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Energy price shocks induced by the Russia-Ukraine conflict jeopardize wellbeing

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ABSTRACT

The significant spike in global energy prices induced by the Russian-Ukrainian (RU) conflict is perceived as highly uncertain that may rise household living costs and adversely affect Sustainable Development Goals such as poverty elimination. However, the impacts on human wellbeing are entirely obscured by conventional economic analyses. Using the input-output price model and a human needs framework, we assess the impact of energy price shocks caused by the RU conflict on eight dimensions of human needs in 49 countries/regions. Our findings show that the non-material dimension Creation and the material dimension Protection are the most affected human needs globally, with declines of 3.7%–8.5% and 3.6%–8.4%, respectively. Households in BRICS countries are hit hardest on these human needs (2.0-2.2 times the global average) owing to higher price increases and higher energy-dependent consumption patterns. The human need satisfaction of low-income groups is not only severely affected, but also the poorer the country in which they reside, the more serious the decline of their satisfaction, while there is no such problem for higher income groups. Our findings underscore the need to consider both material and frequently overlooked non-material dimensions of wellbeing when designing targeted policies to protect the vulnerable from energy price shocks.

1. Introduction

The outbreak of the Russian-Ukrainian (RU) conflict not only triggered military and political turmoil but also drastically increased uncertainty in the global economy owing to the inevitable knock-on effects in a highly connected world (Smit et al., 2022). For example, the RU conflict has resulted in a significant spike in global energy prices. Compared to the average price in 2021, the global average increase in the price of energy goods such as natural gas and crude oil has been 115% and 41%, respectively, in 2022 (World Bank Group, 2022), with further growth expected according to the IEA (IEA, 2022a). The crisis is also seen as a critical opportunity for countries to phase out fossil fuels and accelerate investment in renewable energy, and thus reducing the dependence on carbon-intensity energy and facilitating the low-carbon transition (Tollefson, 2022). However, the multiple social, economic and environmental impacts of this energy price surge and fluctuations should not be overlooked, as the transition can succeed only if policies ensure affordable access to low and zero carbon options (OECD, 2022; Pereira et al., 2022). The direct and indirect impact of rising energy prices due to the geopolitical conflict on people's livelihoods is of particular concern given the already severe socioeconomic consequences of the COVID-19 pandemic (Zhang et al., 2022). In addition to direct impacts of rising energy prices on households' cost of living, there are also indirect impacts of energy prices on production costs through global supply chains causing a price increase in other products. Consequently, households have to adapt to higher prices by changing their consumption patterns to lessen the price shock. That is, while consumer consumption preferences stay the same in the short term, consumers

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may reduce product consumption in the face of rising commodity prices, which further affects human wellbeing (Andreyeva et al., 2010; Campbell and Cocco, 2007; Green et al., 2013; Lederman and Porto, 2016).

Numerous analyses have examined the impact of the energy price shock stemming from the RU conflict, shedding light on its severe impact on households in terms of energy costs (Mahler et al., 2022; Guan et al., 2023; Steckel et al., 2022; Kalkuhl et al., 2022; Adolfsen et al., 2022), energy insecurity (Cozzi et al., 2022; Zakeri et al., 2022) and poverty (Mahler et al., 2022; Guan et al., 2023). For example, Mahler et al. (2022) evaluated the impact of the RU conflict on poverty using the estimation from the Household Impacts of Tariffs (HIT) Simulation Tool, which is based on a harmonized household survey and tariff data for 54 low- and lower-middle income countries. They found that the price increases resulting from the RU conflict would plunge an additional 75–95 million people into poverty in 2022. Guan et al. (2023) utilized a global multi-regional input-output database and detailed household expenditure data to model the direct and indirect impacts of heightened energy prices on households. They found that the total energy costs for households would contribute to a 2.7-4.8% increase in household expenditures, pushing an additional 78–141 million people into extreme poverty. Steckel et al. (2022) estimated the impact of fossil fuel price increases on European households based on representative household expenditure data and a multi-regional input-output model. Their findings revealed that the poorest 10% faced average cost increases of 20% (of total household expenditures), while the richest 10% faced additional average costs of 13%. These studies on the influence of energy price shocks have often used monetary indicators, such as energy cost or cost of living, to quantify changes in household consumption (Global Crisis Response Group, 2022; Guan et al., 2023; Mahler et al., 2022; Smit et al., 2022). However, the impacts of energy price shocks under the sudden geopolitical conflict have not been comprehensively assessed considering other important dimensions of wellbeing (Perelli-Harris et al., 2022; Rao and Wilson, 2021). It is vital to pay attention to such issues as the RU conflict may exacerbate the wellbeing crisis in other than just economic dimensions and further lower the pace towards reaching sustainable development goals (SDGs). In this study, we address the questions of which aspects of human wellbeing are most adversely affected by energy price shocks and who would be most impacted.

Wellbeing-based measures are deemed better and advocated for measuring human welfare compared to monetary measures (Fitouss et al., 2011; Porio, 2015; Vita et al., 2019). One of the ways to portray wellbeing is the satisfaction of human needs, including Subsistence and Protection, Affection, Understanding, Participation, Leisure, Creation, Identity, and Freedom (Ekins and Max-Neef, 1992; Jackson and Marks, 1999; Max-Neef et al., 1991; Vita et al., 2019). These needs can be satisfied by consumption of economic goods and services, which are proposed as satisfiers of human needs. Based on material intensity, human needs be classified as material and non-material (Jackson and Marks, 1999). Material human needs are essentially Subsistence and Protection, the satisfaction of which requires material inputs. Specifically, Subsistence relies heavily on food and shelter for basic living, while Protection includes health care, safety and financial security and can be satisfied by a range of goods, from clothes and heating fuels to medicine (Vita et al., 2019). By contrast, non-material human needs refer more to the process of empowerment or spiritual fulfillment from a personal, social or cultural perspective through the consumption of goods or services. For instance, Creation can be satisfied through activities that transform skills and ideas into material or immaterial objects in both formal and informal work, based on the application of multiple materials, tools and machines, including ideal space, instruments or tools, and to a lesser extent transportation (a detailed description of human needs can be found in Methods) (Costanza et al., 2007; Ekins and Max-Neef, 1992; Max-Neef et al., 1991; Vita et al., 2019). According to the definition from Max-Neef et al. (1991), a market good can satisfy several human needs simultaneously, thus seen as "synergistic satisfiers" (Ekins and Max-Neef, 1992). Energy-related products, for example, can not only ensure home heating (Subsistence and Protection), but also provide ideal space for creativity (Creation), while being closely related to commuting (Freedom) and tourism (Leisure). Although increasing consumption of goods does not necessarily increase the wellbeing, a decrease in consumption of goods may directly exert a negative impact on the satisfaction of human needs and thereby, wellbeing (Ekins and Max-Neef, 1992; Max-Neef et al., 1991). Thus, consumption can be a valuable mediator to measure the changes of wellbeing under the energy price surge through its ability to meet human needs.

In this study, we apply the input-output price model extended by using price elasticities and the fundamental human needs framework to assess the impact of energy (i.e. natural gas and crude oil) price shocks caused by the RU conflict on household consumption and the changes in human needs satisfaction. We find that not only material welfare, but also non-material human needs are jeopardized by the price shock. Country-level results show that household human needs in BRICS countries are more affected. We also found that the poorer the country in which low-income groups reside, the more serious the decline of their human needs satisfaction, whereas no such trend is detected in higher income groups. We thus suggest that under the price surge caused by unexpected issues (such as the RU conflict), the severe impact on both material and non-material human needs of households needs to be noted, and more attention be paid to the uneven impact on low-income groups in BRICS and lower-income countries. Our assessment delivers new insights into the disproportionate social impact of energy price shocks under RU conflict on human needs and human wellbeing, consequently contributing to developing more informed policies to safeguard the human need to ensure human wellbeing on the pathway towards SDGs.

2. Methodology and data

This paper uses an integrated framework that combines the input-output price model, the Extended linear expenditure system (ELES) model and the quantification of fundamental human needs to measure the impact of energy price changes on wellbeing from the human needs perspective (Fig. 1). 1) First, we extend the traditional input-output price model to a global multi-regional input-output price model to analyze the impact of energy price changes on the prices of different products in different regions in the context of the RU conflict. 2) We use the ELES model to construct consumer demand functions and calculate the price elasticities of consumers in different income groups for different products.3) We calculate the changes in consumption under price shocks based on the price changes of different products and the price elasticities of consumers. Finally, we use the fundamental human needs framework to examine the changes in household human needs in different income groups.

2.1. Assessing price changes by product

The input-output (IO) analysis framework provides a comprehensive representation of the production linkages between the various sectors of the national economy. Leontief developed the input-output price model from the point of view of production costs (Leontief, 1953), which is widely used to analyze the impact of a change in the price of one or more products on the price level of other products and can provide a complete description of this impact (Hawkins and Simon, 1949; Jiang and Tan, 2013; Przybyliński and Gorzałczyński, 2022; Siala et al., 2019). When energy prices rise, the input-output price impact model can depict the impact of energy prices on the prices of other products.

According to the column balance of the input-output table, the total output value of sector j is equal to the sum of the intermediate and initial input values, as following:

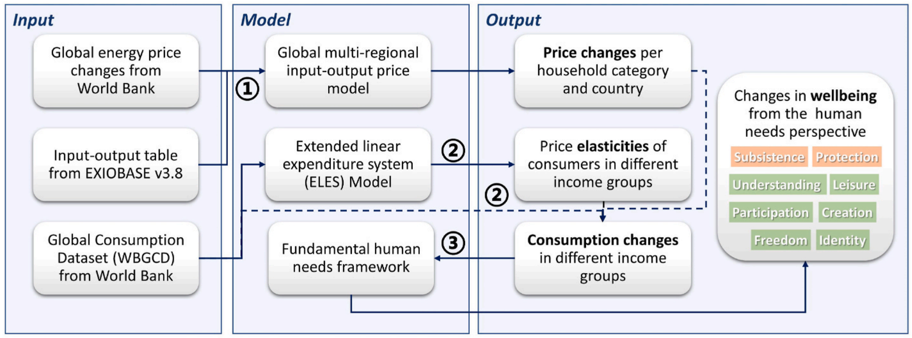

Fig. 1. Methodological framework.

$$X = Z + VA \tag{1}$$

where X is the total output, Z is intermedium input and VA is the value added. When the price is considered, Equation (1) can be written as:

$$P_x X = P_z Z + VA \tag{2}$$

where P_x and P_z represent the price of the total output and intermedium input. When two sides of Equation (2) is divided by X, the Leontief price model is built,

$$P_x = P_z A^{'} + V \tag{3}$$

where $A^{'}$ is the transpose of the direct consumption coefficient matrix from the classical IO model, and V represents the value added per unit of output.

Equation (3) can be written as the matrix,

$$\begin{bmatrix} p_1 \\ p_2 \\ \vdots \\ p_n \end{bmatrix} = \begin{bmatrix} a_{11} & a_{21} & \cdots & a_{n1} \\ a_{12} & a_{22} & \cdots & a_{n2} \\ \vdots & \vdots & \vdots & \vdots \\ a_{1n} & a_{2n} & \cdots & a_{nn} \end{bmatrix} \times \begin{bmatrix} p_1 \\ p_2 \\ \vdots \\ p_n \end{bmatrix} + \begin{bmatrix} v_1 \\ v_2 \\ \vdots \\ v_n \end{bmatrix} \tag{4}$$

Then we divided the matrixes in Equation (4) according to whether the price of the sector is exogenously, and rewrote it as following,

$$\begin{bmatrix} p_{en} \\ p_{ex} \end{bmatrix} = \begin{bmatrix} A^{'}_{en-en} & A^{'}_{ex-en} \\ A^{'}_{en-ex} & A^{'}_{ex-ex} \end{bmatrix} \cdot \begin{bmatrix} p_{en} \\ p_{ex} \end{bmatrix} + \begin{bmatrix} v_{en} \\ v_{ex} \end{bmatrix} \tag{5}$$

$$p_{en} = A^{'}_{en-en} \cdot p_{en} + A^{'}_{ex-en} \cdot p_{ex} + v_{en} \tag{6}$$

$$p_{ex} = A^{'}_{en-ex} \cdot p_{en} + A^{'}_{ex-ex} \cdot p_{ex} + v_{ex} \tag{7}$$

where p_{ex} and p_{en} represent the exogenous and endogenous prices of products, respectively, while p_{en} can be impacted by the change of p_{ex}.

Equation (6) can be written as following,

$$p_{en} = \left(I - A^{'}_{en-en}\right)^{-1} \cdot A^{'}_{ex-en} \cdot p_{ex} + \left(I - A^{'}_{en-en}\right)^{-1} \cdot v_{en} \tag{8}$$

$$\Delta p_{en} = \left(I - A^{'}_{en-en}\right)^{-1} \cdot A^{'}_{ex-en} \cdot \Delta p_{ex} \tag{9}$$

Here Equation (9) denotes the effects of change in the price(s) of one or a bundle of product(s) on the prices of other goods.

It has to be noted that there are four main hypotheses of our simulation. Firstly, e assume the IO price model assume that the change of the product price is only a result of changes in the cost of raw materials, that is, it takes no account of the potential impacts on price caused by wage change, profit tax and depreciation. Secondly, the IO price model we used does not include adaptive actions that enterprises may take to reduce material demand or adjust product decisions. Thirdly, there is no effect of prices on the supply-demand relationship in the IO price model. At last, we take no consideration of the effect of the government's intervention measures in face of the increase in energy price (Jiang and Tan, 2013).

2.2. Calculation of changes in household consumption

We calculate the changes in household consumption on the assumption that the consumer preference (i.e. price elasticity) remains constant and is unaffected by price changes in the short term. First, we estimate the price elasticity of demand of different income-level household groups for each product using the Extend linear expenditure system (ELES) model. ELES model was developed by Lluch (Lluch, 1973; Stone, 1954) based on the linear expenditure system. One advantage of the ELES model over other various demand system models, such as Almost ideal demand system (AIDS) and Quadratic almost ideal demand system (QUAIDS) model, is that it can directly use the least squares method to estimate cross-sectional data and can be solved without price information when calculating the price elasticity. Thus, ELES model is extensively used in consumption research (Li et al., 2018; Lluch and Williams, 1975; Sary et al., 2018; Wang and Deng, 2021; Wu et al., 2011). In the ELES model, it is assumed that during a certain period, the consumers' demand for goods or services depends on the income level and the price of goods, and the demand is divided into the basic demand and the non-basic demand. The basic demand (BD) remains stable over time and does not vary with income. After BD is satisfied, the remaining income is distributed according to the marginal propensity to consume (MPC) of each type of goods to meet the non-basic demand (NBD).

The extended linear expenditure system model appears as follows:

$$P_i X_i = P_i BD_i + \beta_i \left(I - \sum\nolimits_{i=1}^{n} P_i BD_i \right) \tag{10}$$

$$\beta_i \in (0, 1), and \sum\nolimits_{i=1}^{n} \beta_i < 1$$

where P_i, X_i and denote the price and consumption of the i th product of residents, respectively. Then P_iX_i is the total expenditure of the i th product of residents. BD_i is the quantity of the basic demand for the i th product. P_iBD_i is the basic expenditure on the i th product for the household. β_i is the MPC of i th product. I is the income of the household.

Let $Y_i = P_iX_i$ and $\alpha_i = P_iBD_i - \beta_i \sum_{i=1}^{n} P_iBD_i$, then Equation (10) can be written as:

$$Y_i = \alpha_i + \beta_i I \tag{11}$$

By estimating the correlation coefficient through Equation (11), the total basic expenditure and basic expenditure for each product can be calculated by:

$$\sum\nolimits_{i=1}^{n} P_i BD_i = \sum\nolimits_{i=1}^{n} \alpha_i \Big/ \left(1 - \sum\nolimits_{i=1}^{n} \beta_i\right) \tag{12}$$

$$P_iBD_i = \alpha_i + \beta_i \sum_{i=1}^{n} \alpha_i \Bigg/ \left(1 - \sum_{i=1}^{n} \beta_i\right) \quad (13)$$

We can get the self-price elasticity of demand:

$$\varepsilon_{ii} = \frac{\Delta X_i / X_i}{\Delta P_i / P_i} = \frac{\partial X_i}{\partial P_i} \bullet \frac{P_i}{X_i} = (1 - \beta_i) \bullet \frac{P_iBD_i}{Y_i} - 1 \quad (14)$$

To depict the price elasticity of different income groups, we divided the household bins into 4 groups by income levels: low income, lower-medium income, upper-medium income and high income. The products are classified into 13 major categories, which are detailed in SI table S1.

Then changes in household consumption r can be calculated as follows:

$$\varepsilon_{ii} = \frac{\Delta X_i / X_i}{\Delta P_i / P_i} \quad (15)$$

$$r = \Delta X_i / X_i \cdot 100\% = \varepsilon_{ii} \cdot \Delta P_i / P_i \cdot 100\% \quad (16)$$

2.3. Quantifying changes in household human needs satisfaction

To quantify the change in human needs satisfaction, we use the fundamental human needs framework developed by Vita et al. (2019). The concept of the fundamental human needs framework has been applied in a number of studies to explore the relationship between wellbeing and consumption (Jackson and Marks, 1999; Di Giulio and Defila, 2021), energy use (Brand-Correa and Steinberger, 2017), carbon emission (Vita et al., 2019; Steinberger et al., 2020), environmental impact (Wilk, 2002), circular economy (Clube and Tennant, 2020), etc. For example, Brand-Correa and Steinberger (2017) examined the links between energy services and human needs and proposed an analytical framework for the decoupling of energy services and human needs. Vita et al. (2019) quantified the carbon footprint and energy footprint of human needs satisfaction using an environmentally extended input-output model. These provide the methodological reference for our study to combine the fundamental human needs framework with the input-output price model, to explore the impact of energy price increases on wellbeing.

The quantification method of fundamental human needs proposed by Vita et al. (2019) is developed based on expert panel discussion. This method enables a systematical calculation of the consumption and associated energy and carbon emission from human needs satisfaction, which also passes the uncertainty test (i.e. using Monte Carlo simulation to obtain similar results) (Vita et al., 2019). It is assumed that the consumption of one market good can satisfy one or more human needs, following the fundamental human need theory proposed by Max-Neef (Ekins and Max-Neef, 1992; Max-Neef et al., 1991). The fundamental human needs framework provides a correspondence matrix between the 200 economic goods available in the IO database (EXIOBASE v3.8) (Stadler et al., 2018) and human needs. These needs can be classified as material and non-material human needs depending on the material intensity of satisfier (Jackson and Marks, 1999). The material human needs are Subsistence and Protection, while the remaining human needs are non-material needs. Specifically, Subsistence is mainly concerned with food and shelter. Health care, safety, and financial security are all covered by Protection, which may be provided by a variety of products ranging from insurance to heating fuel. Creation can be satisfied through activities like inventing, building, designing, and imagination in both formal and informal work, which applies skills to material and immaterial objects. Freedom relies on market goods that improve space-time accessibility, such as transportation, domestic appliances and household services. Leisure can be satisfied by recreational services and entertainment, while Identity is associated with goods that express preference such as luxury items, apparel or diets. Participation relies on communication devices, media and club memberships, and Understanding is related to education and self-improvement, and can be satisfied by computers and educational services. Note that according to Vita et al. (2019), Affection is not linked to any product in the database and is therefore not included in this analysis. The consumption of market products linearly contributes to the satisfaction of one or different human needs aspects with different weights. For example, 45% of the consumption of wheat contributes to Subsistence, while the rest is linked with Identity. Although the simplified correspondence matrix only shows the linear relationship between goods and human needs satisfaction, this framework provides an opportunity to capture the change in each human need based on the change in a bundle of goods that households consume. A detailed correspondence matrix can be found in the SI Table S3.

2.4. Calculation of the consumer price index (CPI)

Based on the impact of energy price shock on other products, we further calculated the effect of on the consumer price index (CPI), which measures changes in the prices of goods and services purchased or otherwise acquired by households (Jiang and Tan, 2013). As the consumption pattern or weight varies among household groups, the CPI can represent the living cost of different income household groups. We used the column vector of resident consumption in the IO table as the weight to simulate the change in CPI. The change in the price index is expressed as follows:

$$\Delta CPI_g = \sum_{i=1}^{n} \Delta P_i F_{i,g} \Bigg/ \sum_{i=1}^{n} F_{i,g}, i = 1, 2, \ldots, n \quad (17)$$

where, ΔCPI_g denotes the change of CPI of the g th household group. $F_{i,g}$ is the product of the i th product consumed by the g th household group, while ΔP_i is the change in the i th product price.

2.5. Data sources

We simulate the price change using the latest available data from the input-output database EXIOBASE 3.8 (Stadler et al., 2018). The data describe the economic flows among 200 products in 49 countries, territories and regions (see Table S1 & Table S2), where the 44 countries/territories account for 86% of the global GDP in 2019. The wide coverage and detailed sectoral categorization can well describe the complex network of the world's economy.

For the household consumption, we use the detailed consumption data from the World Bank's Global Consumption Dataset (WBGCD), which has been extended to cover 116 countries and approximately 90% of the global population (Bruckner et al., 2022; Hubacek et al., 2017). 201 household expenditure bins and the corresponding population proportion are provided for each country in the WBGCD. The lowest expenditure bin is defined as spending less than US$_{2011}$ 50 PPP, whilst the highest expenditure bin represents the expenditure of more than US $_{2011}$ 951,689 annually (Bruckner et al., 2022; Zhong et al., 2020). The spending for 33 kinds of market products and services is provided for each household bin. We grouped 201 household bins into 4 household groups to facilitate the analysis and extract the findings. The concordance information between EXIOBASE and WBGCD (including the correspondence of products and countries) can be found in SI Table S1 & Table S2.

The energy price data for the simulation is based on the latest World Bank Commodity Price Data (WBCPD). WBCPD provides monthly series of 55 commodity prices and indices (updated to June 2022). We calculated the price change of crude oil and natural gas by comparing the average price from February 2022 to June 2022 with the average price in 2021. We also adopted the minimum and maximum price change to present the range of price shocks.

3. Results

3.1. Price increases per household category and country

The rising energy prices would lead to an overall increase in prices of goods and services by 1.7%–3.9% (Fig. 2a). Energy-related products, electricity and household chemicals (i.e. fertilizers) see the biggest price increases by 9.5%–22.1%, 2.5%–6.4% and 1.2%–2.8%, respectively. The rising prices of primary energy such as natural gas and oil would lead to a significant increase in the cost of production of energy-intensive products, thus increasing the prices of these products. For example, crude oil accounts for 55.5% of the production cost of motor gasoline, while the price of motor gasoline would increase by roughly 24.9% under the energy price shock. In contrast, increasing energy prices have less of an impact on services, with the exception of energy-intensive transportation services with a price increase of 1.2%–2.4% (higher than other services by 3.3-3.7 times). It should be noted that the degree of price changes we estimated for some products is smaller than the observed price increases. For example, prices of food and clothing would rise less significantly, at about 0.8%–1.6%. This is somewhat different from real increases where, for example, soybean prices rose by up to 19% (World Bank Group, 2022). One reason for this difference is that we only take the impact of energy price which will be transferred directly to consumers into account, rather than covering the impact of the supply-demand relationship between companies or producers, or other significant financial-induced mechanisms in our analysis (Chiarucci et al., 2017). This exclusion enables our short-term analysis to provide a lower bound estimation, but also leads to a lower assessment of price changes of particular products which are more easily affected by the market mechanism, such as food (Lagi et al., 2015).

The CPI measures the overall price changes based on the quantity of goods and services that households consume, which can reflect the effect of energy price increases on cost of living changes in this analysis. The average increase in CPI at the global level is 1.8%–4.2%, mostly driven by price increases in food and energy products, which account for around 41% and 38% of the increment of CPI, respectively (Fig. 2b). This is because these products are the main products consumed by households for their daily livelihood, accounting for about 47% of total daily spending (Fig. S1). The CPI would climb the most in the low-income group (increasing by 2.0%–4.6%), which is over 1.2-1.3 times that of the high-income group. Furthermore, when household income increased, the products responsible for the growth in CPI would shift from daily necessities such as food and energy to services such as financial services.

There are some variances in CPI changes at the regional level. First, CPI change in lower income countries would rise by 1.9%–4.2%, comparable to the global average. However, the contribution of higher electricity prices to CPI increment in these countries is 11% higher than the global average. In contrast, higher income countries had a relatively lower increase in the average CPI (1.7%–3.9%). While the low, low-middle and high-middle income groups in these countries faced little difference in CPI changes (around 3.1%), the CPI in the higher income group would rise only 0.7%–1.6%, which is much lower than the global average. The BRICS countries, on the other hand, have the highest CPI growth, about 1.3-1.4 times the global average. Energy products, which accounted for nearly 70%–73% of the CPI rise, are the largest contributor to CPI growth. This may be related to the high reliance of BRICS residents on energy products in the consumption pattern, as well as the sharper price hikes in BRICS countries.

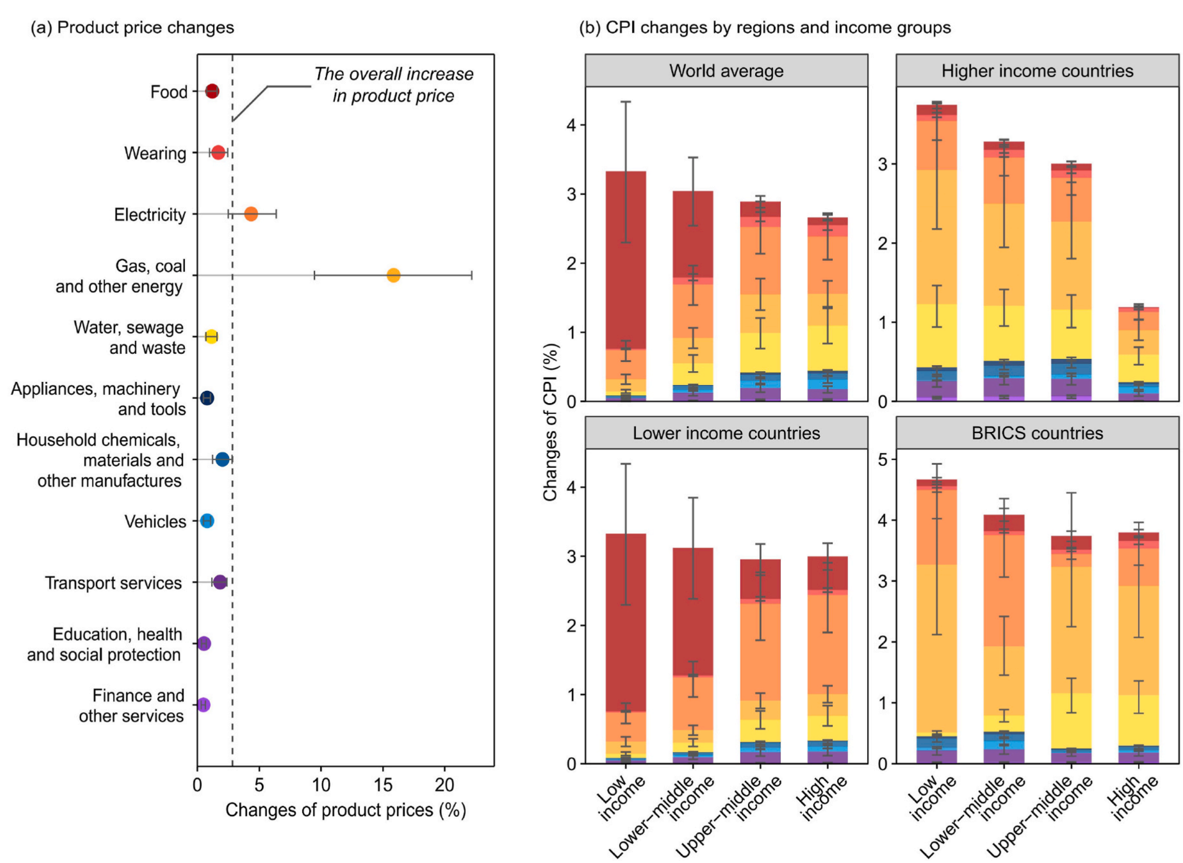

Fig. 2. Changes in product prices and CPI induced by increasing energy prices. Graph (a) shows the price changes by product categories and the overall change in global product prices. Graph (b) describes the impact of the energy price shocks on CPI by income group in each region. Error bars represent the min-max range.

3.2. Household consumption decline by income group and region

Global household consumption would fall by about 2.9%–6.7% due to the increase in energy prices (Fig. 3). Food and energy products accounted for 74% of the decrease, which is mainly due to the significant price increases of these products. Even though consumers have relatively lower price elasticity for these products, the price increase is high enough to curtail household consumption. In contrast, the decline of durable goods (such as applicants, machines and tools) and services is relatively modest, accounting for around 5% and 3% of the total consumption reduction, respectively. This suggests that even though households have more elasticity about these products, the price changes of these products are not large enough to affect households' consumption.

With a reduction in household income, household consumption would shrink significantly. High, upper-middle and lower-middle income groups would decrease consumption by 2.4%–6.5% (Fig. 3). The low-income group consumes 4.1%–9.2% less, about 1.7 times more than the high-income group. Moreover, the low-income group exhibits a higher reduction in the consumption of necessities (including food, clothing and energy) and services than high-income group, by 1.6%–1.9% and 4.8%–5.6%, respectively. This indicates that the low-income group is disproportionately affected by energy price shocks, suffering more from the consumption decline related to both the services and basic livelihoods comparing to high, upper-middle and lower-middle income groups.

The consumption reduction varies considerably between regions. For instance, the decline in consumption is lowest in higher-income countries. Especially, middle- and high-income groups in these countries consume 2.2%–4.8% less. Unlike the global situation, the decline in food consumption is smaller for all income groups in high-income countries, contributing only 1%–5% of the total decline. The main consumption declines come from energy products such as oil and gas (28%–39% of the total decline), for all income groups in these countries. The lower-income countries are similar to the global average, but the low-income group in these countries consumes 3.6%–9.6% less, and about 46%–79% of the decline is from food products. It is worth noting that the consumption decrease in BRICS countries is much higher than the global average, at about 4.6%–10.4%. In addition, the low-income group of these countries has the largest consumption reduction (7.7%–15.6%), which is 1.5-2.3 times more than other groups in these countries, and 6.4-6.9 times more than the global average. Such a large decrease concentrates mostly on energy products (84%–85% of the total decrease in consumption).

We also calculated for each country the change in the Engel coefficient (i.e. proportion of money spent on food in the household expenditure), which is widely used as an indicator of a nation's standard of living. Fig. 4 shows that the global Engel coefficient rises by 2.6%–7.6% on average. The Engel coefficient for the low-income group increased by 5.3%–15.4%, while the Engel coefficient for the high-income group changed slightly (up by only 2.0%–5.0%). At the regional level, countries with large increases in Engel coefficient include Brazil and Mexico, but also high-income countries such as the European Union and the United Kingdom. Brazil shows the highest increase in Engel coefficient with 11%–38%. However, the Engel coefficient of some countries in high-income countries, such as the United States, rose less, only by

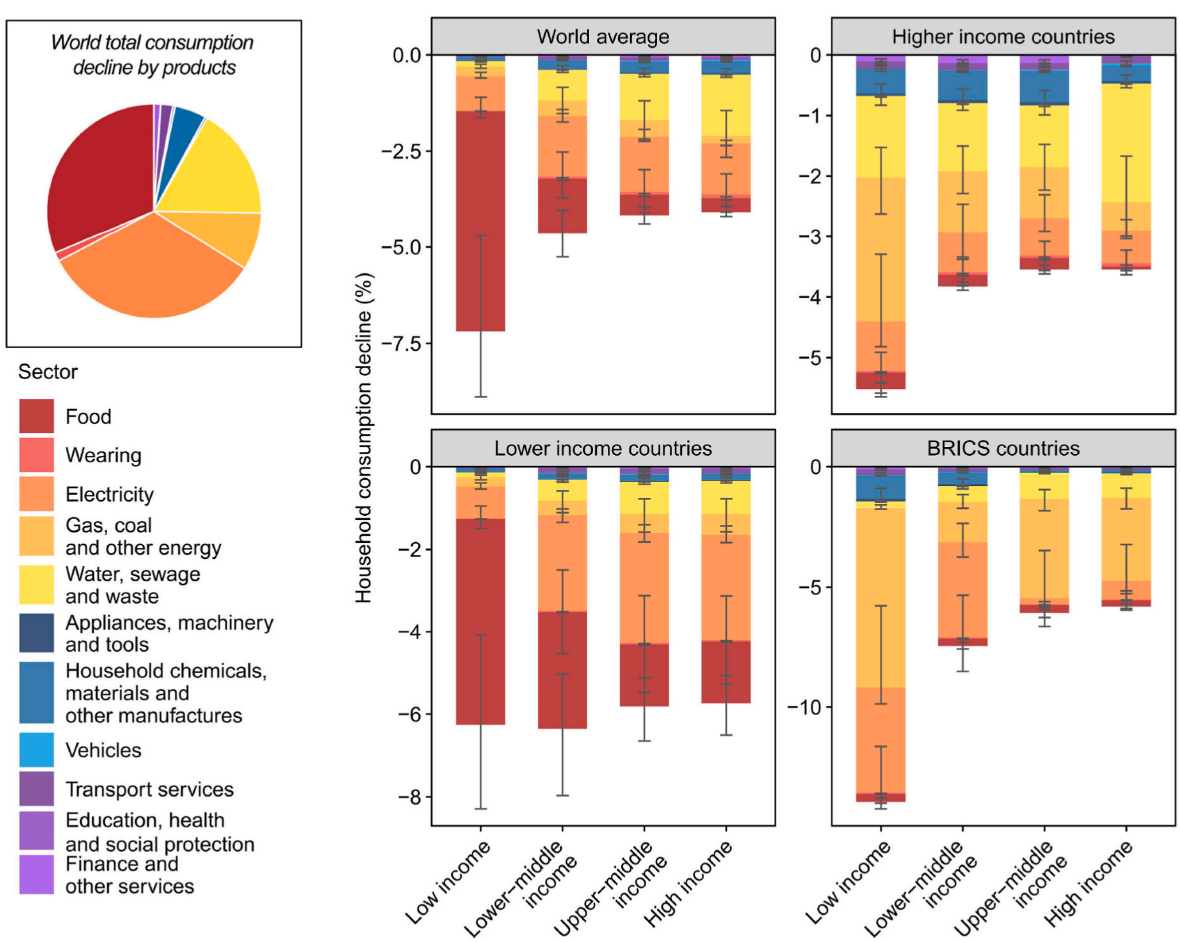

Fig. 3. Changes in household consumption. The pie chart shows the global total consumption decline by product. The bar charts present changes in household consumption by product and income group in each region. Error bars represent the min-max range.

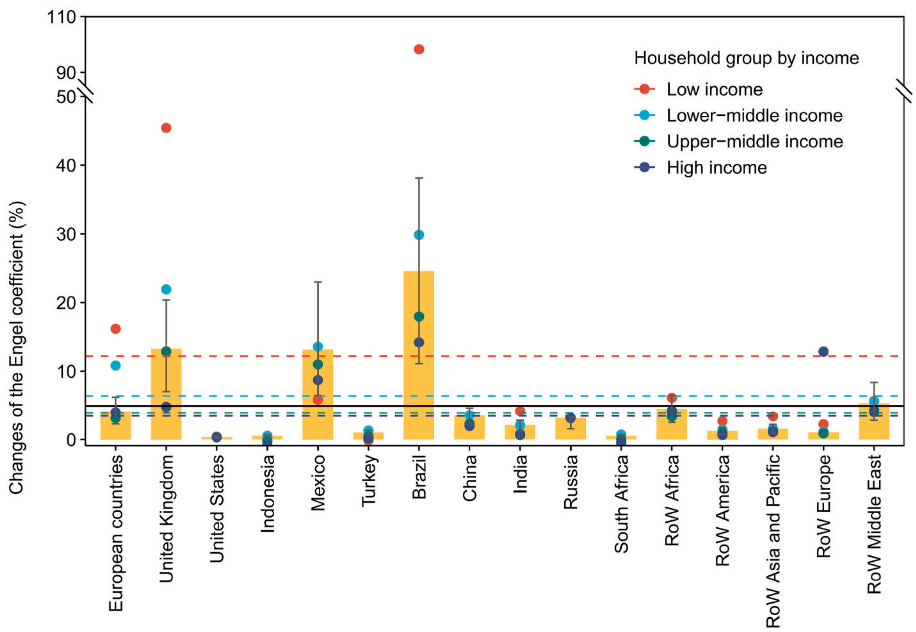

Fig. 4. Changes of Engel coefficient by country and income group. The yellow bars depict the Engel coefficient of countries or regions. The lines in different colors show the changes for the global Engel coefficient by income group, while the dashed line represents the global average change of the Engel coefficient. The points show the changes for the Engel coefficients at the regional level. Error bars represent the min-max range. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

0.2%–0.4%. Further, we find that countries with larger increases in the Engel coefficient have greater inequalities in that coefficient across income groups. For example, the Engel coefficient of the low-income group in Brazil grew by roughly 98%, which is 5.3-5.7 times the change of the high-income group. The change in the Engel coefficient in response to energy price shocks confirms that the disproportionate impact on low-income groups holds in most countries.

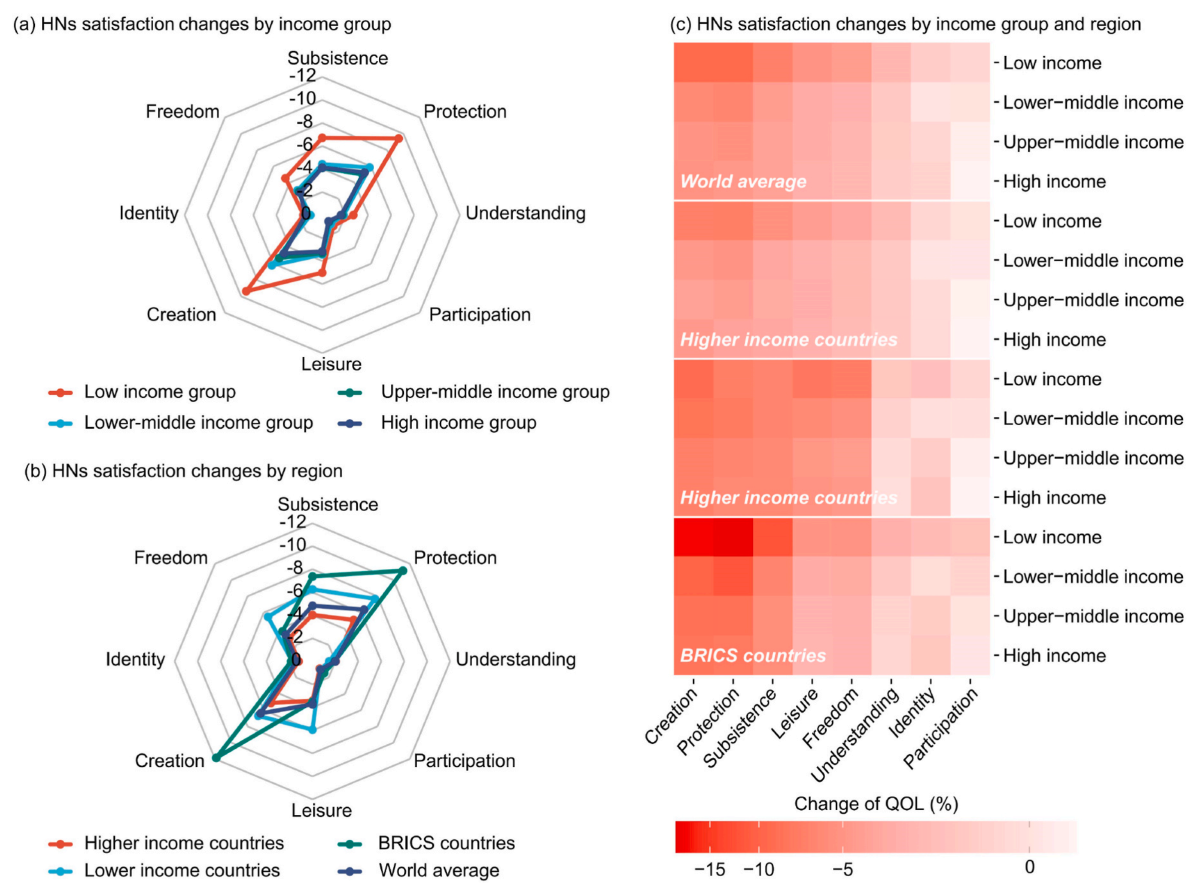

Fig. 5. Changes of human needs satisfaction by income group and region. Graph (a)–(b) present changes in the satisfaction of eight dimensions of human needs by income group and region. Graph (c) shows the detailed changes of human needs by income group and region. Orange in Graph (c) indicates increase in inequality. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

3.3. Disparity in the impacts on human needs satisfaction by dimension

We further assessed changes in the satisfaction of human needs with the fundamental human needs framework established by Vita et al. (2019). (Fig. 5). At the global level, households' satisfaction of human needs would drop by 2.1%–4.9% on average across the eight human needs dimensions, with the most substantial decreases in two dimensions: Creation and Protection, falling by 3.7%–8.5% and 3.6%–8.4%, respectively. Subsistence shows a decline of 2.8%–6.6%, which is in accordance with the change in the Engel coefficient. The satisfaction in Leisure and Freedom would decline by 2.0%–5.1%, close to the overall average change in human needs, whereas the impacts on Understanding, Identity, and Participation are the smallest, ranging from 0.6% to 2.6%.

Changes in the most affected human needs' category satisfaction (Creation and Protection) are closely tied to the decline in the consumption of energy-related goods, such as natural gas. This is evident for material dimensions of human needs, that is, the satisfaction of Protection, which can be provided by energy-related goods (such as heating fuel). For example, as tensions between Russia and Ukraine keep growing and European gas import has not been replenished, rising energy bills could trigger a steep decline in household energy-related consumption, including turning heating down. The IEA recommends lowering the thermostat for building heating by 1 °C to bring down the energy cost (IEA, 2022b). If the natural gas price for consumers keeps rising, the household would have to set a more undesirable room temperature, which avoids spikes in energy bills at the expense of the satisfaction of Protection(Morison, 2022; Nanji, 2022; Sweney and Lawson, 2022). In terms of non-material human needs, Creation can be satisfied through exercising creativity in both formal and informal work with the necessary energy, electricity or material input (Ekins and Max-Neef, 1992; Vita et al., 2019). As the price of energy-related products soared, decent workspace may be limited by less access to desirable temperatures, electronic devices and commuting traffic (ADAC, 2022; Islam, 2022; Silk, 2022), all of which are reflected in the reduction of Creation satisfaction. In addition, the rise in energy prices also increases the cost of raw materials for manufacturing, leading to an extra burden on enterprises, some of which have reduced or stopped production as a result. This has also indirectly shortened employment opportunities and limited the satisfaction of household human needs in Creation. Thus, the decline in energy-related product and food consumption as a result of the energy price shock will impair these human needs aspects that are inextricably tied with energy.

3.4. Disproportionate effects on the human needs by income group and region

Low-income groups show the largest reduction in human needs (decreasing by 3.0%–6.6%), which is about 1.4 times higher than the global average (Fig. 5). In contrast, the average decrease of human needs for the other three income groups (i.e., lower-middle, upper-middle and higher income groups) is around 1.8%–4.7%, which is 30%–33% less than the impact on the low-income group. The drop in human needs for all income groups would be concentrated in Creation and Protection, echoing the global trend. With a reduction in Creation of 5.4%–11.7%, the low-income group bears the most impact.

The degree of impact of energy price shocks on human needs varies among regions. For example, the human needs of residents in high-income countries would decline by around 1.9%–4.1%, with the most affected human needs dimensions remaining consistent with the global situation. Each aspect would be affected fairly evenly, with the magnitude of impact being less than 5.1%. The average decline in human needs in low-income countries is 2.6%–6.5%, around 1.2-1.3 times the global average impact while the main affected human needs aspects are Creation and Protection (declined by 3.8%–9.8% and 4.3%–10.9%). It is worth noting that the BRICS countries would experience the largest and most uneven reduction in human needs. The overall decline in human needs in the BRICS countries is 3.0%–6.8%, with the low-income group seeing a 4.7%–9.9% decline, which is 2.0-2.2 times the global average. The impact of the energy price shock on BRICS countries is more substantial on human needs aspects such as Creation and Protection, with the low-income group living there suffering declines of 10.9%–21.4% and 9.9%–19.8% in these aspects, respectively.

The impact on households' human needs is related to both household income and national development. We used the GDP per capita of 44 countries to analyze the changes of different human needs dimensions in each income level to further explain the correlation between the impact of energy price shocks and the changes in the household human needs. Regression analysis reveals a significant positive correlation between the human needs changes and the GDP per capita in the low-income group, which is not obvious or not reflected in other income groups. For instance, the impact of GDP per capita on the human needs of the low-income group is particularly significant ($p < 0.01$) for Leisure and Freedom, with correlation coefficients of 1.49-1.93 (Fig. 6). This means that these human needs aspects of the low-income group would fall by 14.9%–19.3% with a 10% loss in the GDP per capita of the country where residents dwell. In other words, the low-income group suffers more from the energy price shocks and the magnitude of the impact is further amplified in less developed countries. Such an influence would be higher for Leisure and Freedom than for basic livelihoods (Subsistence). Higher-income groups, on the other hand, are less affected and do not differ considerably by the level of national wealth. A linear fit replacing the GDP per capita with Human Development Index also validates the findings as above (see SI Fig. S2).

4. Discussion and policy implications

Ensuring human wellbeing is a prerequisite for obtaining sustainable development. Our study provides a cross-sectional quantitative assessment of the indivisibility of the impact of energy price shocks and human welfare from the perspective of human needs. Three aspects of our analysis require further elaboration to provide research implications for future attempts to improve the human needs and welfare in the face of not only the energy price shock caused by the sudden geopolitical conflict but also the energy price policy.

The first issue is that not only material but also non-material dimensions of human needs are most significantly affected by energy price shocks. In contrast to previous findings, our research further found that the impact of energy price shocks on residents is not limited to the living burden, such as heating fuel shortages to meet Protection satisfaction. The non-material dimension, i.e. Creation, may also be affected due to the limited access to ideal space for exercising creativity when reducing the consumption of energy products. This implies that attention also needs to be paid to overlooked non-material human needs. On the one hand, it is necessary to expand the assessment system of the impact of energy prices on the household by integrating the multidimensional quantification of human needs as a complement to the monetary indicator such as living costs. This will not only enrich the evidence to link energy poverty, energy inequality and other SDGs with human wellbeing, but also facilitate the development of more comprehensive and systematic policies to offset the potential negative social impacts of energy price shocks or energy price policies (Ekins and Max-Neef, 1992). On the other hand, some policies can facilitate compensating for the inadequacy of human needs in both material and non-material dimensions. For example, subsidies targeting the household energy cost would be more effective in reducing the loss of human wellbeing caused by the RU energy price hike. Examples of such subsidies include energy price controls and direct subsidies for energy consumers (OECD, 2022). Additionally, expediting the replacement of gas boilers with heat pumps through subsidies or preferential policy support can enable more efficient and cost-effective heat provision (IEA, 2022b). It is very important to not lose sight of climate mitigation goals when responding to the

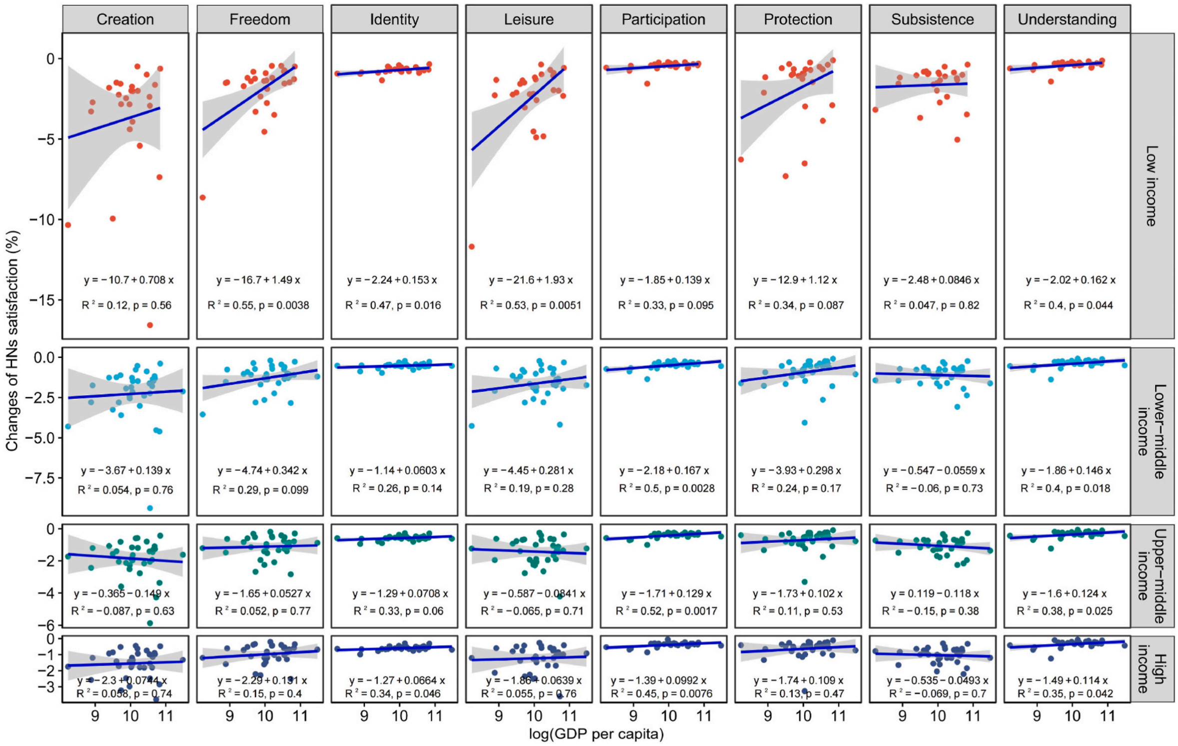

Fig. 6. Correlation of changes in human needs satisfaction and GDP per capita. Each chart shows the fitting line between human needs satisfaction changes of households/regions and GDP per capita (using natural logs) in 49 countries for each income group and human needs dimensions. The shaded area represents the 95% confidential interval.

cost-of-living crises (e.g. Guan et al., 2023; Malerba et al., 2022). It is also suggested to improve public awareness and encourage practices that promote intrinsic motivation (rather than materiality), healthier social norms, or integrate low-impact satisfaction culture into consumption and lifestyle. Avoid-Shift-Improve (A-S-I) strategies, for instance, can ensure the households' accessibility to Leisure and Freedom under the energy price shock (Arioli et al., 2020; Zhang and Hanaoka, 2022).

Second, low-income households are most affected by energy prices, not only in terms of higher cost of living, but also the decline in various human needs dimensions. Moreover, there exists a general tendency for the impact on the low-income group. That is, the low-income group in the poorer country is affected more and the severity is inversely proportional to the wealth of the country, whereas this trend is not found in other income groups. This indicates that energy price shocks have no substantial impact on the lives of higher income groups, regardless of location, while low-income households, particularly those in less developed countries or regions, suffer more. Therefore, policymakers need to take a detailed look at the low-income group, which is currently not receiving sufficient attention in existing energy support policy (Van Dender et al., 2022). Targeted support should incorporate income levels as a key criterion for determining the degree of a household's financial vulnerability during an energy price hike (Malerba et al., 2022). By implementing focused policies such as cash and in-kind subsidy programs, policymakers could safeguard the human needs and welfare of these groups while reducing the risk of widening inequality (Vogt-Schilb et al., 2019).

Third, the integrated framework that combines the input-output price model and the fundamental human needs framework can serve as a valuable policy evaluation instrument for assessing the impact of price fluctuations on human welfare. This assessment can extend beyond energy price increases caused by sudden geopolitical conflicts and also encompass broader price policies. For instance, the imposition of a carbon tax, highly regarded for its efficacy in fostering carbon emission reduction, may result in price hikes, particularly for energy-related goods, consequently constraining household consumption and impacting overall wellbeing. Our integrated framework offers a means to evaluate the impact of carbon taxes on wellbeing. Given the increased attention garnered by the recent implementation of the EU's Carbon Border Adjustment Mechanism (CBAM), it is pertinent to evaluate the changes in wellbeing resulting from this policy and offer policy insights from a wellbeing perspective.

We acknowledge the following limitations of our research. First, the input-output price model explores the impact of commodity prices that are transferred through the supply chain to affect consumers, rather than including other transmission channels, such as the supply-demand relationship. As a result, our assessment excludes price changes caused by a loss in supply through the market mechanism, which may have attenuated the extent of commodity price increases faced by consumers. Second, this study provides an overview of changes in the human needs satisfaction of households through the fundamental human needs framework, rather than considering the interrelation among the human needs aspects. A more detailed indicator framework can be further explored to enhance the assessment of the human needs. Third, the consumption data in WBGCD is from the original data for 2011, which is problematic for the consumption of fast-growing transition economies in 2022. However, it is the best available global database, providing detailed consumption patterns within the expenditure bins for each country. Finally, our human needs satisfaction assessment only focuses on the short-term impacts of energy price shocks, which excludes secondary and long-term effects. On the one hand, the price elasticity was assumed to remain constant and unaffected by energy price shocks, which assumption enables the simulation of short-term changes in household consumption and human needs satisfaction caused by the RU conflict (Lluch and Williams, 1975; Regmi and Seale, 2010; Woo et al., 2018). By contrast, consumer behavior and preference may change due to energy price changes and energy policy in the long term (Clements et al., 2022; Ho et al., 2020; Jachimowicz et al., 2019; Mertens et al., 2022). On the other hand, energy price shocks provide both opportunities and challenges for renewable energy development, which affects the wellbeing of residents through affecting employment opportunities, air pollution, etc. Such long-term dynamic impacts are not included in our short-term analysis.

5. Conclusion

This study evaluates the disproportionate impacts of energy price shocks on wellbeing based on detailed household data from developed and developing countries representing more than 87% of the global population. Our analysis reveals that non-material dimension Creation and the material dimension Protection are the most affected human needs globally, with declines of 3.7%–8.5% and 3.6%–8.4%, respectively. Households in BRICS countries are hit hardest on these human needs satisfaction (2.0-2.2 times the global average). The poorer the country in which low-income groups reside, the more serious the decline of their human needs satisfaction. The findings underscore a need for paying attention to both material and frequently overlooked non-material dimensions of human needs under energy price shocks. Our study converts the vague impression of the uneven impacts of the price spikes on wellbeing to concrete quantification and calls for attention to non-material wellbeing jeopardized by the conflict, especially to low-income and vulnerable households.

CRediT authorship contribution statement

Yaxin Zhang: Conceptualization; Methodology; Formal analysis; Visualization; Writing
Yuli Shan: Conceptualization; Formal analysis; Writing
Xinzhu Zheng: Conceptualization; Formal analysis; Writing
Can Wang: Conceptualization; Writing
Yuru Guan: Writing
Jin Yan: Writing
Franco Ruzzenenti: Writing
Klaus Hubacek: Conceptualization; Methodology; Formal analysis; Writing; Supervision

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.enpol.2023.113743.

References

ADAC, 2022. Spritsparen. Helfen. Mobil bleiben [WWW Document]. URL. https://www.adac.de/news/offener-brief-spritsparen/, 8.13.22.
Adolfsen, J.F., Kuik, F., Schuler, T., Lis, E., 2022. The impact of the war in Ukraine on euro area energy markets. ECB Economic Bulletin.
Andreyeva, T., Long, M.W., Brownell, K.D., 2010. The impact of food prices on consumption: a systematic review of research on the price elasticity of demand for food. Am. J. Publ. Health 100, 216–222, 10/fdndsv.
Arioli, M., Fulton, L., Lah, O., 2020. Transportation strategies for a 1.5 °C world: a comparison of four countries. Transport. Res. Transport Environ. 87, 102526, 10/gqn77q.
Brand-Correa, L.I., Steinberger, J.K., 2017. A framework for decoupling human need satisfaction from energy use. Ecol. Econ. 141, 43–52, 10/gbxrnh.
Bruckner, B., Hubacek, K., Shan, Y., Zhong, H., Feng, K., 2022. Impacts of poverty alleviation on national and global carbon emissions. Nat. Sustain. 1–10, 10/gphxtv.
Campbell, J.Y., Cocco, J.F., 2007. How do house prices affect consumption? Evidence from micro data. J. Monetary Econ. 54, 591–621, 10/d5sx22.
Chiarucci, R., Loffredo, M.I., Ruzzenenti, F., 2017. Evidences for a structural change in the oil market before a financial crisis: the flat horizon effect. Res. Int. Bus. Finance 42, 912–921, 10/gqw484.
Clements, K., Mariano, M.J., Verikios, G., 2022. Expenditure patterns, heterogeneity, and long-term structural change. Econ. Modell. 113, 105888, 10/gqs4tw.
Clube, R.K.M., Tennant, M., 2020. The Circular Economy and human needs satisfaction: promising the radical, delivering the familiar. Ecol. Econ. 177, 106772 https://doi.org/10.1016/j.ecolecon.2020.106772.
Costanza, R., Fisher, B., Ali, S., Beer, C., Bond, L., Boumans, R., Danigelis, N.L., Dickinson, J., Elliott, C., Farley, J., Gayer, D.E., Glenn, L.M., Hudspeth, T., Mahoney, D., McCahill, L., McIntosh, B., Reed, B., Rizvi, S.A.T., Rizzo, D.M., Simpatico, T., Snapp, R., 2007. Quality of life: an approach integrating opportunities, human needs, and subjective well-being. Ecol. Econ. 61, 267–276, 10/fgwg9c.
Cozzi, L., Wetzel, D., Tonolo, G., Hyppolite, J., 2022. For the First Time in Decades, the Number of People without Access to Electricity Is Set to Increase in 2022 – Analysis. IEA, Paris.
Di Giulio, A., Defila, R., 2021. Building the bridge between Protected Needs and consumption corridors. Sustain. Sci. Pract. Pol. 17, 117–134, 10/gscrzb.
Ekins, P., Max-Neef, M., 1992. Real-life Economics: Understanding Wealth Creation. Routledge.
Fitouss, J.-P., Sen, A.K., Stiglitz, J.E., 2011. Mismeasuring Our Lives: Why GDP Doesn't Add up. ReadHowYouWant.com.
Global Crisis Response Group, 2022. Global Impact of the War in Ukraine: Billions of People Face the Greatest Cost-Of-Living Crisis in a Generation (No. 2), Global Impact of the War in Ukraine. United Nations, Global Crisis Response Group.
Green, R., Cornelsen, L., Dangour, A.D., Turner, R., Shankar, B., Mazzocchi, M., Smith, R. D., 2013. The effect of rising food prices on food consumption: systematic review with meta-regression. BMJ Br. Med. J. (Clin. Res. Ed.) 346, f3703, 10/gb3sh6.
Guan, Y., Yan, J., Shan, Y., Zhou, Y., Hang, Y., Li, R., Liu, Y., Liu, B., Nie, Q., Bruckner, B., Feng, K., Hubacek, K., 2023. Burden of the global energy price crisis on households. Nat. Energy 8, 304–316. https://doi.org/10.1038/s41560-023-01209-8.
Hawkins, D., Simon, H.A., 1949. Note: some conditions of macroeconomic stability. Econometrica 17, 245–248, 10/dvxfdw.
Ho, M., Britz, W., Delzeit, R., Leblanc, F., Roson, R., Schuenemann, F., Weitzel, M., 2020. Modelling consumption and constructing long-term baselines in final demand. Journal of Global Economic Analysis 5, 63–108. https://doi.org/10.21642/JGEA.050103AF.
Hubacek, K., Baiocchi, G., Feng, K., Muñoz Castillo, R., Sun, L., Xue, J., 2017. Global carbon inequality. Energ. Ecol. Environ. 2, 361–369, 10/gjgnrn.
IEA, 2022a. Oil Market Report. IEA, Paris.
IEA, 2022b. A 10-Point Plan to Reduce the European Union's Reliance on Russian Natural Gas (Paris).
Islam, F., 2022. Ukraine Conflict: Petrol at Fresh Record as Oil and Gas Prices Soar. BBC News.
Jachimowicz, J.M., Duncan, S., Weber, E.U., Johnson, E.J., 2019. When and why defaults influence decisions: a meta-analysis of default effects. Behavioural Public Policy 3, 159–186, 10/ggcd9r.
Jackson, T., Marks, N., 1999. Consumption, sustainable welfare and human needs—with reference to UK expenditure patterns between 1954 and 1994. Ecol. Econ. 28, 421–441, 10/ctrx6b.
Jiang, Z., Tan, J., 2013. How the removal of energy subsidy affects general price in China: a study based on input–output model. Energy Pol. 63, 599–606. https://doi.org/10.1016/j.enpol.2013.08.059.
Kalkuhl, M., Flachsland, C., Ohlendorf, N., Amberg, M., Stüber, S., Haywood, L., Roolfs, C., Edenhofer, O., 2022. Effects of the Energy Price Crisis on Households in Germany: Socio-Political Challenges and Policy Options. Mercator Research Institute on Global Commons and Climate Change (MCC) gGmbH, Berlin.
Lagi, M., Bar-Yam, Yavni, Bertrand, K.Z., Bar-Yam, Yaneer, 2015. Accurate market price formation model with both supply-demand and trend-following for global food prices providing policy recommendations. Proc. Natl. Acad. Sci. USA 112, E6119–E6128, 10/f7x4f9.
Lederman, D., Porto, G., 2016. The Price Is Not Always Right: on the Impacts of Commodity Prices on Households (And Countries), vol. 31. World Bank Res Obs, p. lkv013, 10/gqnkrq.
Leontief, W., 1953. Studies in the structure of the American economy. J. Polit. Econ. 61, 260–262, 10/c6tj4z.
Li, L., Luo, X., Zhou, K., Xu, T., 2018. Evaluation of increasing block pricing for households' natural gas: a case study of Beijing, China. Energy 157, 162–172, 10/gd5xjv.
Lluch, C., 1973. The extended linear expenditure system. Eur. Econ. Rev. 4, 21–32, 10/ck5ttk.
Lluch, C., Williams, R., 1975. Consumer demand systems and aggregate consumption in the USA: an application of the extended linear expenditure system. Can. J. Econ./Rev. Can. Economique 8, 49–66, 10/bd8tbr.
Mahler, D.G., Yonzan, N., Hill, R., Lakner, C., Wu, H., Yoshida, N., 2022. Pandemic, Prices, and Poverty.

Malerba, D., Chen, X., Feng, K., Hubacek, K., Oswald, Y., 2022. The Impact of Carbon Taxation and Revenue Redistribution on Poverty and Inequality, IDOS Policy Brief. German Institute of Development and Sustainability, Bonn, Germany.
Max-Neef, M.A., Elizalde, A., Hopenhayn, M., 1991. Human Scale Development: Conception, Application and Further Reflections. The Apex Press, New York.
Mertens, S., Herberz, M., Hahnel, U.J.J., Brosch, T., 2022. The effectiveness of nudging: a meta-analysis of choice architecture interventions across behavioral domains. Proc. Natl. Acad. Sci. USA 119, e2107346118, 10/gnz4jq.
Morison, R., 2022. U.K. Energy Price Cap Could Spike to £3,000 Per Household. Bloomberg.
Nanji, N., 2022. Gas Prices Jump as Russia Cuts German Supply. BBC News.
OECD, 2022. Why Governments Should Target Support amidst High Energy Prices, OECD Policy Responses on the Impacts of the War in Ukraine.
Pereira, P., Bašić, F., Bogunovic, I., Barcelo, D., 2022. Russian-Ukrainian war impacts the total environment. Sci. Total Environ. 837, 155865 https://doi.org/10.1016/j.scitotenv.2022.155865.
Perelli-Harris, B., Zavisca, J., Levchuk, N., Gerber, T.P., 2022. Internal Displacement and Subjective Well-Being: the Case of Ukraine (Monograph).
Porio, E., 2015. Sustainable development goals and quality of life targets: insights from Metro Manila. Curr. Sociol. 63, 244–260, 10/gqmh8m.
Przybyliński, M., Gorzałczyński, A., 2022. Applying the input–output price model to identify inflation processes. Journal of Economic Structures 11, 5, 10/gqfvsk.
Rao, N.D., Wilson, C., 2021. Advancing energy and well-being research. Nat. Sustain. 1–6, 10/gm7msd.
Regmi, A., Seale, J.L., 2010. Cross-Price Elasticities of Demand across 114 Countries. https://doi.org/10.2139/ssrn.1576743.
Sary, S., Shiwei, X., Wen, Y., Darith, S., Chorn, S., 2018. An analysis on household expenditure in rural Cambodia extended linear expenditure system model (ELES). In: 2018 IEEE International Conference of Safety Produce Informatization (IICSPI). Presented at the 2018 IEEE International Conference of Safety Produce Informatization (IICSPI), pp. 416–421, 10/gqgndv.
Siala, K., de la Rúa, C., Lechón, Y., Hamacher, T., 2019. Towards a sustainable European energy system: linking optimization models with multi-regional input-output analysis. Energy Strategy Rev. 26, 100391, 10/gk4t93.
Silk, 2022. German Car Club Urges Members to Drive Less to Curb Russia Oil Reliance. DW | 27.04.2022 [WWW Document]. DW.COM. URL. https://www.dw.com/en/german-car-club-urges-members-to-drive-less-to-curb-russia-oil-reliance/a-61608184, 8.13.22.
Smit, Hirt, Buehler, White, Greenberg, Mysore, Govindarajan, Chewning, 2022. The Impact of the Ukraine War on Lives and Livelihoods. McKinsey Global Publishing.
Stadler, K., Wood, R., Bulavskaya, T., Södersten, C.-J., Simas, M., Schmidt, S., Usubiaga, A., Acosta-Fernández, J., Kuenen, J., Bruckner, M., Giljum, S., Lutter, S., Merciai, S., Schmidt, J.H., Theurl, M.C., Plutzar, C., Kastner, T., Eisenmenger, N., Erb, K.-H., Koning, A. de, Tukker, A., 2018. Exiobase 3: developing a time series of detailed environmentally extended multi-regional input-output tables. J. Ind. Ecol. 22, 502–515, 10/gctn86.
Steckel, J.C., Missbach, L., Ohlendorf, N., Feindt, S., Kalkuhl, M., 2022. Effects of the Energy Price Crisis on European Households: Socio-Political Challenges and Policy Options. Mercator Research Institute on Global Commons and Climate Change (MCC) gGmbH, Berlin.
Steinberger, J.K., Lamb, W.F., Sakai, M., 2020. Your money or your life? The carbon-development paradox. Environ. Res. Lett. 15, 044016 https://doi.org/10.1088/1748-9326/ab7461.
Stone, R., 1954. Linear expenditure systems and demand analysis: an application to the pattern of British demand. Econ. J. 64, 511–527, 10/fmvxf3.
Sweney, M., Lawson, A., 2022. Europe Could Face Energy Rationing as 'really Tough Winter' Looms, Shell Boss Warns. The Guardian.
Tollefson, J., 2022. What the war in Ukraine means for energy, climate and food. Nature 604, 232–233, 10/gpxv7c.
Van Dender, K., Elgouacem, A., Garsous, G., Belgroun, H., Mateo, M., Prentice, Amy Cano, 2022. Why Governments Should Target Support amidst High Energy Prices. OECD Publishing.
Vita, G., Hertwich, E.G., Stadler, K., Wood, R., 2019. Connecting global emissions to fundamental human needs and their satisfaction. Environ. Res. Lett. 14, 014002, 10/gfztq2.
Vogt-Schilb, A., Walsh, B., Feng, K., Di Capua, L., Liu, Y., Zuluaga, D., Robles, M., Hubaceck, K., 2019. Cash transfers for pro-poor carbon taxes in Latin America and the Caribbean. Nat. Sustain. 2, 941–948, 10/gm9rtr.
Wang, L., Deng, H., 2021. A ELES Model-based quantitative analysis of the consumption structure of the Chinese urban residents. J. Phys.: Conf. Ser. 1774, 012029, 10/gqgndw.
Wilk, R., 2002. Consumption, human needs, and global environmental change. Global Environ. Change 12, 5–13, 10/bzgfsv.
Woo, C.K., Liu, Y., Zarnikau, J., Shiu, A., Luo, X., Kahrl, F., 2018. Price elasticities of retail energy demands in the United States: new evidence from a panel of monthly data for 2001–2016. Appl. Energy 222, 460–474, 10/gdtdqq.
Wu, K., Liu, Y., Song, H., 2011. Leisure sports consumption structure of Shenzhen citizens based on ELES model. In: 2011 International Conference on Computer Science and Service System (CSSS). Presented at the 2011 International Conference on Computer Science and Service System. CSSS), pp. 484–487, 10/chh433.
Zakeri, B., Paulavets, K., Barreto-Gomez, L., Echeverri, L.G., Pachauri, S., Boza-Kiss, B., Zimm, C., Rogelj, J., Creutzig, F., Ürge-Vorsatz, D., Victor, D.G., Bazilian, M.D., Fritz, S., Gielen, D., McCollum, D.L., Srivastava, L., Hunt, J.D., Pouya, S., 2022. Pandemic, war, and global energy transitions. Energies 15, 6114, 10/gq26tp.
Zhang, R., Hanaoka, T., 2022. Cross-cutting scenarios and strategies for designing decarbonization pathways in the transport sector toward carbon neutrality. Nat. Commun. 13, 3629, 10/gqn77n.
Zhang, Y., Zheng, X., Jiang, D., Luo, H., Guo, K., Song, X., Wang, C., 2022. The perceived effectiveness and hidden inequity of postpandemic fiscal stimuli. Proc. Natl. Acad. Sci. U.S.A. 119, e2105006119 https://doi.org/10.1073/pnas.2105006119.
Zhong, H., Feng, K., Sun, L., Cheng, L., Hubacek, K., 2020. Household carbon and energy inequality in Latin American and Caribbean countries. J. Environ. Manag. 273, 110979 https://doi.org/10.1016/j.jenvman.2020.110979.
World Bank Group, 2022. World Bank Commodity Price Data (Pink Sheets).