ERASMUS UNIVERSITEIT ROTTERDAM
Erasmus School of Economics

Bachelor Thesis Economie en Bedrijfseconomie

FOOD;
from
Wallet to Waste

The relation between economic development, measured as GDP per capita, and food waste generation, measured as the average food waste generation per capita by respectively households, retail and out-of-home-consumption, considered across countries worldwide.

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Date final version: April 2024

ABSTRACT

Food waste is a global concern. Though, nor the definition, nor its determinants are well understood. This paper examines the Environmental Kuznets Curve (EKC), using food waste as the indicator of environmental degradation. The so-called Food Waste Kuznets Curve (FWKC) assumes an inverted U-shaped or N-shaped relationship between GDP and the wasted food per capita. Previously, this has not been analysed across countries worldwide. Data on 190 countries for 2019 are analysed, using ordinary least squares regression with inclusion of control variables such as age, gender, education, household size, employment, urbanization, electricity access, refrigerator, and ethnicity. Contradictory to the FWKC hypothesis, the results provided a statistically significant U-shaped and inverted N-shaped relationship for respectively household and total food waste. By including control variables, the fit of the models improved. Notably, age was a strong factor in explaining food waste generation. Whereby the best explaining model of retail food waste, showed a statistically significant N-shape. The results that followed when running the various regression models for the separate income groups, were statistically insignificant for retail and household food waste. For the out-of-home-consumption, a statistically significant inverted N-shaped relationship was found for high-income countries.

INDEX

1. INTRODUCTION

Could you think of the journey of food from wallet to waste? This might sound special, but just to start, imagine that you are leaving the supermarket with three bags full of groceries, dropping one directly in the dustbin. Would it make a difference if you wasted one of the three bags full of food, at home?

Nothing is less true, yet, as a report by the Food and Agriculture Organization of the United Nations (FAO) (2011) estimates, globally approximately one-third of the food produced for human nutrition is lost or wasted. This amounts to 1.3 billion tonnes of total global food wastage, which is around 190 kilograms of edible food per person (Gjerris & Gaiani, 2013). To put this into perspective, if the total global food wastage was attributed to a single country, it would be the third-largest country in the world as a source of greenhouse gas emissions (FAO, 2015).

Due to the various impacts of food wastage on natural resources, the environment, food security and availability, and human health, it has become a global concern (Xue, et al., 2017). Especially because of the specific adopted target in the Sustainable Development Goals (SDG), which aims to halve the per capita global food waste at the retail and consumer level and reduce food loss along the production and supply chains by 2030 (UN, n.d.).

Although it is a global concern, there is neither consensus about its definition nor the availability and quality of its data. However, a widely used definition of food wastage is *''any food lost by deterioration or waste''* (FAO, 2019a), and thereby includes both food loss and food waste. Enclosed, food loss refers to *''any food that is discarded, incinerated, or otherwise disposed of along the food supply chain, which starts with harvest/slaughter/catch up to but excluding the retail level, and the food does not re-enter the supply chain for any other productive use, such as for feed or seed''* (FAO, 2019a). Food waste refers to *''the decrease in quantity or quality of food resulting from decisions and actions by retailers, food service providers, and consumers''* (FAO, 2019b).

There has been done much research on food wastage at the global, regional, and national levels. It has been determined that food wastage has a clear pattern at the global level. In low-income regions, food wastage occurs mostly during the early stages of the food supply chain. This is due to limited techniques and knowledge in harvesting, inadequate storage facilities, unfavourable climate conditions, lack of infrastructure, and insufficiency in the processing, packaging, and marketing systems (Bräutigam, Jörissen & Priefer, 2014; FAO, 2015). In contrast, food wastage in medium and high-income countries occur mostly at the downstream stages of the food supply chain that are related to consumer preferences and the coordination between different actors in the processing and distribution stages (FAO, 2015; Grethe, Dembélé & Duman, 2011 according to Bräutigam et al., 2014). Moreover, it has been determined that the further along the food chain the food wastage occurs, the more carbon-intensive the food wastage is since the greenhouse gas emissions get accumulated along the different stages (FAO, 2015). That is why it could be concluded that on a global average, the food wastage carbon footprint per capita in high-income countries is twice as big as that of low-income countries. This is due to the more wasteful food patterns at the downstream food chain in high-income countries compared to low-income countries (FAO, 2015).

Previous studies have also determined that there is a positive relationship between the gross domestic product (GDP) per capita and household food waste per capita (Barrera & Hertel, 2021; Gjerris & Gaiani, 2013; UNEP, 2021; Xue et al., 2017). It has been observed that when GDP per capita rises, the amount of food waste generated in households also increases (Barrera & Hertel, 2021; Gjerris & Gaiani, 2013; UNEP, 2021; Xue et al., 2017). Moreover, research of Xue et al. (2017) observed that when GDP per capita gets above a certain level, food waste generation per capita tends to decrease. This might confirm the presence of an Environmental Kuznets Curve (EKC) for the relationship between GDP per capita and food waste. The EKC will be elaborated in the theoretical framework.

Although there has been done previous research on the relationship between economic development and food wastage, it must be noted that it is not consistent as some studies did not find any significant results (UNEP, 2021). Additionally, previous studies often relied on data that was outdated, inconsistent, or based on secondary sources (Xue et al., 2017). Besides, it has been not possible to compare and explore patterns across countries, regions, and commodities (Xue et al., 2017). Moreover, the focus of various previous studies, has relied on a single country level, Europe, or America. To reach a better understanding, research is needed on food waste generation in other segments of the food supply, not just household food waste (Xue et al., 2017). Finally, there has been no specific research on the existence of an EKC for food wastage on a global level, or as it will be called a Food Waste Kuznets Curve (FWKC).

As a result of all the foregoing, this research will examine whether the Food Waste Kuznets Curve hypothesis is validated for the relationship between food waste generation and economic development on a global level, i.e. across countries worldwide. The following research question will be centralized:

Is the Food Waste Kuznets Curve hypothesis validated for the relationship between economic development, measured as GDP per capita, and food waste generation, measured as the average food waste generation per capita by respectively households, retail, and out-of-home-consumption, considered across countries worldwide?

To address this research question, a food waste data set of 190 countries across the world will be analysed. While the whole sample will be studied to analyse the global level, the differences in economic development regions will be factored by dividing the total sample in 4 income groups.

This research will contribute to a better understanding of the situation around global food wastage and its environmental, social, and economic impacts. It will help to identify the existence of an FWKC hypothesis across countries worldwide and contribute to the shortages in food wastage literature as named in Xue et al. (2017) and Bräutigam et al. (2014). One example is the lack of a clear understanding of which of the efforts to prevent and reduce food waste should be prioritized. Filling these gaps will help identify patterns between the driving factors of food waste generation between countries and the food chain, which will ultimately lead to a reduction of food wastage and more sustainability (Xue et al., 2017).

The paper is organized as follows. First the conceptual framework of the EKC will be described, whereafter the determinants of food waste generation for the retail, out-of-home and household sector will be discussed. Thereafter, the hypotheses that will be tested in this study will be developed. Subsequently, the methodology and data will be represented where the mathematical models and technique of analysis will be developed and the dependent, independent and control variables will be set. Besides, the used data and descriptive statistics will be displayed. Furthermore, the results will be illustrated. Afterwards, the results will be summarized and interpreted to validate or reject the hypotheses and answer the research question. Finally, the limitations of this research and implications for future research will be discussed.

2.THEORETICAL FRAMEWORK

2.1 The evolution of the EKC

To set up a framework for the FWKC, first the original EKC should be elaborated. The EKC is based on the research of Kuznets (1955), who hypothesized an inverted U-shaped curve for the relationship between income per capita and income inequality. In the early stages of economic growth, Kuznets (1955) observed an increasing unequal income distribution, which moved towards an equal income distribution in the later stages of economic growth (Kuznets, 1955).

The Kuznets curve attracted much attention and started to be applied in environmental studies (Leal & Marques, 2022). Research by Grossman and Krueger (1991) revealed that the relationship between income per capita and environmental degradation also followed an inverted U-shaped curve. Shortly after, a baseline for the Kuznets curve in an environmental context was provided with the creation of the EKC hypothesis (Boubellouta & Kusch-Brandt, 2021). Since then, it has been excessively applied as a framework for the relationship between any form of economic output and environmental degradation (Leal & Marques, 2022). Research has been done both on macro and micro level for different samples of countries, sectors, or regions, including cross-section, time series and panel data (Boubellouta & Kusch-Brandt, 2021).

Throughout the years, the EKC has been clearly examined for environmental indicators such as air pollution, water consumption, afforestation, and ecological footprint (Leal & Marques, 2022). Moreover, the EKC examination for solid waste generation has led to the Waste Kuznets Curve (WKC) (Boubellouta & Kusch-Brandt, 2021). The WKC has been examined with several indicators for waste generation, such as municipal solid waste, industrial solid waste, and electrical waste (Leal & Marques, 2022). Yet, as the type of indicators differs, the empirical results are sensitive to the variables under analysis and therefore are neither consequent nor unique. To require further evidence, it is therefore important that the relationship between economic development and waste generation is further examined (Boubellouta & Kusch-Brandt, 2021)

2.2 The shape of the EKC

The theoretical framework for both the EKC and the WKC could be interpreted in two different ways. One way is through a division in the early phases and later phases of economic development, as Kuznets first stated. However, more common is the division into three phases, as graphically shown in figure 1.

The first phase, represents the early stages of economic development, characterized by low levels of income and a reinforced use of natural resources. This contributes to a decreasing rise in environmental degradation. The second phase is defined by further economic growth, combined with increased knowledge and technological development, which reduces the demand of non-renewable resources. This phase also displays the turning point of the EKC. The third phase represents the later stages of economic development, characterized by higher levels of income, augmented amounts of research and developments (R&D) and increased environmental awareness. This leads to an increasing decline of environmental degradation (Leal & Marques, 2022; Sinha, Shahbaz & Balsalobre, 2019). However, further economic growth could lead to the case that the scale effect outweighs the technical effect. This leads to technical obsolescence, where technical advancements do not persist and initiate the economy back to a stage with increased environmental degradation (Sinha et al., 2019). This is valid for an N-shaped EKC.

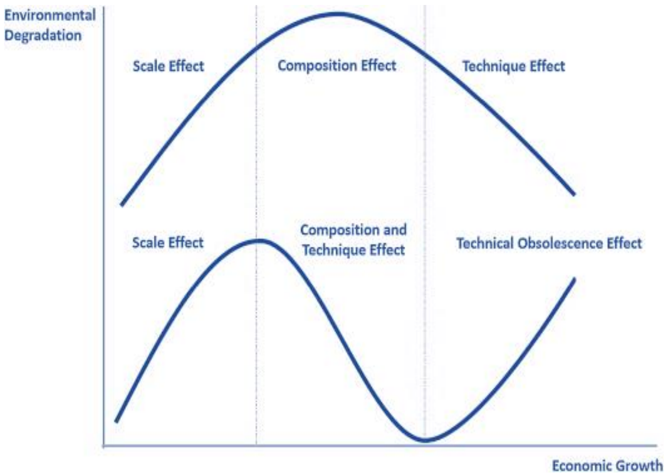

Figure 1 *The graphical representation of the various phases of the EKC hypothesis retrieved from Sinha et al., (2019).*

2.3 The determinants of food wastage

After the shape of the EKC has been defined, it is important to define the structure. The structure includes the determination of the additional variables in the estimation of the assessed EKC relationship. According to Leal and Marques (2022) the EKC assessment and its estimation are, among other things, sensitive, to the inclusion of additional variables. Therefore, an explanation behind the possible determinants of food wastage is required before the FWKC analysis could be examined.

The generation of food wastage occurs at all stages of the food supply chain; *''between farm and fork''* (European Commission Directorate General for the Environment (DG ENV), 2010). In the upstream of the food chain, it is named ''food loss'', while in the downstream it is named ''food waste'' (Bräutigam et al., 2014; FAO, 2015). Research of DG ENV (2010) has documented the principal causes of sector-specific food wastage by manufacturing, wholesale/retail, food service/out-of-home-consumption, and household.

2.3.1 The manufacturing

In the manufacturing sector, food loss is largely a result of limited technologies, knowledge, and skills in the harvesting and processing of food (DG ENV, 2010). Additionally, unfavourable climate conditions, overproduction, inconsistent product quality – such as ''misshapen'' products – inadequate storage facilities, a lack of infrastructure, legal limitations, and inadequate processing, packaging, and marketing play a role (Bräutigam et al., 2014; DG ENV, 2010; FAO, 2015).

2.3.2 The wholesale/retail

In the retail sector, food waste is mainly a result of inefficient marketing strategies between retailers, distributors, wholesalers, consumers, and manufacturers. These can lead to difficulties in stock management, for example (DG ENV, 2010). Moreover, marketing standards on the perishability and acceptability of food lead to food waste while neither food quality nor safety is affected (DG ENV, 2010; Shamsunnahar, Tabassum & Zannatul, 2021). Besides, high product specifications, as different temperature sensitivities, lead to food waste (DG ENV, 2010). Also, store region, type of retail, the unit price of food, and seasonal factors play a role. Furthermore, customer-specific demographics such as ethnicity, age, income, and the existence of families with children are found to be related with retail food waste generation (Davis, 2015; Shamsunnahar et al., 2021; Soma, 2020). Finally, the available technologies and knowledge of employees in the retail food sector are an important cause of food waste (Shamsunnahar et al., 2021).

2.3.3 The food service/ out-of-home-consumption

In the food service sector – mainly known as the out-of-home-consumption of food – food waste is a result of provided portion sizes, challenges with logistics and stocking, and customer awareness and preferences (DG ENV, 2010). Additionally, the attitudes of consumers on their ownership or responsibility of the food consumed out-of-home are related (DG ENV, 2010; WRAP, 2012). Also, the elevated expectations for food quality are a reason (WRAP, 2012). It should be noted that research has found that social norms seem to play a bigger role (DG ENV, 2010; WRAP, 2012).

2.3.4 The households

The theoretical Motivation Opportunity and Ability (MOA) framework of Van Geffen, Van Herpen and Van Trijp (2016), as illustrated in figure 2, is used to address the determinants of household food waste generation. Research from DG ENV (2010), Janssen, Van der Sluis, Jonkers & De Haan (2010) and Van Dooren & Knüppe, (2020) is incorporated to expand the framework.

The motivational part of the framework is separated into the awareness, attitude, and social norms of consumers on food waste (DG ENV, 2010; Van Dooren & Knüppe, 2020). Enclosed, awareness refers to the consciousness of individually generated food waste, its environmental and financial impacts, and the efficient use of food (DG ENV, 2010). According to the report of Van Dooren & Knüppe (2020) this is related to gender, education, and age, with respectively female, intermediate, or highly educated people and people younger than 34 years having a higher sense of food waste behaviour (Van Dooren & Knüppe, 2020). Additionally, research indicates that having children has an impact (Van Dooren & Knüppe, 2020). The attitude refers to the undervaluation, necessity, and efficient use of food (DG ENV, 2010). This is related to the age and experiences of people. For example, generations that have not experienced any wars, are more indifferent to the generation of food waste (Van Dooren & Knüppe, 2020). Social norms refer to the personal norms, values, and preferences of consumers (DG ENV, 2010; Janssen, et al.2010; Van Dooren & Knüppe, 2020). Preferences include parts of food that are wasted because of personal taste – such as peels of fruits and vegetables or the crust of bread (DG ENV, 2010). Also, the extent of food wasted by others, or the fact that others can see or know about them individual food waste generation, is an element (Van Dooren & Knüppe, 2020). Moreover, social norms are related to the knowledge and skills of people (European Commission Directorate General for the Environment, 2010; Van Dooren & Knüppe, 2020).

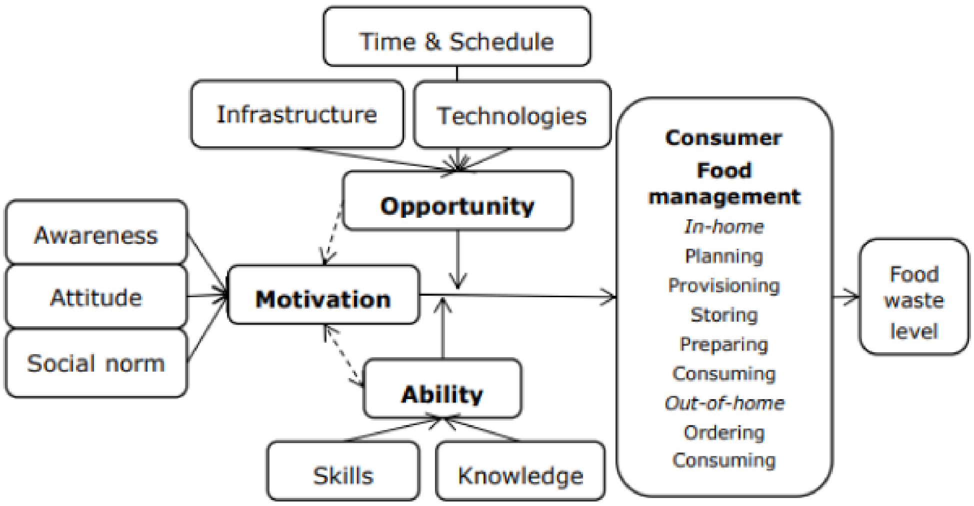

***Figure 2** The consumer food waste model (MOA framework) of Van Geffen (2016) Retrieved from Van Geffen et al. (2016).*

The ability part of the framework is distinguished to the knowledge and skills on how to buy, store, pack, and use food (DG ENV, 2010). Enclosed, this refers, among other things, to planning issues on buying food or the misinterpretation or confusion about labels leading to food waste that is still edible (DG ENV, 2010). With examples of Gjerris & Gaiani (2013) and Van Dooren & Knüppe (2020) it could then be concluded that the ability depends on education, age, and cultural values.

The opportunity part of the framework consists of the time, technology, and available infrastructure (DG ENV, 2010; Van Dooren & Knüppe, 2020). Time refers to the distribution between work and leisure to spend on food planning, buying, cooking, etcetera (DG ENV, 2010; Van Dooren & Knüppe, 2020). Therefore, it is dependent on employment and therewith age and education. The infrastructure is related to the store access and availability of food (European Commission Directorate General for the Environment, 2010; Van Dooren & Knüppe, 2020) which depends on the degree of urbanization. Finally, technology is related to the knowledge and skills of consumers, but also the way of food packaging and storage at home (DG ENV t, 2010; Van Dooren & Knüppe, 2020). Access to electricity, and the presence of a refrigerator at home, could also be noted as a determinant as it influences the availability of cooling and suitable ways of food storage (Van Dooren & Knüppe, 2020).

According to research, in addition to the MOA framework, socio-demographic factors such as age, household size, gender, geographical conditions of the country, culture, employment status, disposable income and education are influencing food waste generation (DG ENV, 2010; Gjerris & Gaiani, 2013 Grasso et al., 2019; Janssen, et al., 2010; Van Dooren & Knüppe, 2020). Other studies have shown that food waste generation is significantly related to the composition of the household, whereby a larger household size is related to more food waste generation compared to those living in a single-person household (WRAP, 2009 according to Gjerris & Gaiani, 2013; Grasso et al., 2019) while households with children are more likely to show food waste behaviour (Grasso et al., 2019). Moreover, previous studies have shown a negative correlation between age and food waste (Grasso et al., 2019). Specifically, younger people tend to have more food waste than older people. Adults above 65 are more into food waste-reducing behaviours such as planning meals ahead, saving and recycling, and have more experienced knowledge compared to younger adults (Gjerris & Gaiani, 2013; Grasso et al., 2019). Besides, the study of Grasso et al. (2019) has shown a negative relationship between employment status and food waste, whereby unemployed people tend to waste less food compared to full-time employed people. Also, being male is associated with more food waste generation as women could be considered on average more food conscious (Grasso et al., 2019). However, it is noted that the relationship between gender and food waste may greatly vary between countries (Grasso et al., 2019) and the impact of disposable income on food waste generation is sensitive to the research characteristics (Gjerris & Gaiani, 2013).

2.4 The FWKC hypothesis

Based on all literature above, it could be stated that the relationship between GDP per capita and the food waste generation for respectively retail, out-of-home-consumption and households will be positively correlated. This indicates that when the GDP per capita increases, the amount of food waste generation per capita will also increase. That may be related to the assumption that with a higher GDP per capita and therewith a higher disposable income, people tend to consume more food. This holds especially for food of higher quality or specificity – which leads to more retail and household food waste. The same applies to the out-of-home-consumption of food, as it is assumed that people spend more on food outside the home with a higher disposable income and higher living standards (Xue et al. (2017)).

However, it is expected that as GDP per capita further rises, the food waste per capita will tend to decrease after a specific threshold. This is a result of the increasing individual and public awareness, attitudes, and social norms. For example, stricter regulations and campaigns on food waste behaviour or simple the preference to consume more prepared meals (Xue et al., 2017). Also, the increasing ability and opportunity of consumers – like appropriate food storage – due to technologies and skills will cause a decrease in food waste generation. Therefore, the following hypothesis is proposed:

The relationship between GDP per capita and food waste generation per capita will show an inverted U-shaped curve, and therewith the existence of a Food Waste Kuznets Curve hypothesis in the context of this research. *(1)*

Although an inverted U-shaped curve is expected, it should be noted that as GDP per capita rises even more, it is possible that food waste generation will again increase. Imaginable is that, despite all the increased motivation, opportunity, and ability of food waste-decreasing behaviour, people will have higher living standards. Then, they could simply afford wasted food or even not consider it any more as a concern. Therefore, the second hypothesis is proposed:

The relationship between GDP per capita and food waste generation per capita will show an N-shaped curve. *(2)*

3. DATA AND METHODOLOGY

This section will describe the regression models that will be used in this study to estimate whether the FWKC hypothesis is validated. The mathematical model with the dependent, independent, and control variables will be outlined, while the used data will be described.

3.1 Methodology

To test the validation of the FWKC hypothesis between GDP per capita and the food waste generation per capita, the following core model will be used:

$$FW.cap_i = \beta_0 + \beta_1(GDP.cap_i) + \beta_2(GDP.cap_i)^2 + \beta_3(GDP.cap_i)^3 + \beta_4(Z_i) + \varepsilon_i \qquad (1)$$

where $FW.cap_i$ refers to the food waste generation per capita, $GDP.cap_i$ is the gross domestic product per capita, i is the country, and ε is the included error term. The coefficient β_1 represents the extent of a linear relationship, whereas β_2 represents the extent of a non-linear relationship and β_3 represents the extent of a cubical relationship between GDP per capita and food waste generation. The coefficient β_4 represents the vector of coefficients of Z_i which represents the vector of control variables that might affect the food waste generation. This term will be included to determine if the results of the GDP per capita effect rely on the estimated model and therewith to prevent omitted variable bias. The further specification and justification of the included control variables will be developed in section (3.1.2.3).

For the assessment of the foregoing model, one of the following conditions, with a graphical representation in figure 3, could be validated:

1. $\beta_1 = \beta_2 = \beta_3 = 0$ there is no relationship between $GDP.cap_i$ and $FW.cap_i$
2. $\beta_1 > 0$ and $\beta_2 = \beta_3 = 0$ there is a positive linear relationship between $GDP.cap_i$ and $FW.cap_i$
3. $\beta_1 < 0$ and $\beta_2 = \beta_3 = 0$ there is a negative linear relationship between $GDP.cap_i$ and $FW.cap_i$
4. $\beta_1 < 0$, $\beta_2 > 0$ and $\beta_3 = 0$ there is a U-shaped relationship between $GDP.cap_i$ and $FW.cap_i$
5. $\beta_1 > 0$, $\beta_2 < 0$ and $\beta_3 = 0$ there is an inverted U-shaped relationship between $GDP.cap_i$ and $FW.cap_i$
6. $\beta_1 < 0$ and $\beta_2 > 0$ and $\beta_3 < 0$ there is an inverted N-shaped relationship between $GDP.cap_i$ and $FW.cap_i$
7. $\beta_1 > 0$ and $\beta_2 < 0$ and $\beta_3 > 0$ there is a N-shaped relationship between $GDP.cap_i$ and $FW.cap_i$

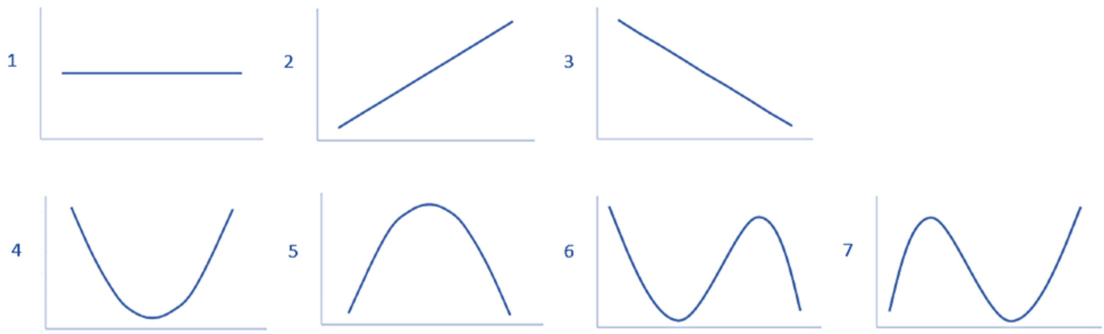

Figure 3 *The graphical representation of the possible conditions that could be validated by the EKC-analysis*
Note. (1) no relationship; (2) positive linear relationship; (3) negative linear relationship; (4) U-shaped relationship; (5) inverted U-shaped relationship; (6) inverted N-shaped relationship; (7) N-shaped relationship.

Thus, to confirm the FWKC hypothesis, the fifth, or seventh condition should be validated. Specifically, to accept hypothesis 1 the fifth condition should be validated, while for hypothesis 2 the seventh condition should be validated. Both hypotheses are tested on a significance level of 10%, 5% and 1%.

3.1.1 Technique of the analysis

The foregoing model will be applied first in the simplified quadratic form, without GDP cube and control variables. Secondly, control variables will be added to the quadratic model to determine if the results for the effect of GDP on food waste generation rely on the estimated model and to prevent omitted variable bias. For the assessment of the second hypothesis, the model will be applied in the simplified cubic form, whereafter the control variables will be included. It should be highlighted that this happens towards a shrinking dataset, because not all countries have complete data on all included control variables.

The software SPSS will be used to analyse the available cross-sectional data on food waste generation and its determinants. As the ordinary least squares method has been widely used in previous research to examine the EKC hypothesis and is a common way to analyse cross-sectional data, this study is also appropriate to use the OLS method. Other methods that are widely used for the EKC analysis, such as the fixed effect regression, require panel data, which is not available in this case. Therefore, it is impossible to correct for eventual unobserved heterogeneity between countries and years.

Consequently – as an extended robustness check – it will be tested whether for group dummies based on income group[1] the results will be different. Additionally, the interaction effects of these group dummies with GDP per capita will be incorporated. This way, it could be determined if the effect of GDP on food waste generation depends on the income group of a country. The foregoing results in the following equation:

[1] According to the *World Bank*, the defined income levels are set on the base of economic development.

$$FW.cap_i = \beta_0 + \beta_1(GDP.cap_i) + \beta_2(GDP.cap_i)^2 + \beta_3(GDP.cap_i)^3 + \beta_4(Z_i) + \beta_5(Incomegroup) + \beta_6(Incomegroup * GDP.cap_i) + \varepsilon_i \quad (2)$$

where $Incomegroup$ is an ordinal variable ranging from 1 to 4, encompassing the categories of high-income, low-income, lower-middle-income, and upper-middle-income countries. It should be noted that the high-income group represents the benchmark, which means that all results are considered with respect to high-income countries. The coefficient β_5 represents the observed average increase in $FW.cap_i$ for the relevant $Incomegroup$ with respect to the high-income group. $Incomegroup * GDP.cap_i$ refers to the interaction effect of the income group with GDP per capita, whereas the coefficient β_6 represents – together with β_1 – the effect of GDP on food waste generation per capita for the relevant income group.

Finally, the simplified quadratic and cubic model are separately estimated for high-income, low-income, lower-middle-income, and upper-middle-income countries. These groups are based on their distinct levels of economic development. This allows for a closer examination of food waste generation across countries of the various income groups, which could provide useful information for solving the food waste problem in specific regions.

3.1.2 Defining the variables

3.1.2.1 The dependent variables

To ensure a better understanding of the relationship between GDP per capita and food waste generation per capita, this study uses retail food waste generation per capita ($FWretail.cap_i$), out-of-home-consumption food waste generation per capita ($FWoutofhomeconsumption.cap_i$), household food waste generation per capita ($FWhouseholds.cap_i$) and total food waste generation per capita ($FWtotal.cap_i$) as dependent variables. All types of food waste generation per capita refer to the amount of food wasted per capita, measured in kilograms.

3.1.2.2 The independent variable

As independent variable of this study, the gross domestic product per capita ($GDP.cap_i$), measured in current dollars using purchasing power parity (ppp) is used. According to previous literature, this is generally used as a standard measure for economic development in the assessment of an EKC analysis (Grossman & Krueger, 1991; Boubellouta & Kusch-Brandt, 2021). To test appropriately for the FWKC, GDP square ($(GDP.cap_i)^2$) and GDP cube ($(GDP.cap_i)^3$) are included into the models.

3.1.2.3 The control variables

In section 2.3 the determinants of food waste generation across the downstream food chain were displayed. This leads to a specific subset of control variables that will be included in the prescribed econometric model.

It was stated that for the retail sector, food waste is mainly a result of inefficient marketing strategies and standards on food perishability, acceptability, and quality additional to store-and customer-specific demographic factors (Davis, 2015; DG ENV, 2010; Shamsunnahar, et al., 2021). To represent these determinants, variables such as age, household size, ethnicity, and urbanization will be used. For the household sector, the MOA framework formed the leading wire, with additional elaboration of research from DG ENV, 2010; Gjerris & Gaiani, 2013 Grasso et al., 2019; Janssen, et al., 2010 and Van Dooren & Knüppe, 2020. Variables such as gender, education, age, and household size are set to represent the motivational part. Whereas the ability and opportunity part are represented by factors such as, education, age, employment status, urbanization, and ethnicity, but also the access to electricity and the availability of a refrigerator are considered. The determinants for out-of-home-consumption food waste are comparable to the motivational part of the MOA framework, whereby variables such as age, gender, education, and household size will be used.

Table 1 illustrates the operationalization of the control variables in this study.

Table 1 *Specification of the used control variables.*

Age_i	Median age.
$Gender_i$	Total average female population, derived from the average percentage of female population.
$Education_i$	Mean years of schooling, which refers to the completed years of education of the population above 25 years.
$Householdsize_i$	Average household size.
$Employment_i$	Average annual working hours per worker.
$Urbanization_i$	Total average population that lives in urban areas, which is derived from the percentage of urban population.
$Elektricityaccess_i$	Total average population with access to electricity, which is derived from the percentage of the total population with access to electricity. ''Access to electricity'' refers to the delivery of electricity and the requirement to consume a certain minimum amount.
$Refrigerator_i$	Total average households with a refrigerator, which is derived from the percentage of households with a refrigerator. The average amount of households is calculated by dividing the total population by the average household size of a country.
$Ethnicity_i$	The amount of various ethnicity groups. To determine the number of ethnicity groups, the mentioned groups are counted whereby the groups listed in brackets are considered as one ethnicity group except when it is stated as ''other'' then it is added up as a separate ethnicity group.

3.1.3 Specification to the hypotheses

In the foregoing sections, the core model[2] and the dependent, independent and control variables were displayed. Altogether, this results to the following elaborated equations:

$$FWretail.cap_i = \beta_0 + \beta_1(GDP.cap_i) + \beta_2(GDP.cap_i)^2 + \beta_3(GDP.cap_i)^3 + \beta_4(Age_i) + \beta_5(Householdsize_i) + \beta_6(Ethnicity_i) + \beta_7(Urbanization_i) + \varepsilon_i \quad (3)$$

[2] Represented by equation (1).

$$FWoutofhomeconsumption.cap_i = \beta_0 + \beta_1(GDP.cap_i) + \beta_2(GDP.cap_i)^2 + \beta_3(GDP.cap_i)^3 + \beta_4(Age_i) + \beta_5(Gender_i) + \beta_6(Education_i) + \beta_7(Householdsize_i) + \varepsilon_i \quad (4)$$

$$FWhouseholds.cap_i = \beta_0 + \beta_1(GDP.cap_i) + \beta_2(GDP.cap_i)^2 + \beta_3(GDP.cap_i)^3 + \beta_4(Age_i) + \beta_5(Gender_i) + \beta_6(Education_i) + \beta_7(Householdsize_i) + \beta_8(Employment\ status_i) + \beta_9(Urbanization_i) + \beta_{10}(Electricityaccess_i) + \beta_{11}(Refrigerator_i) + \varepsilon_i \quad (5)$$

$$FWtotal.cap_i = \beta_0 + \beta_1(GDP.cap_i) + \beta_2(GDP.cap_i)^2 + \beta_3(GDP.cap_i)^3 + \beta_4(Age_i) + \beta_5(Gender_i) + \beta_6(Education_i) + \beta_7(Householdsize_i) + \beta_8(Employment\ status_i) + \beta_9(Urbanization_i) + \beta_{10}(Electricityaccess_i) + \beta_{11}(Refrigerator_i) + \beta_{12}(Ethnicity_i) + \varepsilon_i \quad (6)$$

3.2 Data

The data for the dependent variable is derived from the database *Our World in Data* which represents data originating from United Nations statistics division on the average food wasted per capita, measured in kilograms. The database is subdivided into the amount of food waste generated for retail, out-of-home-consumption, household and the total cumulative. The dataset consists of 215 countries for the year of 2019.

For the independent variable, data on GDP per capita is derived from the *World Databank* and consists of 190 countries selected for the year 2019. As the data of the GDP falls short with respect to the data of food waste generation, the data for food waste generation will be selected for those corresponding 190 countries.

The data for the control variables are retrieved from various databases. For the variable *Age,* the database on median age of *Our World in Data* is used. *Gender*, *Urbanization* and *Electricityaccess* are collected from data on corresponding percentages from *Our World in Data*. To transform the data of *Gender*, *Urbanization* and *Electricityaccess* into total population sizes, data on the amount of total population of a country from the *World Databank* is used.

Additionally, data on *Employment* is retrieved from the meta-entry on working hours from *Our World in Data*. This meta-entry consists of a comparison of various sources on annual working hours estimates, of which in this study, the PWT data column is used. The variables *Education*, *Householdsize* and *Refrigerator* are coming from the *Global Data Lab Area Database*. The data for the variable *Ethnicity* is retrieved from the *World Factbook,* where the most recent percentages of various ethnic groups are listed per country. All data is selected for the year of 2019 as this is the most recent dataset available with respect to food waste generation across countries around the world, making an appropriate created dataset possible.

3.2.1 Descriptive statistics

Table 1 (Appendix A) displays the main descriptive statistics of the variables used in this study. Additionally, table 2 (Appendix A) displays the food waste generation around the world in 2019, disaggregated by income group. It reveals that the data for low-income countries is least available compared to the other income groups. Furthermore, it could be seen that total food waste generation is highest for low-income countries, whereas it is lowest for high-income countries. This could indicate that there is a negative relationship between income and food waste.

Table 3 (Appendix A) provides the correlation coefficients between the various pairs of variables, indicating the strength and direction of the relationship. It is important to note that non-causal relationships are estimated, where statistically significant results are marked for ease of use. It is revealed that there are strong positive correlations between *Age* and *GDP*, *Education* and *GDP*, and *Education* and *Age*. There is a moderately negative correlation between *Employment* and *GDP, Age* and *Education*. The correlation between *Employment* and *Gender* is weakly positive. Additionally, *Electricityaccess* shows weakly negative correlations with *GDP*, *Age* and *Education*, while weakly positive correlations with *Employment*. *Urbanization* and *Electricityaccess* have a weak correlation. *Household size* has a moderately negative correlation with *GDP, Ag*e and *Education*. *Ethnicity* has a weak negative correlation with *Age* and *Education*.

Looking closer to the correlations of the variables for food waste generation in table 3 (Appendix A), it should be noted that it is expected that it has a weakly negative correlation with *GDP* across total, retail and household sectors. This indicates that as food waste generation increases, *GDP* per capita decreases. Additionally, there is a moderate negative correlation with *Age* and *Education*, suggesting that younger and more educated people tend to produce more food waste. *Retail food wast*e is moderately positively correlated with *Employment*, while *out-of-home-consumption food waste* is weakly positively correlated with *Householdsize* and *Urbanization*.

Figures 4 and 5 display the relationship between GDP per capita and total food waste generation per capita. It has been shown that for all countries a slightly bent U-shaped curve is visible, while for lower-middle and low-income countries a slightly bent inverted U-shaped curve is visible. Figures 1 – 6 (Appendix A), represent the scatter plots of the relationships between GDP per capita and respectively retail, out-of-home-consumption and household food waste generation.

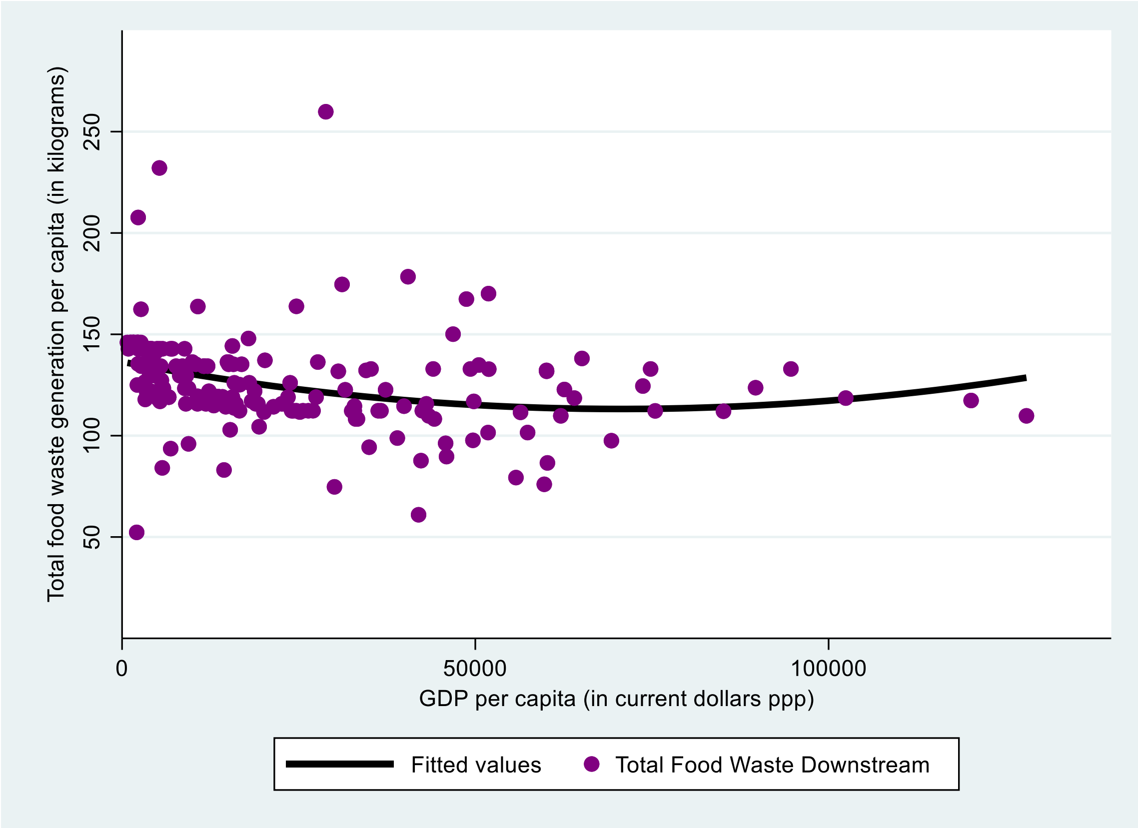

Figure 4 *Total food waste generation per capita versus GDP per capita across countries worldwide for 2019.*

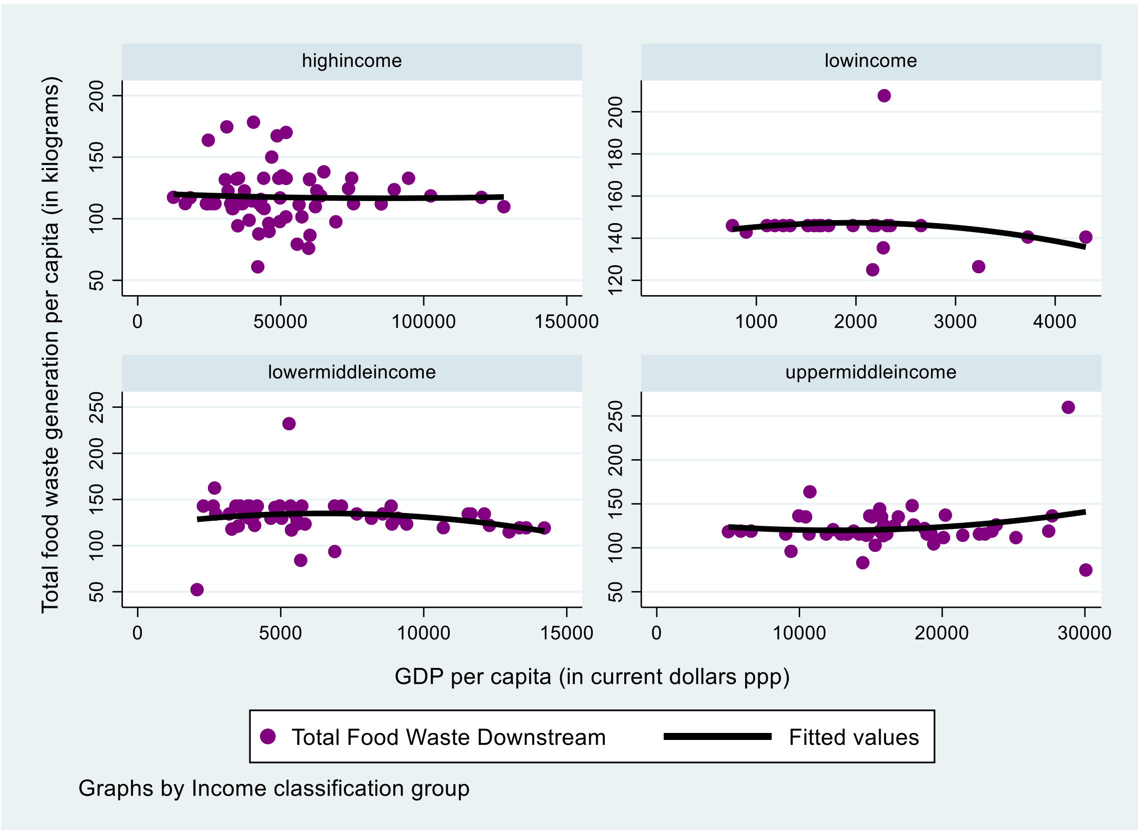

Figure 5 *Total food waste generation per capita versus GDP per capita across countries worldwide for 2019 by income group.*

4. RESULTS

In this section, the results of the performed regressions will be presented. First, the simplified quadratic and cubic model will be estimated, without control variables. Then, control variables will be added to ensure a better specification. The potential presence of unobservable heterogeneity among countries and years will be addressed by the inclusion of group dummies. Finally, the results separated by income group will be described.

4.1 Hypothesis 1

The first hypothesis that will be tested, states that there will be an inverted U-shaped relationship between GDP per capita and food waste generation per capita. This means that as GDP increases, the amount of food waste generated per capita for retail, out-of-home-consumption and household will also increase until a certain point whereafter further increases in GDP per capita will lead to a decline in food waste generation. To confirm an inverted U-shaped relationship between GDP and food waste, the coefficient of GDP per capita and its square need a positive and negative sign respectively.

To gain structure, hypothesis 1 is analysed separately for each sector, including retail (table 1, Appendix B), out-of-home-consumption (table 2, Appendix B), household (table 3, Appendix B) and the cumulative total of these sectors (table 4, Appendix B). Additionally, to create an overview of the GDP effect on food waste generation, table 2 only contains the found results for the GDP variables. Significant results are marked for ease of use.

Model 1 of table 2 represents the basic quadratic regression results for the relationship between GDP per capita and food waste generation. For retail food waste generation (table 2 panel A), it is shown that the coefficients of GDP and its square have both a negative sign. This indicates that the relationship curve is shaped by a horizontal parabola opening to the right. For out-of-home-consumption (table 2,

Table 2 *Quadratic regression results for the relationship between GDP and Food waste generation per capita.*

Dependent variable	$Food\ waste\ generation\ per\ capita$						
All countries Independent variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
Panel A Retail							
$(GDP.cap)$	-0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000*** (0.000)		
$(GDP.cap)^2$	-0.000 (0.000)	-0.000* (0.000)	-0.000* (0.000)	-0.000 (0.000)	-0.000*** (0.000)		
Observations	190	189	189	180	63		
R^2	0.030	0.061	0.061	0.068	0.396		
Adjusted R^2	0.019	0.046	0.040	0.041	0.331		
Fstatistic	2.863* (2, 187)	3.996*** (3, 185)	2.981** (4, 184)	2.547** (5, 174)	6.117*** (6, 56)		

Table 2 *continued*

Dependent variable	$Food\ waste\ generation\ per\ capita$						
All countries Independent variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
Panel B Out-of-home-consumption							
$(GDP.cap)$	-0.000	0.000	0.000	0.000	0.000		
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)		
$(GDP.cap)^2$	0.000	-0.000	-0.000	-0.000	-0.000		
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)		
Observations	190	189	179	172	67		
R^2	0.001	0.014	0.014	0.014	0.069		
Adjusted R^2	-0.010	-0.000	-0.010	-0.016	-0.024		
Fstatistic	0.082	0.869	0.630	0.464	0.744		
	(2, 187)	(3, 185)	(4, 174)	(5, 166)	(6, 60)		
Panel C Household							
$(GDP.cap)$	-0.001***	0.000	0.000	0.000	0.000	-0.001	-0.015*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.002)	(0.001)
$(GDP.cap)^2$	0.000***	-0.000	-0.000	-0.000	-0.000	0.000	0.000*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	190	189	189	179	172	67	12
R^2	0.102	0.197	0.208	0.217	0.244	0.291	0.999
Adjusted R^2	0.093	0.184	0.186	0.190	0.212	0.179	0.996
Fstatistic	10.630***	15.160***	9.597***	7.959***	7.565***	2.604**	243.482*
	(2, 187)	(3, 185)	(5, 183)	(6, 172)	(7, 164)	(9, 57)	(10, 1)
Panel D Total							
$(GDP.cap)$	-0.001***	0.001*	0.000	0.000	0.000	0.001	-0.001
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.002)
$(GDP.cap)^2$	0.000**	-0.000	-0.000	-0.000	-0.000	-0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	190	189	189	180	170	163	61
R^2	0.096	0.210	0.222	0.230	0.237	0.247	0.317
Adjusted R^2	0.087	0.198	0.200	0.203	0.204	0.208	0.181
Fstatistic	9.952***	16.425***	10.416***	8.595***	7.194***	6.325***	2.322**
	(2, 187)	(3, 185)	(5, 183)	(6, 173)	(7, 162)	(8, 154)	(10, 50)

Note. Standard errors are given in parentheses under the regression coefficients; The individual regression coefficient is significant at the *10%; **5% or ***1% significance level; The full regression results are represented in table 1, 2, 3, and 4 of Appendix B; For all panels, model 1 represents the simplified basic quadratic regression results; Additionally, panel A contains [Age] (2), [Age and Urbanization] (3) [Age, Urbanization and Ethnicity] (4), [Age, Urbanization, Ethnicity and Householdsize] (5); panel B contains [Age] (2), [Age and Gender] (3), [Age, Gender and Education] (4), [Age, Gender, Education and Householdsize] (5); panel C contains [Age] (2), [Age, Urbanization and Electricityaccess] (3), [Age, Urbanization, Electricityaccess and Gender] (4), [Age, Urbanization, Electricityaccess, Gender and Education] (5), [Age, Urbanization, Electricityaccess, Gender, Education, Refrigerator and Householdsize] (6), [Age, Urbanization, Electricityaccess, Gender, Education, Refrigerator, Householdsize and Employment] (7); panel D contains [Age] (2), [Age, Urbanization and Electricityaccess] (3), [Age, Urbanization, Electricityaccess and Ethnicity] (4), [Age, Urbanization, Electricityaccess, Ethnicity and Gender] (5), [Age, Urbanization, Electricityaccess, Ethnicity, Gender and Education] (6), [Age, Urbanization, Electricityaccess, Ethnicity, Gender, Education, Refrigerator and Householdsize] (7).

panel B), household (table 2 panel C), and total food waste generation (table 2 panel D), it is shown that the coefficients of GDP and its square have a negative and positive sign respectively, indicating a

U-shaped relationship. This relationship is confirmed for household and total food waste generation on a 1% and 5% significance level respectively. It is important to note that, for all estimated models, the coefficients sizes of GDP and its square, limit its economic significance.

When evaluating the inclusion of the control variables, it becomes evident that there is a lack of robustness for retail and out-of-home-consumption food waste generation. The coefficients of GDP now predict an inverted U-shaped relationship, which could be confirmed for model 5 (table 2 panel A) of retail food waste generation at 1% significance level. In table 2 panel C it is shown that the basic quadratic regression model for household food waste generation stays robust except for models 2, 3, 4 and 5 where an insignificant inverted U-shaped relationship is predicted. The same holds true for total food waste generation where the robustness is limited to model 5 (table 2 panel D).

Looking at the different control variables, it could be seen that the coefficient of *Urbanization* suggests a slightly positive relationship on 5% significance levels for model 6 (table 3, Appendix B) of household food waste generation and model 7 (table 4, Appendix B) of total food waste generation. The coefficient of *Electricityaccess* submits a slightly negative relationship with household and total food waste generation for models 5, 6 and 7 (table 3 and 4, Appendix B). However, both variables are economically insignificant. Additionally, *Education* predicts a negative relationship with household food waste generation for the specific subset of model 5 (table 3, Appendix B). This indicates that as the average years of schooling of a country increase, the average household food waste will decrease. Finally, all variables are statistically significant on 10% significance level for model 7 (table 3, Appendix B).

According to the performed F(df)-tests[3], the fit of model 2 is strongly improved compared to the baseline equation in model 1. Indicating, that the control variable *Age* played the biggest role in better explaining the relationship between GDP per capita and food waste generation with respect to the other control variables. This holds true for retail, and total food waste generation. Considering relationship of household food waste generation, this holds true for the subset of model 5 (table 3, Appendix B), indicating that the variables *Age*, *Electricityaccess*, and *Education* improve the explanation. It should be noted that the inclusion of control variables has no added value compared to the baseline model for the relationship between GDP per capita and out-of-home-consumption food waste (table 6, Appendix B). With respect to the analysed sectors, the best fit model hypothesizes an insignificant inverted U-shaped relationship between GDP per capita and food waste generation. Additionally, it suggests a negative relationship between age and food waste generation. This means that for a given country, if the median age increases, the generation of food waste will decrease.

[3] See specific subscriptions of table 1, 3 and 4 Appendix B.

Overall, when comparing the performed basic quadratic regression results, there is no inverted U-shaped relationship found between GDP per capita and food waste generation per capita. However, the best fit models, predict is a statistically insignificant inverted U-shaped relationship. Therefore, there is no empirical evidence for hypothesis 1 in this context.

4.2 Hypothesis 2

Secondly, hypothesis 2 will be tested which, posits that the relationship between GDP per capita and food waste generation per capita will show an N-shaped curve. In simpler terms, this means that as GDP per capita rises, the amount of food waste generated by retail, out-of-home-consumption and household will initially increase until reaching a peak. Subsequently, with further increases in GDP per capita, food waste generation per capita is expected to decline until a threshold whereafter it will rise again. To confirm an N-shaped relationship between GDP and food waste, it is necessary that the coefficient of GDP and its cube are positive, while the coefficient of GDP square needs to be negative.

To gain structure, hypothesis 2 is analysed separately for each sector, including retail (table 5, Appendix B), out-of-home-consumption (table 6, Appendix B), household (table 7, Appendix B) and the cumulative total of these sectors (table 8, Appendix B). Additionally, to create an overview of the GDP effect on food waste generation, table 3 only contains the found results for the GDP variables. Significant results are marked for ease of use.

Model 1 of table 3 represents the basic cubic regression for the relationship between GDP per capita and food waste generation. For retail food waste generation, it is shown that the coefficients of GDP, its square and its cube are positive, negative, and positive respectively (table 3 panel A). This indicates that the relationship is shaped by a N-curve. For out-of-home-consumption, household, and total food waste generation the coefficients of GDP, its square and its cube are negative, positive, and negative respectively, hypothesizing an inverted N-shaped relationship (see respectively table 3 panel B, C and D). This relationship is confirmed for household food waste generation and total food waste generation at 5% significance level and 10% significance level respectively, without economic significance.

When considering the different subsets of control variables, it becomes clear that the relationship for retail food waste generation appears to be remarkably robust (table 3 panel A). For out-of-home-consumption food waste generation and total food waste generation, it becomes evident that there is a lack of robustness except for the last models. The coefficients of GDP, its square and its cube now oppositely hypothesize an insignificant N-shaped curve (table 3 panel B and D). In table 3 panel C it is shown that the basic cubic regression model for household food waste generation is not robust, as the models show varying coefficients for GDP, its square and its cube.

Table 3 *Quadratic regression results for the relationship between GDP and Food waste generation per capita.*

Dependent variable	*Food waste generation per capita*						
All countries Independent variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
Panel A Retail							
$(GDP.cap)$	0.000	0.000**	0.000**	0.000**	0.000**		
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)		
$(GDP.cap)^2$	-0.000	-0.000**	-0.000**	-0.000**	-0.000**		
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)		
$(GDP.cap)^3$	0.000	0.000*	0.000*	0.000*	0.000*		
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)		
Observations	190	189	189	180	63		
R^2	0.031	0.079	0.079	0.079	0.727		
Adjusted R^2	0.016	0.059	0.054	0.054	0.692		
Fstatistic	2.009	3.967	3.157***	2.779**	20.870***		
	(3, 186)	(4, 184)	(5, 183)	(6, 173)	(7, 55)		
Panel B Out-of-home-consumption							
$(GDP.cap)$	-0.000	0.000	0.000	0.000	-0.000		
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)		
$(GDP.cap)^2$	0.000	-0.000	-0.000	-0.000	0.000		
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)		
$(GDP.cap)^3$	-0.000	0.000	0.000	0.000	-0.000		
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)		
Observations	190	189	179	172	67		
R^2	0.001	0.016	0.017	0.017	0.073		
Adjusted R^2	-0.015	-0.005	-0.012	-0.019	-0.038		
Fstatistic	0.060	0.758	0.588	0.480	0.659		
	(3, 186)	(4, 184)	(5, 173)	(6, 165)	(7, 59)		
Panel C Household							
$(GDP.cap)$	-0.001***	0.000	0.000	0.000	0.000	0.001	-0.016
	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.004)	
$(GDP.cap)^2$	0.000***	0.000	0.000	0.000	-0.000	-0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	
$(GDP.cap)^3$	-0.000**	-0.000	-0.000	-0.000	0.000	0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	
Observations	190	189	189	179	172	67	12
R^2	0.131	0.198	0.209	0.218	0.245	0.295	1.000
Adjusted R^2	0.117	0.181	0.183	0.186	0.207	0.169	-
Fstatistic	9.326***	11.388***	8.024***	6.820***	6.592***	2.343**	-
	(3, 186)	(4, 184)	(6, 182)	(7, 171)	(8, 163)	(10, 56)	
Panel D Total							
$(GDP.cap)$	-0.001***	0.001	0.001	0.001	0.001	0.001*	-0.001
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.005)
$(GDP.cap)^2$	0.000**	-0.000	-0.000	-0.000	-0.000	-0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$(GDP.cap)^3$	-0.000*	0.000	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	190	189	189	180	170	163	61
R^2	0.114	0.211	0.222	0.222	0.239	0.254	0.317
Adjusted R^2	0.100	0.194	0.196	0.196	0.201	0.210	0.164
Fstatistic	7.974***	12.289***	8.649***	7.345***	6.302***	5.775***	2.069**
	(3, 186)	(4, 184)	(6, 182)	(7, 172)	(8, 161)	(9, 153)	(11, 49)

Note. Standard errors are given in parentheses under the regression coefficients; The individual regression coefficient is significant at the *10%; **5% or ***1% significance level; The full regression results are represented in table 5, 6, 7, and 8 of Appendix B; For all panels, model 1 represents the simplified basic quadratic regression results; Additionally, **panel A** contains [Age] *(2)*, [Age and Urbanization] *(3)* [Age, Urbanization and Ethnicity] *(4),* [Age, Urbanization, Ethnicity and Householdsize] *(5)*; **panel B** contains [Age] *(2)*, [Age and Gender] *(3),* [Age, Gender and Education] *(4*), [Age, Gender, Education and Householdsize] *(5)*; **panel C** contains [Age] *(2)*, [Age, Urbanization and Electricityaccess] *(3)*, [Age, Urbanization, Electricityaccess and Gender] *(4)*, [Age, Urbanization, Electricityaccess, Gender and Education] *(5)*, [Age, Urbanization, Electricityaccess, Gender, Education, Refrigerator and Householdsize] (*6),* [Age, Urbanization, Electricityaccess, Gender, Education, Refrigerator, Householdsize and Employment] *(7)*; **panel D** contains [Age] *(2)*, [Age, Urbanization and Electricityaccess] *(3*), [Age, Urbanization, Electricityaccess and Ethnicity] *(4)*, [Age, Urbanization, Electricityaccess, Ethnicity and Gender] *(5)*, [Age, Urbanization, Electricityaccess, Ethnicity, Gender and Education] *(6)*, [Age, Urbanization, Electricityaccess, Ethnicity, Gender, Education, Refrigerator and Householdsize] *(7)*.

Upon closer examination of the control variables, it could be stated that the coefficient of electricity predicts a slightly negative relationship at 10% significance level, while the coefficient of urbanization indicates a slightly positive relationship at 1% significance level. This holds true for model 5 and 6 for household food waste generation (table 7, Appendix B) and models 5, 6 and 7 for total food waste generation (table 8, Appendix B). However, both are economically insignificant due to its coefficient sizes. Additionally, the coefficient of education predicts a negative relationship with household food waste generation for model 5 (table 7, Appendix B) at 10% significance level. This indicates that if the average years of schooling of a country increase, the household food wasted per capita will decrease.

According to the performed F(df)-tests[4] the fit of model 2 is strongly improved compared to model 1. Indicating, that the control variable *Age* played the biggest role in better explaining the relationship between GDP and food waste generation per capita. This holds true for the retail, household, and total food waste generation (see respectively table 5, 7 and 8, Appendix B). For out-of-home-consumption, it should be highlighted that the inclusion of control variables provides no added value with respect to the baseline model (table 6, Appendix B).

The best fit model for the relationship between GDP per capita and retail food waste generation, confirms an N-shaped relationship curve at 10% significance level (table 5 column 2, Appendix B). Whereas, for total food waste, an insignificant N-shaped relationship is assumed (table 8 column 2, Appendix B). Considering table 7 column 2 (Appendix B), the coefficients of GDP and its square are positive while its cube is negative. Graphically, this predicts a relationship with an overall upward trend, which at some point is downwards concave. This indicates that the relationship between GDP and food waste generation per capita initially rapidly increases, but as the GDP further increases, the effect will diminish and eventually decrease. However, further discussion is restricted as it is not statistically significant.

[4] See subscriptions of table 5, 6 ,7 and 8 Appendix B

Furthermore, all best fit models suggest a negative relationship between age and food waste generation. This means that for a given country, if the median age increases, the generation of food waste will decrease. Comparable results are obtained for out-of-home-consumption food waste generation.

When comparing the simplest cubic regression models, it could be stated that only the relationship between GDP per capita and retail food waste generation predicts an insignificant N-shaped curve. For the best fit cubic model of retail food waste generation, a statistically insignificant N-shaped curve. Therefore, hypothesis 2 could only be accepted for the specific subset of the best fit cubic model for the relationship between GDP per capita and retail food waste generation.

4.3 Preliminary conclusion

To give a preliminary summary of the results of both hypotheses, it could be said that the relationship between GDP and food waste generation does not follow a statistically significant inverted U-shaped or N-shaped curve. On the contrary, for out-of-home-consumption, household and total food waste generation, the simplest quadratic regression models assume a U-shaped and inverted N-shaped relationship. For household and total food waste generation, these relationships are statistically significant. However, the lack of economic significance and robustness, restricts its importance.

Furthermore, a remarkable robust negative relationship between food waste generation and age is found. This indicates that a country's median age plays an explaining role in the amount of food waste generation. On average, it could be said that as the median age of a country increases by one unit, it is associated with an approximately average 1.7 units decrease of total food wasted in a country.

When comparing the quadratic and cubic best fit models with each other, the relationship between GDP per capita and retail food waste generation is best explained by the cubic model with inclusion of the control variable *Age*[5]. For household food waste generation this holds for the quadratic model with inclusion of the variables *Age*, *Urbanization*, *Electricityaccess*, *Gender* and *Education*[6]. With respect to total food waste generation, this holds for the quadratic regression model with inclusion of the control variable *Age*[7]. For out-of-home-consumption, the inclusion of GDP cube or control variables has no added value compared to the baseline quadratic regression model.

[5] The cubic model including the variable *Age*, with respect to retail food waste generation, is offering a statistical improvement compared to the quadratic form with *Age* F(df)(1, 184)=3.706, p<0.1

[6] The cubic model with *Age*, with respect to household food waste generation, is not improving compared to the quadratic form with *Age* F(df)(1 184)=0.254, p>0.1; while the quadratic model with *Age*, *Urbanziation, Electricityaccess, Gender,* and *Education* is improving F(df)(1, 164)=3.954, p<0.05.

[7] The cubic model with *Age*, with respect to total food waste generation, is not improving compared to the quadratic form F(df)(1,184)=0.117, p>0.1.

So altogether, only in the best explaining model of the relationship between GDP per capita and retail food waste generation a statistically significant N-shaped curve is found. This indicates that only for that specific subset of variables, hypothesis 2 could be accepted. Moreover, there is no additional empirical evidence to support hypothesis 1 or 2 within the context of this study.

4.4 Extended robustness check

From a methodological perspective, it is unfeasible to correct for unobserved heterogeneity across countries and years due to the absence of a panel dataset. Therefore, the basic quadratic, cubic and best explaining model are repeated with inclusion of group dummies and its interaction effects. Table 9, 10, 11 and 12 (Appendix B) represent these results.

Comparing the basic quadratic regression models of table 1 column 1 (Appendix B) and table 9 column 1 (Appendix B) for retail food waste generation, it could be seen that the coefficients of GDP and its square are not robust and predict now an inverted U-shaped relationship. When the basic cubic models of table 5 column 1 (Appendix B) and table 9 column 3 (Appendix B) are compared, it could be stated that the hypothesized N-shaped relationship stays robust to the inclusion of group dummies. The same holds true for the best explaining models of table 5 column 2 (Appendix B) and table 9 column 5 (Appendix B). Additionally, it should be noted that all income groups are expected to differ significantly in the amount of retail food waste generation. In other words, all income groups are expected to have an average higher retail food waste generation per capita with respect to high-income countries, holding all other independent variables constant. Comparatively, it could be said that the difference in retail food waste generation is greatest for low-income countries with respect to high-income countries.

Table 10 (Appendix B) makes it possible to compare the results of out-of-home-consumption food waste generation. It could be seen that the basic quadratic model in table 2 column 1 (Appendix B) and the basic cubic model in table 6 column 1 (Appendix B) are not robust to the inclusion of group dummies. Furthermore, it should be noted that only upper-middle-income countries are expected to have an average higher out-of-home-consumption food waste generation per capita with respect to high-income countries, holding all other independent variables constant.

For the household and total food waste generation, it could be stated that respectively the quadratic and best explaining models of table 3 and 4 (Appendix B), and the cubic models of table 7 and 8 (Appendix B) are robust to the inclusion of group dummies. Furthermore, it should be highlighted that the expected average amount of household and total food waste generation is statistically significant higher for low-income countries with respect to high-income countries.

When considering the inclusion of interaction effects, it is important to mention that the coefficient signs of GDP, its square, and its cube are not stable. Additionally, the expected average differences of the income groups compared to high-income countries are also not consistent. This holds true for the analysed relationship between GDP per capita and retail, out-of-home-consumption, household and total food waste generation. Besides, it is noticeable that for out-of-home-consumption food waste generation, oppositely to the other models, all income groups are expected to have an average lower out-of-home-consumption food waste generation per capita with respect to high income group countries (see table 10, Appendix B). Comparatively, it could be said that the difference is greatest for upper-middle-income countries. Additionally, it is noticeable that the cubic model with inclusion of interaction effects (table 10 column 4, Appendix B) predicts a statistically significant inverted N-shaped relationship on 1% significance level for the high-income countries. Considering the significant differences in coefficient sizes of GDP for lower-middle and upper-middle-income countries, it could be stated that also an inverted N-shaped relationship is predicted.

All other remaining models predict no significant difference between the coefficients of GDP for the different income groups with respect to high income groups. This makes further discrepancies about the possible different relationships for food waste generation and GDP per capita impossible.

4.5 Results on income groups

The empirical evidence in the previous sector showed that there was a difference between the amount of food waste generation for the different group dummies with respect to high income countries. Therefore, the relationship between GDP per capita and food waste generation might change from one income group to another. This raised the question whether the relationship between GDP per capita and food waste generation would be different if each income group is examined separately. Therefore, as a final extended robustness check, the regression results will be repeated on income group level.

Table 13 (Appendix B) represents the results of retail food waste by income groups. It is shown that only for lower-middle-income countries, the quadratic and cubic model are in line with each other, hypothesizing an insignificant U-shaped and inverted N-shaped relationship. For the best explaining model in table 14 (Appendix B) it is noticeable that there is an insignificant N-shaped curve predicted for high-income and upper-middle-income countries, while for lower-middle-income countries an insignificant inverted N-shaped curve is hypothesized.

In table 15 (Appendix B) the results by income group for out-of-home-consumption food waste are represented. It should be noted that only for high-income countries the quadratic and cubic model are in line with each other, confirming an inverted N-shaped curve at 10% significance level.

Looking at the results of the different income groups of household food waste in table 16 (Appendix B), it could be seen that the quadratic and cubic models for low-income countries and lower-middle-income countries are in line with each other. Both hypothesize an insignificant inverted U-shaped and N-shaped relationship between GDP per capita and food waste. Furthermore, it is noticeable that for the best explaining model (table 17, Appendix B) all income groups hypothesize an insignificant inverted U-shaped relationship.

In table 18 (Appendix B) the results for total food waste generation are represented. For high-income countries the quadratic and cubic model predict in line with each other, an insignificant U-shaped and inverted N-shaped curve. Contrary, the models for low and lower-middle-income countries hypothesize an insignificant inverted U-shaped and N-shaped relationship. The best explaining model in table 19 (Appendix B) predicts for all separate income groups, except high-income countries, an insignificant inverted U-shaped relationship.

Upon closer analysis of the variable age, it should be noted that the predicted negative relationship is greatest for lower-middle-income countries for household and total food waste generation (table 17 and 19, Appendix B). Furthermore, the relationship between age and respectively household and total food waste generation is expected to be slightly positive for low-income countries. The same holds for the relationship between age and retail food waste generation with respect to lower-middle-income countries (table 14, Appendix B).

Overall, both hypotheses could not be validated for the various income groups and therefore must be rejected as there is found no inverted U-shaped or N-shaped relationship.

5. DISCUSSION AND CONCLUSION

When all results are taken together, it was shown that the simplified quadratic and cubic regressions models showed a statistically significant U-shaped and inverted N-shaped relationship between GDP per capita and respectively household and total food waste generation per capita. This is not in line with standard EKC literature.

Furthermore, a remarkable robust negative relationship between age and food waste generation was found for all examined sectors. This indicated that as the median age of a country increases, the amount of food wasted in a country decrease. This is in line with previous research, stating that younger people tend to have more food waste than older people (Gjerris & Gaiani, 2013; Grasso et al., 2019). Furthermore, urbanization showed a positive relationship with food waste generation which is in line with previous research stating that people have for example less time on food waste reducing behaviours in higher degrees of urbanization (DG ENV, 2010; Gjerris & Gaiani, 2013 Grasso et al., 2019; Janssen, et al., 2010; Van Dooren & Knüppe, 2020). Electricityaccess also showed a negative relationship, indicating that as the average access to electricity of a country increases, the amount of food wasted decreases. This is in line with the theoretical framework, considering that the electricity access of a country is an indication for the availability of cooling and therewith appropriate storage of food, which could prevent food waste. Lastly, Education also showed a negative relationship with food waste generation. Also, this is in line with previous research, stating that more known ledged and educated people tend to have less food waste (DG ENV, 2010; Gjerris & Gaiani, 2013 Grasso et al., 2019; Janssen, et al., 2010; Van Dooren & Knüppe, 2020).

This, altogether, showed the importance of additional explanatory variables in the models for the relationship between GDP per capita and food waste generation per capita. Like that, the relationship for households was best explained by the quadratic regression model with variables as *Age*, *Urbanization*, *Electricityaccess*, *Gender* and *Education,* indicating an insignificant inverted U-shaped curve. For total food waste, the relationship was best explained by the quadratic model with inclusion of *Age*, indicating also an insignificant inverted U-shaped curve. For retail, the best explained model was formed by the cubic regression with the variable Age, indicating a statistically significant N-shaped curve. Contradictory, for out-of-home-consumption nor the inclusion of GDP cube or control variables, had added value to the baseline quadratic regression model.

Taking this all above into consideration, it could be concluded that additional explanatory variables are needed in the examination of the FWKC. This is in line with previous research on the EKC, stating that the examination is sensitive to additional variables (Leal & Marques, 2022).

Finally, it was shown that all income groups were expected to have an average higher food waste generation per capita with respect to high-income countries. Looking to the specific income groups, low and lower-middle-income countries predicted an insignificant inverted U-shaped and N-shaped relationship for respectively household and total food waste generation. Additionally, an insignificant inverted U-shaped relationship was found for high and upper-middle-income countries with respect to retail food waste. For high-income countries a statistically significant inverted N-shaped relationship was found with respect to out-of-home-consumption food waste. As there is no comparable previous research on the existence of an EKC for food waste, these results are undecided in light of existing empirical evidence (Grasso, et al., 2019; Setti, et al., 2016; Mann, et al., 2023).

In the end, both hypotheses[8] are rejected with respect to the simplified quadratic and cubic form of the relationship between GDP per capita and food waste generation per capita in the respective sectors. However, on behalf of the specific subset of the best explaining model for retail food waste, there is found an N-shaped relationship with GDP on a 10% significance level. This means that only for that specific subset of variables, hypothesis 2 could be validated for the retail sector. However, the small sizes of the regression coefficient restrict its further importance.

Overall, all results are both consistent and inconsistent with earlier research since the empirical results on a FWKC are not conclusive on the existence. As stated earlier, previous studies have provided only some important findings on the possible relationship between disposable income and food waste generation (Grasso, et al, 2019). Which could only be served as an indicator that the EKC could also be implemented for the food waste concern (Mann, et al., 2023). Both the strength and direction of possible relationships with economic factors were limited to specific regions or countries and varied between the studies (Grasso, et al., 2019; Setti, et al., 2016; Mann, et al., 2023). The existence of a FWKC is not conclusive and limited in existing literature and therefore not comparable to the found results in this research.

To conclude, there is little till no empirical evidence found for a FWKC between economic development, measured as GDP per capita, and total food waste generation per capita by respectively retail, out-of-home-consumption, and households.

Though, this holds only for this specific context and therefore does not mean that there is no relationship between economic development and food waste generation shaped by a FWKC. Therefore, it is encouraged to address the limitations of this research and implicate further research on the existence of a FWKC.

[8] See hypothesis 1 and 2 in section 2.4.

5.1 Limitations and implications

This research has provided findings on the main determinants of food waste generation across the retail, out-of-home, and household sectors. Therewith, it makes an important contribution to support theoretical arguments regarding the possible existence of a FWKC. Nevertheless, this research contains some limitations.

One of the major limitations is the limited sample size. The reason for this is the scarcity of available food waste data across several years for countries across the world. Besides, the restricted data on the included control variables, create even a more limited sample size. The existence of a panel data would make it possible to control for omitted variables that differ across countries but are constant over time when incorporating time fixed effects. This way, unobserved variables as international food waste campaigns or policies would be controlled. This is essential as most research on food waste generation argue that policy implications are a major driver of food waste reduced behaviours (WRAP, 2012). It might also be interesting to determine long- and short-term effects of food waste. Therefore, it is encouraged to implement future research with a larger data set covering a longer period of time and with a wider range of control variables to control for other time-invariant factors. This way also heterogeneity bias could be prevented. A larger data sample might also encounter the economic significance.

Another major limitation is the drawback of food waste data. According to previous research there are little till no theoretical models on how to collect and report food waste data (Xue, et al., 2017). Besides, there is no unambiguous definition of food waste, making it even more difficult to have reliable data. Furthermore, it is imaginable that less developed countries are less consistent in their collection and reporting of food waste data due to inabilities. Therefore, despite the food waste data is collected from one source, this altogether could still lead to selection bias.

Finally, it would be encouraged to gather data for the retail or out-of-home sector on food waste to be able to analyse the existence of a FWKC with specific and reliable data on these sectors. With this, it would also be interesting to perform analyses on social values on behalf of food waste reducing behaviours.

Anyway, it is encouraged to implement any future research on food waste to address, understand, and solve the food waste concern. This way we could reduce the journey of food from wallet to waste and create a new journey, as it should be, from wallet to planet. Cause as Tristram Stuart (2012) said ''*cutting food waste is a delicious way of saving money, helping to feed the world and protect the planet*''.

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7. APPENDIX A – TABLES AND FIGURES DESCRIPTIVE STATISTICS

Table 1 *Descriptive statistics.*

Variable	Obs.	Mean	Std. Dev.	Min.	Max.
GDP per capita	190	23352.510	23838.970	760	128006
Age	189	29.143	9.118	14.4	47.6
Gender	180	3.00^{e}12	3.91^{e}13	614418	5.24^{e}14
Education	176	8.811	3.222	1.13	14.09
Employment	63	1844.524	270.799	1381	2475
Electricityaccess	190	3.71^{e}10	1.23^{e}11	12132	1.35^{e}12
Refrigerator	69	2.86^{e}14	2.74^{e}14	183713.2	9.84 ^{e}14
Urbanization	190	1.14^{e}11	3.07^{e}11	12132	2.71 ^{e}12
Householdsize	69	5.085	1.879	0.9	12.5
Ethnicity	181	6.624	3.653	1	23
Total food waste	190	126.242	23.680	52.3	259.82
Retail food waste	190	14.955	6.079	3.12	78.82
Out-of-home-consumption food waste	190	27.161	7.444	2.65	89.56
Household food waste	190	84.127	19.704	9.01	188.8

Table 2 *Descriptive statistics by income group.*

Variable	High-income countries	Low-income countries	Lower-middle-income countries	Upper-middle-income countries
Observations	66	24	49	51
GDP per capita	49044.36	2019.708	6541.041	16295.37
Total food waste	117.805	145.839	131.168	123.206
Retail food waste	12.810	15.64	15.544	16.84
Out-of-home-consumption food waste	26.056	27.65	26.715	28.788
Household food waste	78.938	102.549	88.909	77.577

Table 3 *Correlation matrix.*

Variable		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	GDP	1													
2	Age	0.708***	1												
3	Gender	-0.052	-0.063	1											
4	Education	0.683***	0.770***	0.061	1										
5	Employment	-0.515***	-0.505***	0.212*	-0.629***	1									
6	Electricity access	-0.196***	-0.176**	-0.021	-0.224***	0.301**	1								
7	Refrigerator	0.060	0.015	-0.115	0.153	0.079	-0.099	1							
8	Urbanization	0.069	0.103	-0.025	0.100	-0.044	0.188***	0.064	1						
9	Household size	-0.511***	-0.566***	-0.160	-0.498***	0.175	-0.001	0.115	-0.103	1					
10	Ethnicity	-0.083	-0.151**	-0.015	-0.157**	0.046	-0.002	0.060	-0.005	0.068	1				
11	Total food waste	-0.259***	-0.441***	-0.024	-0.363***	0.219*	-0.024	0.122	0.002	0.206	0.070	1			
12	Retail food waste	-0.172**	-0.212***	0.007	-0.096	0.226*	0.033	0.050	-0.011	0.175	-0.057	0.533***	1		
13	Out-of-home-consumption food waste	-0.025	-0.085	0.005	-0.025	0.194	-0.009	0.131	0.199***	0.015	0.055	0.452***	0.528***	1	
14	Household food waste	-0.248***	-0.433***	-0.033	-0.398***	0.087	-0.036	0.098	-0.070	0.208*	0.083	0.867***	0.132*	0.002	`1

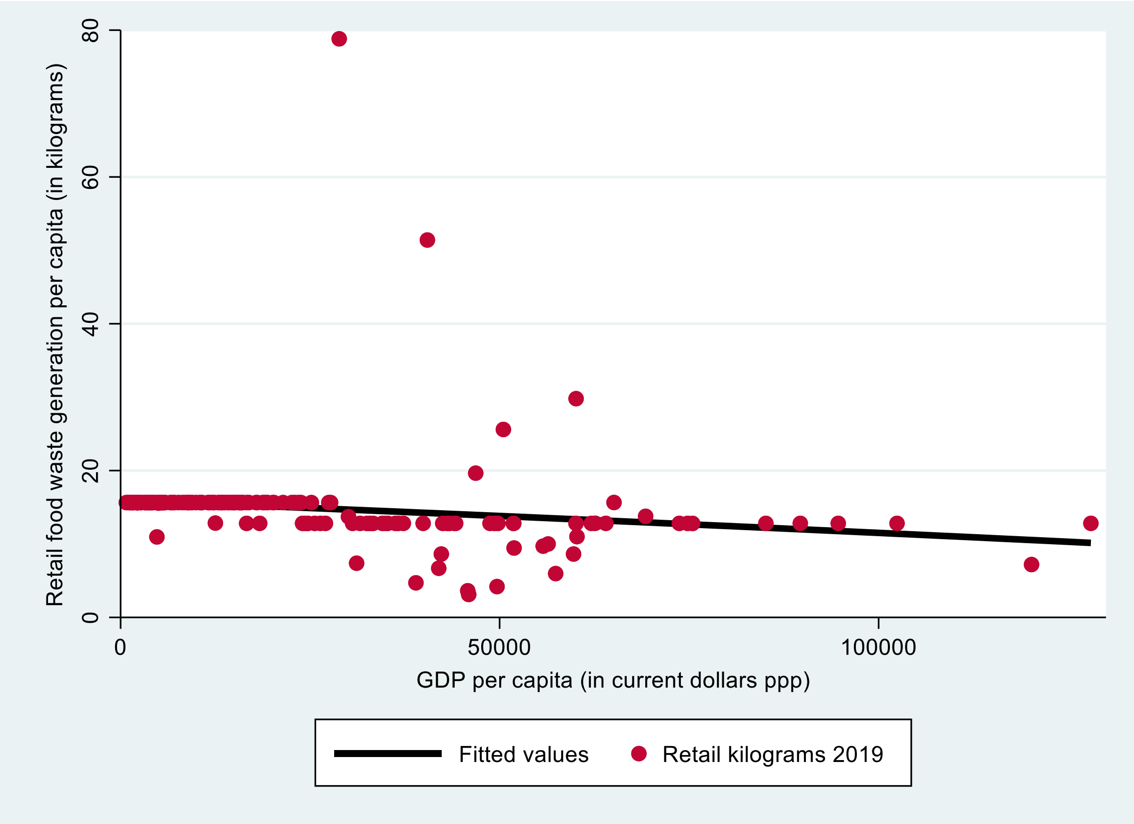

Figure 1 *Retail food waste generation per capita versus GDP per capita across countries worldwide for 2019.*

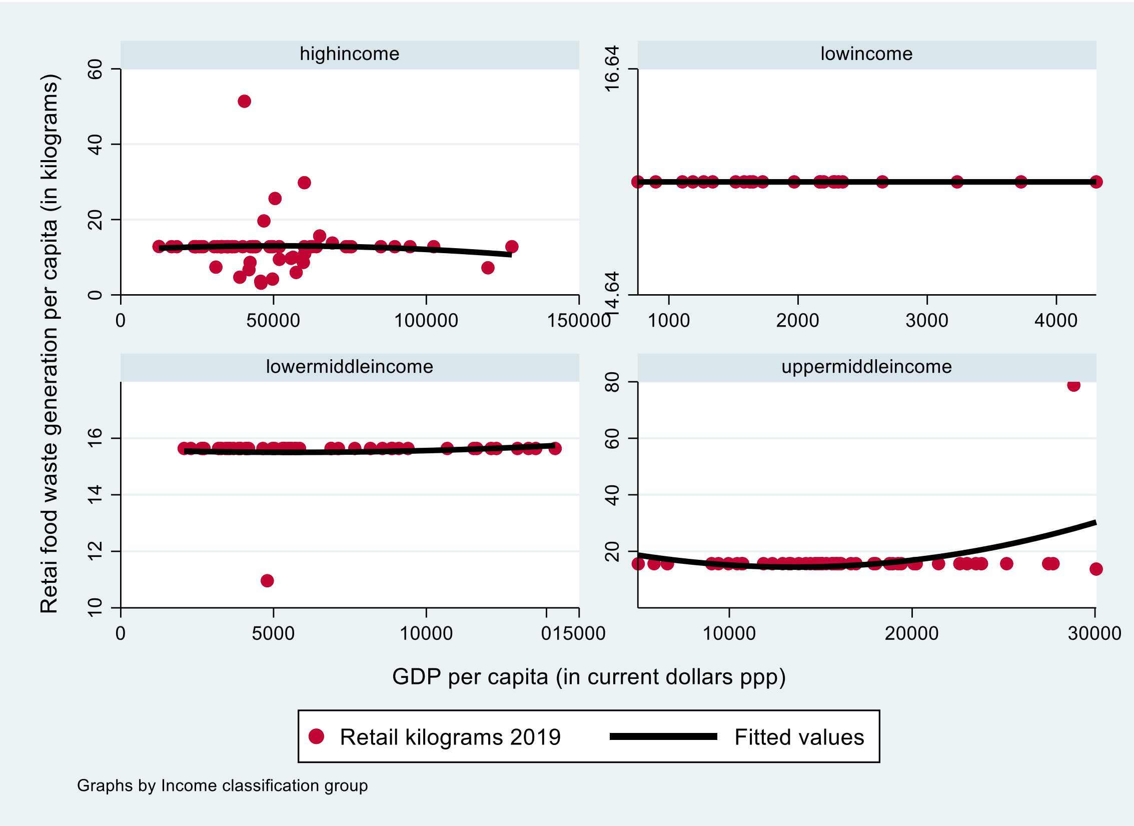

Figure 2 *Retail food waste generation per capita versus GDP per capita across countries worldwide for 2019 by income group.*

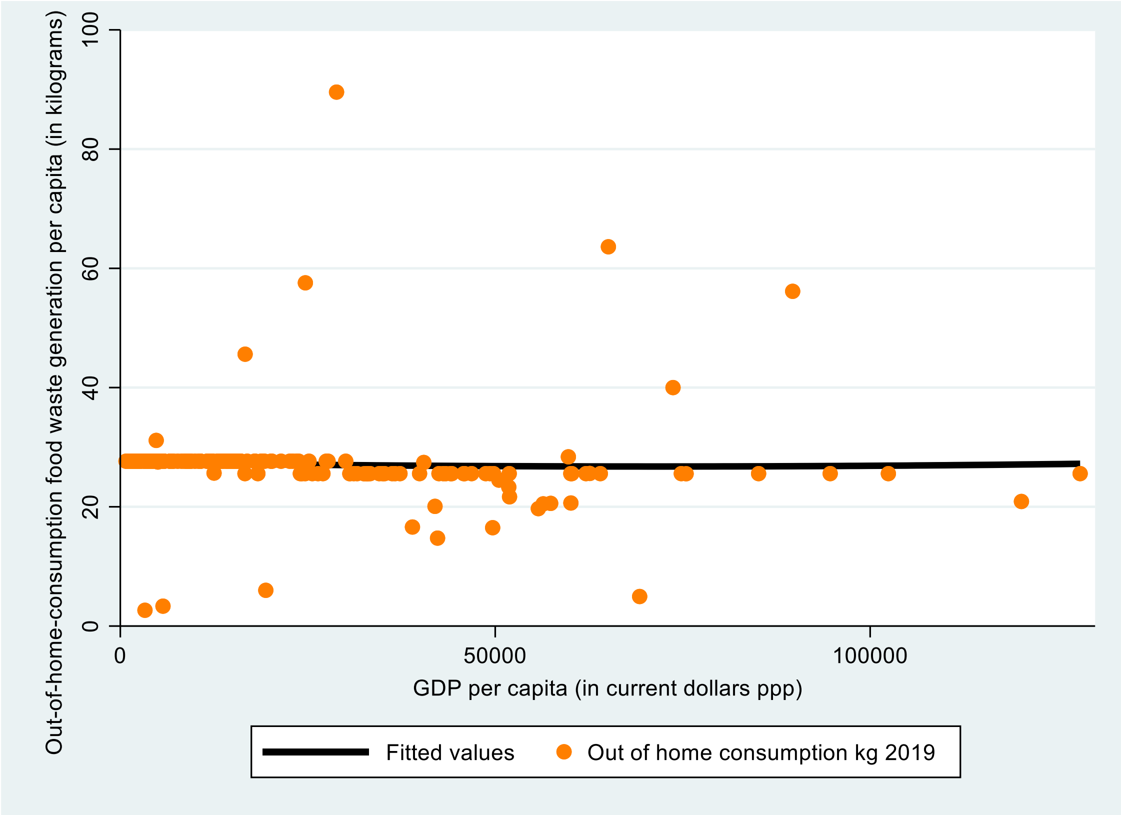

Figure 3 *Out-of-home-consumption food waste generation per capita versus GDP per capita across countries worldwide for 2019.*

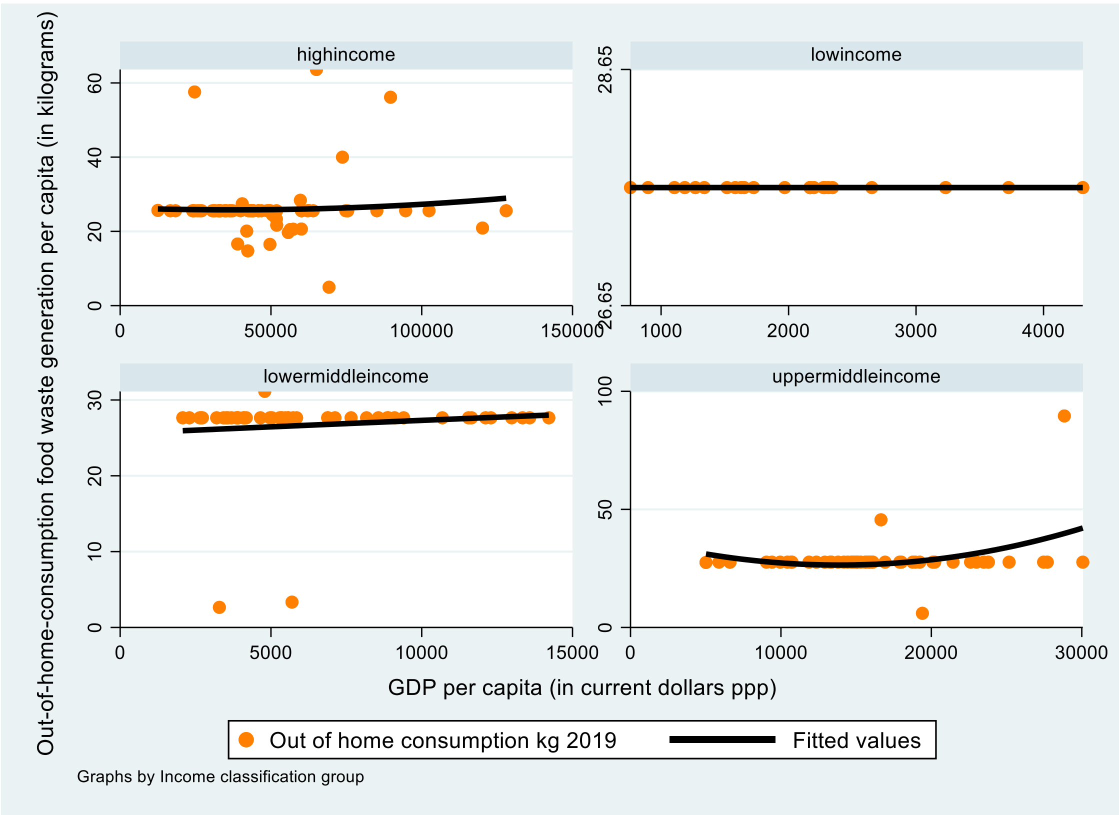

Figure 4 *Out-of-home-consumption food waste generation per capita versus GDP per capita across countries worldwide for 2019 by income group.*

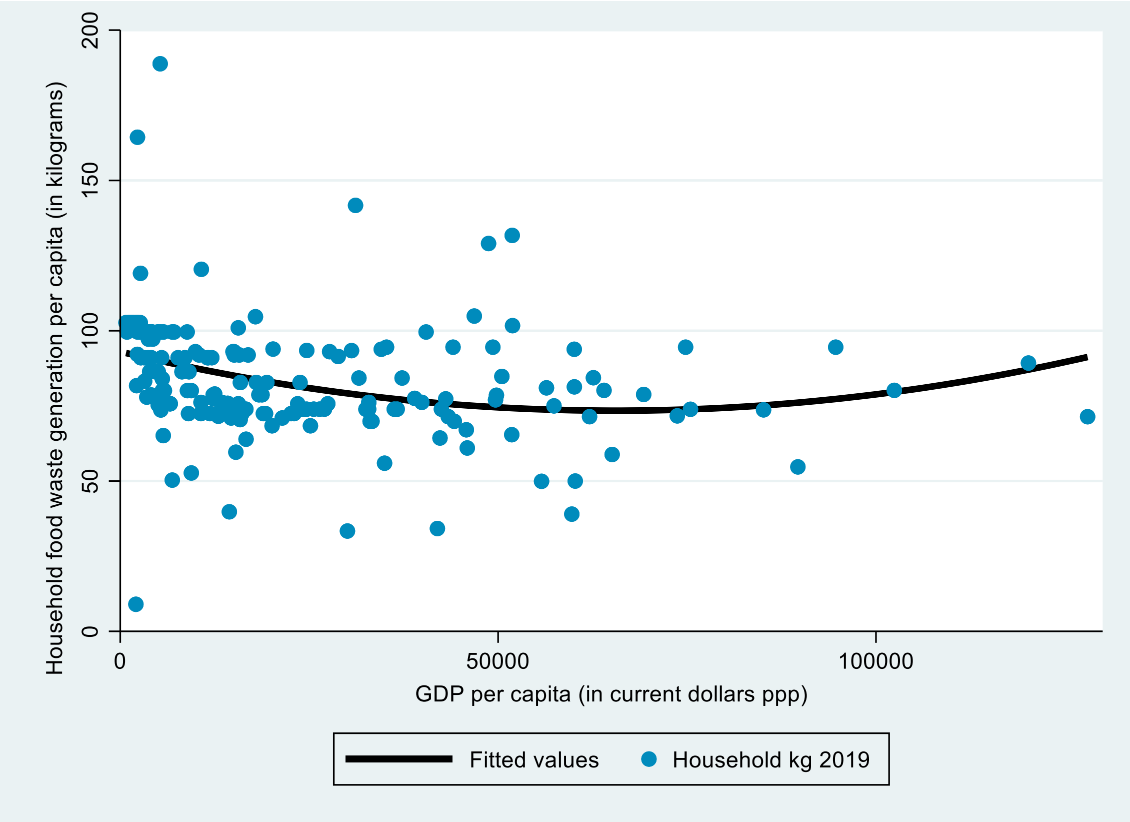

Figure 5 *Household food waste generation per capita versus GDP per capita across countries worldwide for 2019.*

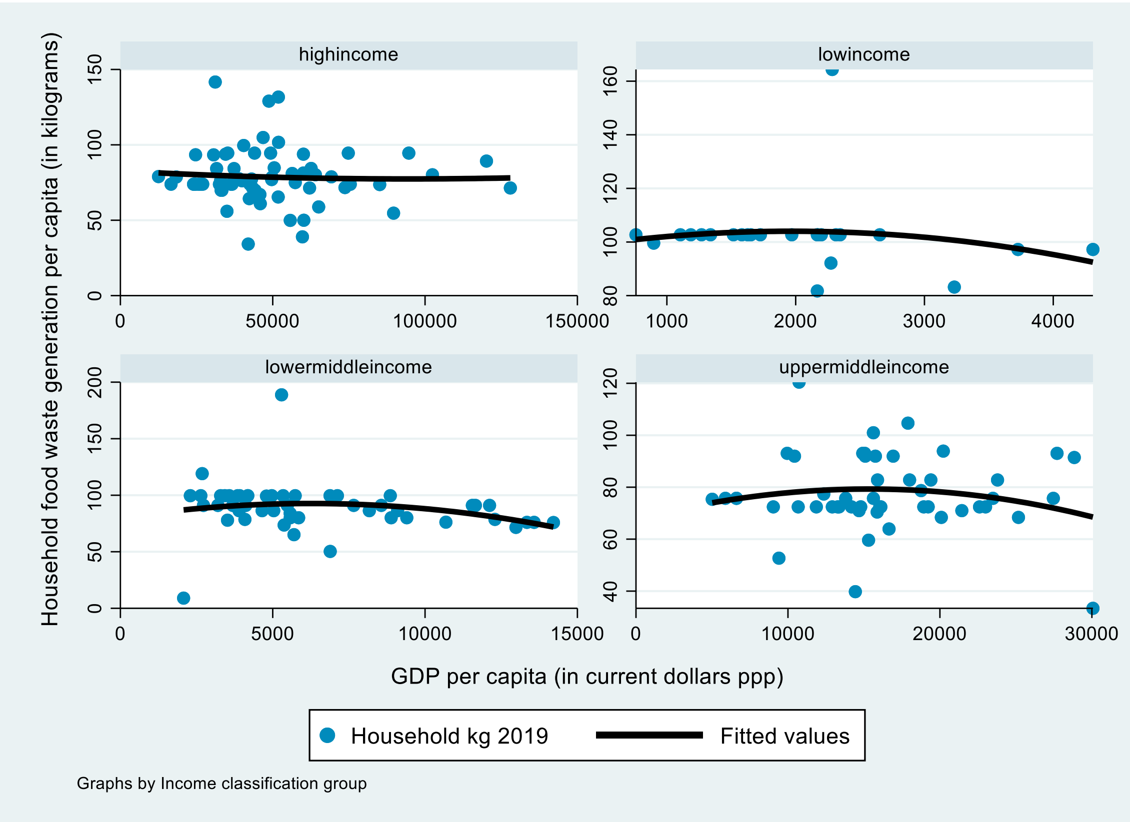

Figure 6 *Household food waste generation per capita versus GDP per capita across countries worldwide for 2019 by income group.*

8. APPENDIX B – TABLES ON REGRESSION RESULTS

Table 1 *Quadratic-regression results for the relationship between GDP per capita and the Retail food waste generation per capita.*

Dependent variable	*Retail food waste generation per capita*				
All countries					
Independent variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
$(GDP.cap)$	-0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000*** (0.000)
$(GDP.cap)^2$	-0.000 (0.000)	-0.000* (0.000)	-0.000* (0.000)	-0.000 (0.000)	-0.000*** (0.000)
Age		-0.225** (0.090)	-0.225** (0.090)	-0.240** (0.095)	0.002 (0.011)
$Urbanization$			-0.000 (0.000)	0.000 (0.000)	-0.000 (0.000)
$Ethnicity$				-0.144 (0.126)	0.004 (0.008)
$Householdsize$					0.006 (0.024)
Summary statistics					
Intercept	15.951*** (0.763)	20.081*** (1.824)	20.081*** (1.831)	21.442*** (2.191)	15.303*** (0.281)
Observations	190	189	189	180	63
R^2	0.030	0.061	0.061	0.068	0.396
Adjusted R^2	0.019	0.046	0.040	0.041	0.331
F statistic	2.863* (2, 187)	3.996*** (3, 185)	2.981** (4, 184)	2.547** (5, 174)	6.117*** (6, 56)
Hierarchical regression					
R^2 change		0.031	0.000	0.007	0.328
F-statistic difference		6.132** (1, 185)	0.000 (1, 184)	1.359 (1, 174)	560 (1, 56)

Note. Standard errors are given in parentheses under the regression coefficients; The individual regression coefficient is significant at the *10%; **5% or ***1% significance level. To predict the best fit model of the performed regression models, a hierarchical regression is performed. It would be concluded that model 2 offered a significant improvement over model 1 Fdf (1,185) =6.132, $p < 0.05$.

Table 2 *Quadratic regression results for the relationship between GDP per capita and Out-of-home-consumption food waste generation per capita.*

Dependent variable	$Out\_of\_home\_consumption\ food\ waste\ generation\ per\ capita$				
All countries					
Independent variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
$(GDP.cap)$	-0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
$(GDP.cap)^2$	0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)
Age		-0.177 (0.113)	-0.186 (0.119)	-0.195 (0.132)	-0.385** (0.186)
$Gender$			0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)
$Education$				0.064 (0.330)	0.222 (0.356)
$Householdsize$					-0.214 (0.411)
Summary statistics					
Intercept	27.467*** (0.948)	30.727*** (2.289)	30.854**** (2.400)	30.647*** (2.668)	33.135*** (4.608)
Observations	190	189	179	172	67
R^2	0.001	0.014	0.014	0.014	0.069
Adjusted R^2	-0.010	-0.000	-0.010	-0.016	-0.024
F statistic	0.082 (2, 187)	0.869 (3, 185)	0.630 (4, 174)	0.464 (5, 166)	0.744 (6, 60)
Hierarchical regression					
R^2 change		0.013	0.000	-0.000	0.055
F change statistic		2.442 (1, 185)	0.062 (1, 174)	-0.085 (1, 166)	-1.297 (1, 60)

Note. Standard errors are given in parentheses under the regression coefficients; The individual regression coefficient is significant at the *10%; **5% or ***1% significance level. To predict the best fit model of the performed regression models, a hierarchical regression is performed. It would be concluded that none of the models offered a significant improvement over model 1.

Table 3 *Quadratic regression results for the relationship between GDP per capita and Household food waste generation per capita.*

Dependent variable	$Household\ food\ waste\ generation$						
All countries							
Independent variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
$(GDP.cap)$	-0.001*** (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	-0.001 (0.002)	-0.015* (0.001)
$(GDP.cap)^2$	0.000*** (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	0.000 (0.000)	0.000* (0.000)
Age		-1.272*** (0.270)	-1.262*** (0.270)	-1.295*** (0.281)	-1.070*** (0.301)	-0.7003 (0.804)	0.827* (0.128)
$Urbanization$			-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	0.000** (0.000)	-0.000 (0.000)
$Elektricityaccess$			-0.000 (0.000)	-0.000 (0.000)	-0.000* (0.000)	-0.000** (0.000)	-0.000** (0.000)
$Gender$				-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.000** (0.000)
$Education$					-1.313* (0.755)	-1.494 (1.579)	-18.396** (0.001)
$Refrigerator$						0.000 (0.000)	0.000** (0.000)
$Householdsize$						-0.711 (1.764)	-33.008** (1.129)
$Employment$							-0.090** (0.006)
Summary statistics							
Intercept	93.041*** (2.379)	116.448 (5.466)	117.518*** (5.503)	119.003*** (5.712)	122.611*** (6.145)	123.836*** (19.833)	666.147** (23.936)
Observations	190	189	189	179	172	67	12
R^2	0.102	0.197	0.208	0.217	0.244	0.291	0.999
Adjusted R^2	0.093	0.184	0.186	0.190	0.212	0.179	0.996
F statistics	10.630*** (2, 187)	15.160*** (3, 185)	9.597*** (5, 183)	7.959*** (6, 172)	7.565*** (7, 164)	2.604** (9, 57)	243.482* (10, 1)

***Table 3** continued.*

Dependent variable	*Household food waste generation*						
All countries							
Independent variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
Hierarchical regression							
R^2 change		0.095	0.010	0.010	0.027	0.047	0.708
F change statistic		21.930*** (1, 185)	1.203 (2, 183)	1.594 (1, 172)	3.954** (1, 164)	-7.659 (2, 57)	-7500 (1, 1)

Note. Standard errors are given in parentheses under the regression coefficients; The individual regression coefficient is significant at the *10%; **5% or ***1% significance level. To predict the best fit model of the performed regression models, a hierarchical regression is performed. It would be concluded that model 2 offered a significant improvement over model 1 Fdf (1, 185) =21.930, p < 0.01 and that model 5 offered a significant improvement over model 2 Fdf (4, 164) =1.991, p < 0.01.

Table 4 *Quadratic regression results for the relationship between GDP per capita and Total food waste generation per capita.*

Dependent variable	$Total\ food\ waste\ generation\ per\ capita$						
All countries							
Independent variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
$(GDP.cap)$	-0.001***	0.001*	0.000	0.000	0.000	0.001	-0.001
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.002)
$(GDP.cap)^2$	0.000**	-0.000	-0.000	-0.000	-0.000	-0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Age		-1.674***	-1.661***	-1.698***	-1.761***	-1.597***	-1.154
		(0.3222)	(0.322)	(0.328)	(0.343)	(0.375)	(0.892)
$Urbanization$			0.000	0.000	0.000	0.000	0.000**
			(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$Elektricityaccess$			-0.000	-0.000	-0.000*	-0.000*	-0.000**
			(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$Ethnicity$				0.006	-0.075	0.001	0.107
				(0.437)	(0.452)	(0.468)	(0.634)
$Gender$					-0.000	-0.000	-0.000
					(0.000)	(0.000)	(0.000)
$Education$						-0.992	-1.294
						(0.969)	(1.913)
$Refrigerator$							0.000
							(0.000)
$Householdsize$							-1.012
							(1.880)
Summary statistics							
Intercept	136.459***	167.256***	168.240***	168.678***	171.343***	173.354***	170.737***
	(2.868)	(6.514)	(6.555)	(7.638)	(7.985)	(8.668)	(22.562)
Observations	190	189	189	180	170	163	61
R^2	0.096	0.210	0.222	0.230	0.237	0.247	0.317
Adjusted R^2	0.087	0.198	0.200	0.203	0.204	0.208	0.181
F statistics	9.952***	16.425***	10.416***	8.595***	7.194***	6.325***	2.322**
	(2, 187)	(3, 185)	(5, 183)	(6, 173)	(7, 162)	(8, 154)	(10, 50)

Table 4 *continued.*

Dependent variable	$Total\ food\ waste\ generation\ per\ capita$						
All countries							
Independent variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
Hierarchical regression							
R^2 change		0.114	0.011	0.008	0.007	0.010	0.070
F change statistic		26.710*** (1, 185)	1.317 (2, 183)	-1.024 (1, 173)	1.022 (1, 162)	0.636 (1, 154)	-13.864 (2, 50)

Note. Standard errors are given in parentheses under the regression coefficients; The individual regression coefficient is significant at the *10%; **5% or ***1% significance level. To predict the best fit model of the performed regression models, a hierarchical regression is performed. It would be concluded that model 2 offered a significant improvement over model 1 Fdf (1,185) =26.710, p < 0.01.

Table 5 *Cubic regression results for the relationship between GDP per capita and Retail food waste generation per capita.*

Dependent variable	*Retail food waste generation per capita*				
All countries					
Independent variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
$(GDP.cap)$	0.000 (0.000)	0.000** (0.000)	0.000** (0.000)	0.000** (0.000)	0.000** (0.000)
$(GDP.cap)^2$	-0.000 (0.000)	-0.000** (0.000)	-0.000** (0.000)	-0.000** (0.000)	-0.000** (0.000)
$(GDP.cap)^3$	0.000 (0.000)	0.000* (0.000)	0.000* (0.000)	0.000* (0.000)	0.000* (0.000)
Age		-0.312*** (0.100)	-0.312*** (0.101)	-0.335*** (0.106)	-0.003 (0.008)
$Urbanization$			0.000 (0.000)	0.000 (0.000)	-0.000 (0.000)
$Ethnicity$				-0.134 (0.125)	0.000 (0.006)
$Householdsize$					0.010 (0.016)
Summary statistics					
Intercept	15.627*** (0.955)	20.472*** (1.822)	20.471*** (1.892)	21.833*** (2.183)	15.895*** (0.204)
Observations	190	189	189	180	63
R^2	0.031	0.079	0.079	0.079	0.727
Adjusted R^2	0.016	0.059	0.054	0.054	0.692
F statistic	2.009 (3, 186)	3.967 (4, 184)	3.157*** (5, 183)	2.779** (6, 173)	20.870*** (7, 55)
Hierarchical regression					
R^2 change		0.048	0.000	0.009	0.639
F change statistic		9.592*** (1, 184)	0.000 (1, 183)	1.599 (1, 173)	1500 (1, 55)

Note. Standard errors are given in parentheses under the regression coefficients; The individual regression coefficient is significant at the *10%; **5% or ***1% significance level. To predict the best fit model of the performed regression models, a hierarchical regression is performed. It would be concluded that model 2 offered a significant improvement over model 1 Fdf (1,184) =9.592, p < 0.01.

Table 6 *Cubic regression results for the relationship between GDP per capita and Out-of-home-consumption food waste generation per capita.*

Dependent variable	$Out\_of\_home\_consumption\ food\ waste\ generation\ per\ capita$				
All countries					
Independent variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
$(GDP.cap)$	-0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	-0.000 (0.001)
$(GDP.cap)^2$	0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	0.000 (0.000)
$(GDP.cap)^3$	-0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	-0.000 (0.000)
Age		-0.215* (0.127)	-0.228* (0.135)	-0.236 (0.143)	-0.386** (0.187)
$Gender$			0.000 (0.000)	0.000 (0.000)	-0.000 (0.000)
$Education$				-0.002 (0.341)	0.224 (0.358)
$Householdsize$					-0.187 (0.418)
Summary statistics					
Intercept	27.556*** (1.187)	30.896*** (2.307)	31.064*** (2.426)	31.046*** (2.724)	33.767*** (4.912)
Observations	190	189	179	172	67
R^2	0.001	0.016	0.017	0.017	0.073
Adjusted R^2	-0.015	-0.005	-0.012	-0.019	-0.038
F statistic	0.060 (3, 186)	0.758 (4, 184)	0.588 (5, 173)	0.480 (6, 165)	0.659 (7, 59)
Hierarchical regression					
R^2 change		0.015	0.001	0.000	0.055
F change statistic		2.851* (1, 184)	0.086 (1, 173)	0.067 (1, 165)	-2.455 (1, 59)

Note. Standard errors are given in parentheses under the regression coefficients; The individual regression coefficient is significant at the *10%; **5% or ***1% significance level. To predict the best fit model of the performed regression models, a hierarchical regression is performed. It would be concluded that model 2 offered a significant improvement over model 1 Fdf (1,184) =2.851, $p < 0.1$.

Table 7 *Cubic regression results for the relationship between GDP per capita and Household food waste generation per capita.*

Dependent variable	$Household\ food\ waste\ generation\ per\ capita$						
All countries							
Independent variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
$(GDP.cap)$	-0.001*** (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.001)	0.000 (0.001)	0.001 (0.004)	-0.016
$(GDP.cap)^2$	0.000*** (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	0.000
$(GDP.cap)^3$	-0.000** (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	-0.000
Age		-1.203*** (0.304)	-1.183*** (0.303)	-1.227*** (0.320)	-1.106*** (0.327)	-0.667 (0.811)	0.905
$Urbanization$			-0.000 (0.000)	-0.000 (0.000)	0.000 (0.000)	0.000** (0.000)	-0.000
$Elektricityaccess$			-0.000 (0.000)	-0.000 (0.000)	-0.000* (0.000)	-0.000** (0.000)	-0.000
$Gender$				-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.000
$Education$					-1.370* (0.782)	-1.562 (1.594)	-18.587
$Refrigerator$						0.000 (0.000)	0.000
$Householdsize$						-0.872 (1.800)	-32.613
$Employment$							-0.090
Summary statistics							
Intercept	97.394*** (2.932)	116.138*** (5.511)	117.181*** (5.544)	118.675*** (5.772)	122.957*** (6.279)	120.509*** (20.890)	665.222
Observations	190	189	189	179	172	67	12
R^2	0.131	0.198	0.209	0.218	0.245	0.295	1.000
Adjusted R^2	0.117	0.181	0.183	0.186	0.207	0.169	-
F statistics	9.326*** (3, 186)	11.388*** (4, 184)	8.024*** (6, 182)	6.820*** (7, 171)	6.592*** (8, 163)	2.343** (10, 56)	-

Table 7 *continued.*

Dependent variable	*Household food waste generation*						
All countries							
Independent variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
Hierarchical regression							
R^2 change		0.068	0.011	0.009	0.026	0.051	0.705
F change statistic		15.510*** (1, 184)	1.237 (2, 182)	1.471 (1, 171)	3.806 (1, 163)	-7.449 (2, 56)	-

Note. Standard errors are given in parentheses under the regression coefficients; The individual regression coefficient is significant at the *10%; **5% or ***1% significance level. To predict the best fit model of the performed regression models, a hierarchical regression is performed. It would be concluded that model 2 offered a significant improvement over model 1 Fdf (1,184) =15.510, p < 0.01.

Table 8 *Cubic regression results for the relationship between GDP per capita and Total food waste generation per capita.*

Dependent variable	$Total\ food\ waste\ generation\ per\ capita$						
All countries							
Independent variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
$(GDP.cap)$	-0.001***	0.001	0.001	0.001	0.001	0.001*	-0.001
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.005)
$(GDP.cap)^2$	0.000**	-0.000	-0.000	-0.000	-0.000	-0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$(GDP.cap)^3$	-0.000*	0.000	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Age		-1.730***	-1.707***	-1.755***	-1.862***	-1.779***	-1.147
		(0.362)	(0.362)	(0.372)	(0.394)	(0.407)	(0.911)
$Urbanization$			0.000	0.000	0.000	0.000	0.000**
			(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$Elektricityaccess$			-0.000	-0.000	-0.000*	-0.000*	-0.000*
			(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$Ethnicity$				0.012	-0.066	0.008	0.108
				(0.438)	(0.454)	(0.468)	(0.641)
$Gender$					-0.000	-0.000	-0.000
					(0.000)	(0.000)	(0.000)
$Education$						-1.330	-1.307
						(1.013)	(1.949)
$Refrigerator$							0.000
							(0.000)
$Householdsize$							-1.026
							(1.920)
Summarry statistics							
Intercept	140.576***	167.507***	168.433***	168.901***	171.804***	175.299***	170.344***
	(3.558)	(6.571)	(6.608)	(7.688)	(8.051)	(8.828)	(24.069)
Observations	190	189	189	180	170	163	61
R^2	0.114	0.211	0.222	0.222	0.239	0.254	0.317
Adjusted R^2	0.100	0.194	0.196	0.196	0.201	0.210	0.164
F statistics	7.974***	12.289***	8.649***	7.345***	6.302***	5.775***	2.069**
	(3, 186)	(4, 184)	(6, 182)	(7, 172)	(8, 161)	(9, 153)	(11, 49)

Table 8 *continued.*

Dependent variable	*Total food waste generation per capita*						
All countries							
Independent variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
Hierarchical regression							
R^2 change		0.097	0.011	0.008	0.008	0.015	0.064
F change statistic		22.554*** (1, 184)	1.291 (2, 182)	-0.988 (1, 172)	1.191 (1, 161)	1.643 (1, 153)	-14.218 (2, 49)

Note. Standard errors are given in parentheses under the regression coefficients; The individual regression coefficient is significant at the *10%; **5% or ***1% significance level. To predict the best fit model of the performed regression models, a hierarchical regression is performed. It would be concluded that model 2 offered a significant improvement over model 1 Fdf (1,184) =22.554, p < 0.01.

Table 9 *Quadratic and cubic regression results for the relationship between GDP per capita and Retail food waste generation per capita with inclusion of income group.*

Dependent variable	*Retail food waste generation per capita*					
All countries						
Independent variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
$(GDP.cap)$	0.000*	0.000	0.000	-0.000	0.001***	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$(GDP.cap)^2$	-0.000*	-0.000	-0.000	0.000	-0.000**	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$(GDP.cap)^3$			0.000	-0.000	0.000*	-0.000
			(0.000)	(0.000)	(0.000)	(0.000)
Age					-0.309***	-0.299***
					(0.099)	(0.985)
$Incomegroup$						
Low income	7.025**	3.214	8.229**	-1.631	8.074**	-2.950
	(4.664)	(4.664)	(7.247)	(7.247)	(3.249)	(7.1229)
Lower middle income	6.227**	3.012	7.008***	-1.626	7.282***	-2.725
	(3.885)	(3.885)	(6.579)	(6.579)	(2.590)	(6.470)
Upper middle income	6.186***	-2.929	6.341***	-6.679	6.238***	-7.046
	(4.072)	(4.072)	(5.917)	(5.917)	(1.783)	(5.809)
$Incomegroup * GDP.cap$						
Low income		-0.000		0.000		0.000
		(0.001)		(0.001)		(0.001)
Lower middle income		-0.000		0.000		0.000
		(0.000)		(0.000)		(0.000)
Upper middle income		0.000**		0.000**		0.001**
		(0.000)		(0.000)		(0.000)
Summarry statistics						
Intercept	8.278***	12.424***	6.845**	17.295***	11.557***	22.750***
	(2.824)	(3.477)	(3.404)	(6.570)	(3.658)	(6.697)
Observations	190	190	190	190	189	189

Table 9 *continued.*

Dependent variable	$Retail\ food\ waste\ generation\ per\ capita$					
All countries						
Independent variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Summarry statistics						
R^2	0.089	0.123	0.092	0.127	0.138	0.170
Adjusted R^2	0.064	0.085	0.062	0.084	0.105	0.123
F statistic	3.60*** (5, 184)	3.18*** (8, 181)	3.09*** (6, 183)	2.91*** (9, 180)	4.14*** (7, 181)	3.63*** (10, 178)

Note. Standard errors are given in parentheses under the regression coefficients; The individual regression coefficient is significant at the *10%; **5% or ***1% significance level.

Table 10 *Regression results for the relationship between GDP per capita and Out-of-home-consumption food waste generation per capita with inclusion of income group.*

Dependent variable	$Out\_of\_home\_consumption\ food\ waste\ generation\ per\ capita$			
All countries				
Independent variables	**(1)**	**(2)**	**(3)**	**(4)**
$(GDP.cap)$	0.000 (0.000)	-0.000 (0.000)	0.000 (0.000)	-0.001*** (0.000)
$(GDP.cap)^2$	-0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000*** (0.000)
$(GDP.cap)^3$			-0.000 (0.000)	-0.000*** (0.000)
$Incomegroup$				
Low income	5.638 (3.670)	0.828 (5.930)	5.011 (4.194)	-18.211** (9.047)
Lower middle income	4.141 (3.068)	-1.197 (4.940)	3.735 (3.341)	-19.423** (8.212)
Upper middle income	5.107** (2.278)	-4.700 (5.177)	5.026** (2.298)	-19.434*** (7.387)
$Incomegroup * GDP.cap$				
Low income		0.000 (0.002)		0.001 (0.002)
Lower middle income		0.000 (0.000)		0.001** (0.000)
Upper middle income		0.000** (0000)		0.001** (0.000)
Summary statistics				
Intercept	21.748*** (3.566)	26.825*** (4.422)	22.494*** (4.304)	45.962*** (8.202)
Observations	190	190	190	190
R^2	0.031	0.055	0.032	0.093
Adjusted R^2	0.005	0.013	0.000	0.047
F statistic	1.19 (5, 184)	1.31 (8, 181)	1.00 (6, 183)	2.05** (9, 180)

Note. Standard errors are given in parentheses under the regression coefficients; The individual regression coefficient is significant at the *10%; **5% or ***1% significance level.

Table 11 *Quadratic and cubic regression results for the relationship between GDP per capita and Household food waste generation per capita with inclusion of income group.*

Dependent variable	$Household\ food\ waste\ generation\ per\ capita$					
All countries						
Independent variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
$(GDP.cap)$	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.001)	0.001 (0.001)	0.000 (0.000)	-0.000 (0.001)
$(GDP.cap)^2$	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	0.000 (0.000)
$(GDP.cap)^3$			-0.000 (0.000)	0.000 (0.000)		
Age					-1.016*** (0.595)	-1.073*** (0.330)
$Urbanization$					0.000 (0.000)	0.000 (0.000)
$Elektricityaccess$					-0.000* (0.000)	-0.000* (0.000)
$Gender$					-0.000 (0.000)	-0.000 (0.000)
$Education$					-0.733 (0.807)	-0.739 (0.817)
$Incomegroup$						
Low income	15.875* (8.912)	24.212* (14.517)	14.542 (10.185)	37.007 (22.572)	-1.185 (11.218)	-12.726 (19.143)
Lower middle income	3.381 (7.450)	13.805 (12.091)	2.516 (8.115)	26.054 (20.490)	-6.945 (9.193)	-17.345 (16.935)
Upper middle income	-5.721 (5.532)	-1.181 (12.674)	-5.893 (5.582)	8.722 (18.429)	-9.994 (6.487)	-22.137 (16.893)
$Incomegroup * GDP.cap$						
Low income		-0.002 (0.004)		-0.003 (0.005)		0.001 (0.004)
Lower middle income		-0.001 (0.001)		-0.002 (0.001)		0.001 (0.001)

Table 11 *continued.*

Dependent variable	$Household\ food\ waste\ generation\ per\ capita$					
All countries						
Independent variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
$Incomegroup * GDP.cap$						
Upper middle income		-0.000 (0.001)		-0.001 (0.001)		0.000 (0.001)
Summary statistics						
Intercept	87.215*** (8.660)	82.155*** (10.824)	88.802*** (10.453)	69.294*** (20.463)	125.257*** (13.592)	135.980*** (19.193)
Observations	190	190	190	190	172	172
R^2	0.185	0.192	0.185	0.194	0.272	0.275
Adjusted R^2	0.163	0.156	0.158	0.154	0.227	0.216
F statistic	8.34*** (5, 184)	5.36*** (8, 181)	6.92*** (6, 183)	4.82*** (9, 180)	6.02*** (10, 161)	4.62*** (13,158)

Note. Standard errors are given in parentheses under the regression coefficients; The individual regression coefficient is significant at the *10%; **5% or ***1% significance level.

Table 12 *Quadratic and cubic regression results for the relationship between GDP per capita and Total food waste generation per capita with the inclusion of income group.*

Dependent variable	$Total\ food\ waste\ generation\ per\ capita$					
All countries						
Independent variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
$(GDP.cap)$	0.000 (0.000)	-0.000 (0.000)	-0.000 (0.001)	-0.001 (0.001)	0.001** (0.000)	0.000 (0.000)
$(GDP.cap)^2$	-0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	-0.000* (0.000)	-0.000 (0.000)
$(GDP.cap)^3$			-0.000 (0.000)	-0.000 (0.000)		
Age					-1.478*** (0.335)	-1.647*** (0.356)
$Incomegroup$						
Low income	28.538** (10.955)	28.253 (17.792)	27.782** (12.522)	17.165 (27.685)	18.134* (10.734)	1.753 (17.852)
Lower middle income	13.750 (9.158)	15.620 (14.819)	13.259 (9.977)	5.005 (25.132)	8.793 (8.830)	-8.851 (15.043)
Upper middle income	5.572 (6.800)	-8.809 (15.533)	5.475 (6.862)	-17.391 (22.605)	3.837 (6.521)	-25.738* (15.210)
$Incomegroup * GDP.cap$						
Low-income		-0.002 (0.005)		-0.001 (0.006)		0.000 (0.005)
Lower-middle-income		-0.001 (0.001)		-0.000 (0.001)		0.001 (0.001)
Upper-middle-income		0.001 (0.001)		0.001 (0.001)		0.001** (0.001)
Summary statistics						
Intercept	117.242*** (10.645)	121.405*** (13.266)	118.142*** (12.851)	132.551*** (25.100)	151.316*** (12.768)	170.79*** (16.516)
Observations	190	190	190	190	189	189

Table 12 *continued.*

Dependent variable	*Total food waste generation per capita*					
All countries						
Independent variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Summary statistics						
R^2	0.147	0.159	0.147	0.161	0.229	0.248
Adjusted R^2	0.124	0.122	0.119	0.119	0.203	0.210
F statistic	6.34*** (5, 184)	4.29*** (8, 181)	5.26*** (6, 183)	3.82*** (9, 180)	8.99*** (6, 182)	6.56*** (9, 179)

Note. Standard errors are given in parentheses under the regression coefficients; The individual regression coefficient is significant at the *10%; **5% or ***1% significance level.

Table 13 *Quadratic and cubic regression results for the relationship between GDP per capita and Retail food waste generation per capita for the various income groups.*

Dependent variable	$Retail\ food\ waste\ generation\ per\ capita$							
income group	**All**		**High-income**		**Lower-middle-income**		**Upper-middle-income**	
Independent variables	**(1)**	**(2)**	**(1)**	**(2)**	**(1)**	**(2)**	**(1)**	**(2)**
$(GDP.cap)$	-0.000 (0.000)	-0.000 (0.000)	0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.001)	-0.002* (0.001)	0.003 (0.003)
$(GDP.cap)^2$	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000** (0.000)	-0.000 (0.000)
$(GDP.cap)^3$		0.000 (0.000)		-0.000 (0.000)		-0.000 (0.000)		0.000 (0.000)
Summary statistics								
Intercept	15.951*** (0.763)	15.627*** (0.955)	11.945*** (3.783)	12.676* (7.404)	15.608*** (0.501)	16.395*** (1.072)	25.088*** (7.706)	3.412 (16.155)
Observations	190	190	66	66	49	49	51	51
R^2	0.030	0.031	0.004	0.004	0.008	0.023	0.174	0.213
Adjusted R^2	0.019	0.016	-0.028	-0.044	-0.035	-0.042	0.140	0.163
Fstatistic	2.86* (2, 187)	2.01 (3, 186)	0.13 (2, 63)	0.09 (3, 62)	0.19 (2, 46)	0.36 (3, 145)	5.07 (2, 48)	4.24 (3, 47)

Note. Standard errors are given in parentheses under the regression coefficients; The individual regression coefficient is significant at the *10%; **5% or ***1% significance level.

Table 14 *Regression results for the best explaining model on the relationship between GDP per capita and Retail food waste generation per capita for the various income groups.*

Dependent variable	$Retail\ food\ waste\ generation\ per\ capita$			
income group Independent variables	**All**	**High-income**	**Lower-middle-income**	**Upper-middle-income**
$(GDP.cap)$	0.000** (0.000)	0.000 (0.000)	-0.000 (0.001)	0.003 (0.003)
$(GDP.cap)^2$	-0.000** (0.000)	-0.000 (0.000)	0.000 (0.000)	-0.000 (0.000)
$(GDP.cap)^3$	0.000* (0.000)	0.000 (0.000)	-0.000 (0.000)	0.000 (0.000)
Age	-0.312*** (0.100)	-0.413** (0.160)	0.020 (0.030)	-0.204 (0.232)
Summary statistics				
Intercept	20.472*** (1.822)	20.648 (7.796)	16.091*** (1.171)	7.451 (16.828)
Observations	189	65	49	51
R^2	0.079	0.103	0.033	0.226
Adjusted R^2	0.059	0.044	-0.055	0.159
Fstatistic	3.97*** (4, 184)	1.73 (4, 60)	0.37 (4, 44)	3.36 (4, 46)

Note. Standard errors are given in parentheses under the regression coefficients; The individual regression coefficient is significant at the *10%; **5% or ***1% significance level.

Table 15 *Quadratic and cubic regression results for the relationship between GDP per capita and Out-of-home-consumption food waste generation per capita for the various income groups.*

Dependent variable	$Out\_of\_home\_consumption\ food\ waste\ generation\ per\ capita$							
Income group	**All**		**High-income**		**Lower-middle-income**		**Upper-middle-income**	
Independent variables	**(1)**	**(2)**	**(1)**	**(2)**	**(1)**	**(2)**	**(1)**	**(2)**
$(GDP.cap)$	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.001* (0.001)	0.000 (0.001)	-0.001 (0.004)	-0.002 (0.001)	0.004 (0.004)
$(GDP.cap)^2$	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000* (0.000)	-0.000 (0.000)	0.000 (0.000)	0.000** (0.000)	-0.000 (0.000)
$(GDP.cap)^3$		-0.000 (0.000)		-0.000* (0.000)		-0.000 (0.000)		0.000* (0.000)
Summarry statistics								
Intercept	27.467*** (0.948)	27.556*** (1.187)	26.340*** (5.046)	42.388*** (9.584)	25.578*** (3.713)	28.125** (7.996)	37.935*** (8.454)	10.566 (17.581)
Observations	190	190	66	66	49	49	51	51
R^2	0.001	0.001	0.005	0.062	0.014	0.017	0.145	0.198
Adjusted R^2	-0.010	-0.015	-0.027	0.017	-0.029	-0.049	0.109	0.147
Fstatistic	0.08 (2, 187)	0.06 (3, 186)	0.14 (2, 63)	1.37 (3, 62)	0.32 (2, 46)	0.25 (3, 45)	4.06** (2, 48)	3.87** (3, 47)

Note. Standard errors are given in parentheses under the regression coefficients; The individual regression coefficient is significant at the *10%; **5% or ***1% significance level.

Table 16 *Quadratic and cubic regression results for the relationship between GDP per capita and Household food waste generation for the various income groups.*

Dependent variable	$Household\ food\ waste\ generation\ per\ capita$									
income group	**All**		**High-income**		**Low-income**		**Lower-middle-income**		**Upper-middle-income**	
Independent variables	**(1)**	**(2)**	**(1)**	**(2)**	**(1)**	**(2)**	**(1)**	**(2)**	**(1)**	**(2)**
$(GDP.cap)$	-0.001*** (0.000)	-0.001*** (0.000)	-0.000 (0.000)	0.000 (0.001)	0.008 (0.016)	0.033 (0.063)	0.004 (0.005)	0.020 (0.016)	0.002 (0.002)	-0.003 (0.006)
$(GDP.cap)^2$	0.000*** (0.000)	0.000*** (0.000)	0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	0.000 (0.000)
$(GDP.cap)^3$		-0.000** (0.000)		0.000 (0.000)		0.000 (0.000)		0.000 (0.000)		-0.000 (0.000)
Summary statistics										
Intercept	93.041*** (2.379)	97.394*** (2.932)	82.712*** (11.088)	74.446*** (21.666)	95.843*** (17.685)	80.157* (42.362)	79.954*** (16.017)	48.597 (34.136)	67.587*** (13.788)	86.537*** (29.442)
Observations	190	190	66	66	24	24	49	49	51	51
R^2	0.102	0.131	0.003	0.006	0.033	0.041	0.053	0.075	0.030	0.185
Adjusted R^2	0.093	0.117	-0.029	-0.042	-0.059	-0.103	0.012	0.014	-0.011	0.158
Fstatistic	10.63*** (2, 187)	9.33*** (3, 186)	0.09 (2, 63)	0.12 (3, 62)	0.36 (2, 21)	0.28 (3, 20)	1.29 (2, 46)	1.22 (3, 45)	0.74 (2, 48)	6.92 (3, 47)

Note. Standard errors are given in parentheses under the regression coefficients; The individual regression coefficient is significant at the *10%; **5% or ***1% significance level.

Table 17 *Regression results for the best explaining model of the relationship between GDP per capita and Household food waste generation per capita for the various income groups.*

Dependent variable	$Household\ food\ waste\ generation\ per\ capita$				
income group Independent variables	**All countries**	**High-income**	**Low-income**	**Lower-middle-income**	**Upper-middle-income**
$(GDP.cap)$	0.000 (0.000)	-0.000 (0.001)	0.013 (0.018)	0.003 (0.004)	0.003 (0.002)
$(GDP.cap)^2$	-0.000 (0.000)	0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)
Age	-1.272*** (0.270)	-1.350** (0.595)	-0.345 (2.391)	-1.586* (0.795)	-0.684 (0.498)
$Urbanization$		0.000 (0.000)	-0.000 (0.000)	0.000*** (0.000)	-0.000 (0.000)
$Elektricityaccess$		-0.000 (0.000)	0.000* (0.000)	-0.000*** (0.000)	-0.000 (0.000)
$Gender$		-0.000 (0.000)	-0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
$Education$		-1.529 (2.005)	-1.593 (2.117)	-0.739 (1.223)	-0.343 (1.603)
Summary statistics					
Intercept	116.448*** (5.466)	156.338*** (29.125)	110.308*** (32.367)	115.786*** (21.092)	74.912** (25.424)
Observations	189	51	24	49	48
R^2	0.197	0.184	0.283	0.469	0.128
Adjusted R^2	0.184	0.051	-0.030	0.379	-0.025
Fstatistic	15.16*** (3, 185)	1.38 (7,43)	0.90 (7, 16)	5.18*** (7,41)	0.84 (7,40)

Note. Standard errors are given in parentheses under the regression coefficients; The individual regression coefficient is significant at the *10%; **5% or ***1% significance level.

Table 18 *Quadratic and cubic regression results for the relationship between GDP per capita and Total food waste generation per capita for the various income groups.*

Dependent variable	$Total\ food\ waste\ generation\ per\ capita$									
Income group	**All countries**		**High-income**		**Low-income**		**Lower-middle-income**		**Upper-middle-income**	
Independent variable	**(1)**	**(2)**	**(1)**	**(2)**	**(1)**	**(2)**	**(1)**	**(2)**	**(1)**	**(2)**
$(GDP.cap)$	-0.001*** (0.000)	-0.001*** (0.000)	-0.000 (0.000)	-0.001 (0.001)	0.008 (0.016)	0.033 (0.063)	0.004 (0.005)	0.018 (0.017)	-0.002 (0.003)	0.005 (0.010)
$(GDP.cap)^2$	0.000** (0.000)	0.000** (0.000)	0.000 (0.000)	0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	0.000 (0.000)	-0.000 (0.000)
$(GDP.cap)^3$		-0.000* (0.000)		-0.000 (0.000)		0.000 (0.000)		0.000 (0.000)		0.000 (0.000)
Summarry statistics										
intercept	136.459*** (2.868)	140.576*** (3.585)	120.997*** (13.288)	129.501*** (25.976)	139.133*** (17.685)	123.447*** (42.362)	121.140*** (16.729)	93.117** (35.768)	130.610*** (22.880)	100.515** (48.879)
Observations	190	190	66	66	24	24	49	49	51	51
R^2	0.096	0.114	0.001	0.004	0.033	0.041	0.041	0.057	0.041	0.051
Adjusted R^2	0.087	0.100	-0.031	-0.045	-0.059	-0.103	-0.001	-0.006	0.001	-0.010
Fstatistic	9.95*** (2, 187)	7.97*** (3, 186)	0.04 (2, 63)	0.07 (3, 62)	0.36 (2, 21)	0.28 (3, 20)	0.98 (2, 46)	0.91 (3, 45)	1.03 (2, 48)	0.84 (3, 47)

Note. Standard errors are given in parentheses under the regression coefficients; The individual regression coefficient is significant at the *10%; **5% or ***1% significance level.

Table 19 *Regression results for the best explaining model of the relationship between GDP per capita and Total food waste generation per capita for the various income groups.*

Dependent variable	$Total\ food\ waste\ generation\ per\ capita$				
income group Independent variables	**All countries**	**High-income**	**Low-income**	**Lower-middle-income**	**Upper-middle-income**
$(GDP.cap)$	0.001* (0.000)	0.000 (0.000)	0.008 (0.017)	0.005 (0.005)	0.000 (0.003)
$(GDP.cap)^2$	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	0.000 (0.000)
Age	-1.674*** (0.322)	-1.616*** (0.527)	0.291 (2.068)	-2.543*** (0.928)	-1.294* (0.672)
Summary statistics					
Intercept	167.256*** (6.514)	169.764*** (20.271)	135.404*** (32.072)	167.204*** (22.966)	146.783*** (23.792)
Observations	189	65	24	49	51
R^2	0.210	0.134	0.034	0.178	0.111
Adjusted R^2	0.198	0.092	-0.111	0.123	0.055
F statistics	16.43*** (3, 185)	3.16** (3, 61)	0.23 (3, 20)	3.25** (3, 45)	1.96 (3, 47)

Note. Standard errors are given in parentheses under the regression coefficients; The individual regression coefficient is significant at the *10%; **5% or ***1% significance level.