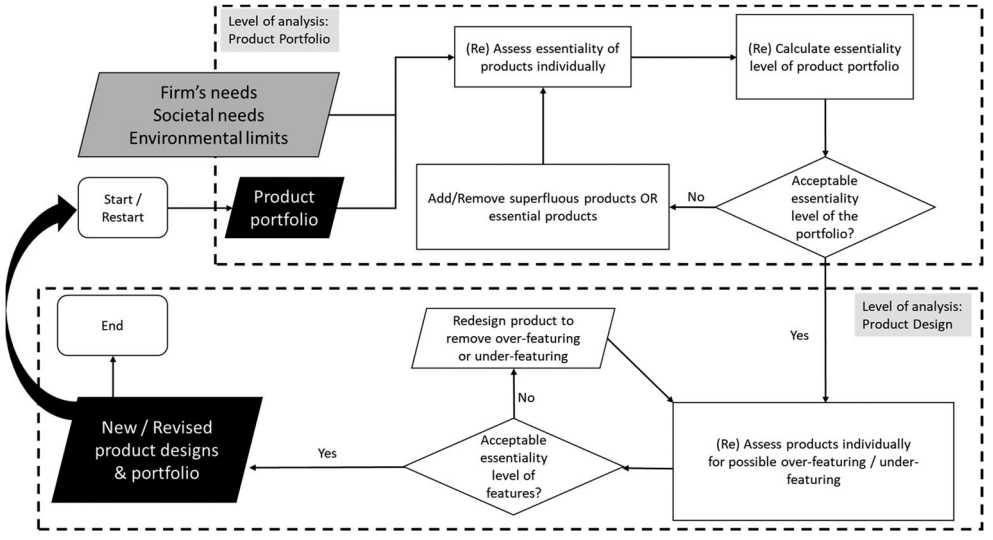

Figure 9. A process to manage essentiality of product portfolio and product design for higher levels of sustainability.

However, companies rarely assess (or are assessed by) the essentiality of their product portfolio. On the contrary, professional innovation management systems usually lead to so-called overengineered products (Marzi 2022). Here a plethora of resources leads to products and functions customer do not value or do not even recognise. However, for essential sectors such as healthcare, affordable and customer-centred product developments are much needed in developing countries (Agarwal, Brem, and Grottke 2018).

This paper provides the preliminary steps towards including essentiality as a concept and measure that organisations and managers can consider when evaluating the robustness and sustainability of their product portfolio. The essentiality concept will help in aligning sustainable production with sustainable consumption goals through a quantitative and easy-to-understand measure. Eventually, products and services are the 'public face' of companies and should represent their purpose, role, and contribution towards a more sustainable society (Nunes et al. 2022). New product development approaches can also be focused on essentials, i.e. sustainable frugal innovation (Albert 2019). Thus, organisations can strategically combine high-technological product development with a sustainability mindset and a high customer focus, including product features as pointed by Marzi (2022). With this ambitious task in mind, we offer an integrated framework to assess essentiality at both product portfolio and product design levels in Figure 9.

Finally, governments and individuals will also find the concept useful. For the former, it can assist with determining tax policy for essentials and non-essentials. For the latter, the concept can be a powerful tool to encourage sustainable consumption. To do more with less is not only a concept from and for emerging markets anymore. Also, Western countries suffer from extreme consequences from external shocks. Systemic changes (such as Brexit in 2016 or political turmoil in Brazil) affect the production and consumption of goods and services and are becoming more frequent. Hence, not only companies, but also governments and individuals need a strategic approach in coping with these situations on the long term.

Conclusion

The introduction of the *essentiality* concept and its measurement method are the key contributions of this paper. The empirical findings illustrate the meaningfulness of the concept. As for the practical contribution, the paper is quite timely since several countries are still in the aftermath of the

COVID-19 pandemic and having to choose what activities need to be prioritised in recovering the economy. In the UK, for example, the post-pandemic economic policy is strongly linked with new policies namely: Green Growth, Build Back Better, and NetZero. There have also been changes in regulations to tax excessive and harmful consumption (e.g. sugar tax) and even to ban products such as diesel and petrol vehicles and gas boilers. In addition, many nations continuously discuss reforms in their tax system to battle dysfunctional characteristics of modern societies (e.g. obesity, inequality, drug and alcohol abuse, etc). Reflecting on what is essential and what is not for both consumption and production is a primary step to fight socio-economic and ecological dysfunctions.

Limitations and future research

Our study has some possible methodological limitations, namely: (1) the use of a binary choice in the questionnaire, (2) the focus on similar-age individuals, and (3) the number of products included in the questionnaire. Hence, we recommend an agenda for future research below.

More in-depth and focused studies on the essentiality of specific segment of products (e.g. electronics) using of non-binary measurement scales is also important. Future research should also consider experiments in sustainable consumption and production systems. Other variables such as age of consumer, age of product, and number of substitute products as well as individual characteristics (e.g. Wang et al. 2022) can also be included to study the perceptions of essentiality. In addition, future studies should also employ a longitudinal approach to compare developments over time. In this context, intercultural differences should also be considered in more detail.

The geographical limitations of surveying UK and Brazil only would suggest that future research could compare countries with more different cultures (both UK and Brazil are western industrialised democracies). Thus, the concept could be expanded to other cultural contexts, e.g. in Asia, and to diversity categories such as gender.

Another possibility to enhance the significance of the essentiality concept may include cross-data analysis against product environmental impact. For industrial policy and business strategy studies, we recommend investigating the connection between essential and superfluous consumption against local and global production systems (Brem et al. 2020). It would be useful to examine the evolution of product essentiality over time, i.e. the connection between product essentiality and product life-cycle.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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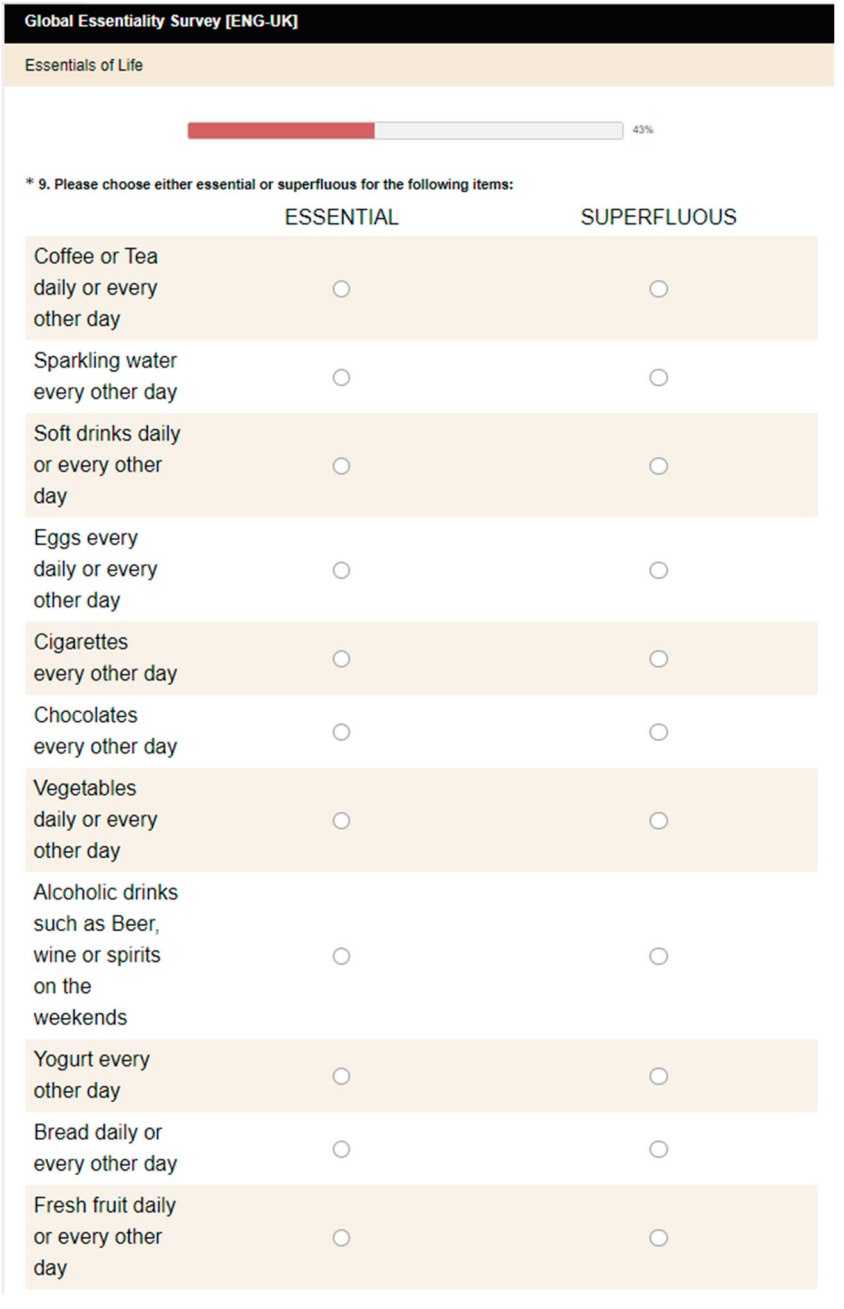
Appendices

1. Sample page of online questionnaire



Global Essentiality Survey [ENG-UK]

Essentials of Life

43%

* 9. Please choose either essential or superfluous for the following items:

	ESSENTIAL	SUPERFLUOUS
Coffee or Tea daily or every other day	○	○
Sparkling water every other day	○	○
Soft drinks daily or every other day	○	○
Eggs every daily or every other day	○	○
Cigarettes every other day	○	○
Chocolates every other day	○	○
Vegetables daily or every other day	○	○
Alcoholic drinks such as Beer, wine or spirits on the weekends	○	○
Yogurt every other day	○	○
Bread daily or every other day	○	○
Fresh fruit daily or every other day	○	○

2. Estimation of essentiality

The measure of essentiality proposed in this paper can be interpreted as the probability p_i that an individual, chosen uniformly randomly from the given population, will classify the i-th product as essential. Our estimate of p_i is simply given by the fraction of individuals in the population that classified the product as essential in the dataset. We can show that this estimation is simply the maximum a posteriori solution given our dataset. Consider product i and the

dataset $D_i = \{a_1^i, a_2^i, \ldots, a_N^i\}$, where N is the total number of respondents of the survey with $a_n^i = 1$ if individual n classified the product i as essential and $a_n^i = 0$ if they classified it as superfluous. The posterior distribution $P(p_i|D_i)$ of the probability p_i given the dataset D_i is then, apart from a normalisation factor,

$$P(p_i|D_i) \propto P(D_i|p_i)P(p_i),$$

where $P(D_i|p_i)$ is the likelihood of the parameter given the dataset and $P(p_i)$ is the prior distribution of p_i. The prior is assumed to be flat in the interval [0, 1] as we do not want to assume anything else about p_i except that it is a probability. Note that an implicit conditioning of the probabilities on the population is omitted as the estimations we make are explicitly population-dependent (in our case, in terms of country). Given this knowledge, we assume that respondents independently answered each question (without a direct influence from others), which allows us to write the likelihood as the product

$$P(D_i|p_i) = \prod_{n=1}^{N} P(a_n^i|p_i) = \prod_{n=1}^{N} p_i^{a_n^i}(1-p_i)^{1-a_n^i} = p_i^M(1-p_i)^{N-M},$$

where M is the number of individuals classifying the product as essential. The normalised posterior distribution is the given by

$$P(p_i|D_i) = \frac{(N+1)!}{N!(N-M)!}p_i^M(1-p_i)^{N-M},$$

which is known as a Beta distribution. Maximising this expression with respect to p_i gives simply $p_i = M/N$, which is equivalent to calculating the fraction of essential classifications. The fact that we are using a flat prior, implies that this is also equivalent to the **maximum likelihood** estimator.

The mean μ and variance σ^2 of the posterior are given by

$$\mu = \frac{M+1}{N+2}, \quad \sigma^2 = \frac{(M+1)(N-M+1)}{(N+2)^2(N+3)}.$$

The expression for the variance shows that the standard deviation is proportional to $1/N$. For population sizes $N \gtrsim 10^2$, the size of the populations will not influence the results for the precision we are using in our analysis.