

Article

Behavioral Economics in EU: Meat, ESG, Macroeconomics

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Abstract: This study examines the impact of macroeconomic and ESG (Environmental, Social, and Governance) factors on meat consumption in EU countries through a behavioral economics framework. Using panel data from 27 EU countries (2000–2021), the analysis applies Fixed Effects (FE), Random Effects (RE), and Generalized Estimating Equations (GEE) models to identify key drivers of meat consumption. The results reveal that GDP PPP (purchasing power parity) per capita, livestock availability, and methane emissions have a significant positive impact on meat consumption, reflecting the role of economic prosperity and agricultural production in dietary choices. In contrast, unemployment and inflation negatively influence meat consumption, highlighting the importance of economic stability. The GEE model, which corrects for autocorrelation, confirms that methane emissions and GDP PPP per capita remain significant predictors, suggesting that economic growth and environmental impact are critical determinants of dietary behavior. These findings underscore the complex interplay between economic development, sustainability, and consumer behavior, providing valuable insights for policymakers aiming to balance economic growth with environmental goals in the EU.

Keywords: meat consumption; behavioral economics; ESG factors; panel data analysis; random effects model; generalized estimating equations; EU food policy



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1. Introduction

“Let them eat cake!”—a phrase famously attributed to Marie Antoinette—encapsulates the historical disconnect between economic realities and societal perceptions of well-being (Herber, 2019). In contemporary economies, meat consumption has supplanted cake as a symbol of prosperity, reflecting not only economic status but also behavioral patterns shaped by financial and socio-environmental dynamics (Mroczek et al., 2022). The presence of meat on the daily table serves as more than a dietary choice; it functions as a behavioral economic indicator, revealing underlying consumer preferences, economic stability, and social values (Weibel et al., 2019).

The interplay between economic growth, ESG (Environmental, Social, and Governance) factors, and meat consumption patterns in the EU is complex, reflecting both environmental imperatives and economic realities. While reducing meat consumption is essential for sustainability and health, it poses challenges to economic growth, particularly in the livestock sector (Marques et al., 2018). Meat consumption contributes positively to economic growth, as evidenced by a study of 14 European high-income countries over four decades (Pais et al., 2020). The livestock sector is a significant economic driver, and a reduction in meat consumption could threaten jobs and economic stability (Pais et al.,

2020). However, strategies promoting plant-based diets can mitigate negative economic impacts while supporting sustainability (Pais et al., 2020).

ESG factors are increasingly relevant in guiding investment decisions, with strong corporate governance linked to better stock returns in the EU (Ciocîrlan et al., 2024). The EU's Green Deal emphasizes the need for sustainable practices, including reduced meat consumption, to align economic growth with environmental goals (Cué Rio et al., 2022).

Meat consumption patterns vary significantly across Western European countries, influenced by situational factors such as meal type and location (Laffan, 2024). Understanding these patterns is crucial for designing effective interventions to promote sustainable diets (Laffan, 2024).

Meat consumption is often linked to economic stability; higher meat intake typically correlates with wealthier populations. Studies show a high price elasticity of demand for meat, indicating that economic factors significantly influence consumption patterns (Hestermann et al., 2020).

The “meat paradox” illustrates how individuals reconcile their empathy for animals with meat consumption, often leading to self-deception about the ethical implications of their dietary choices (Hestermann et al., 2020). Gendered perceptions of meat consumption further complicate this dynamic, with meat often associated with masculinity and power, while lighter foods are linked to femininity (Van Dyke, 2015).

The portrayal of meat as a vital food source is contested, with some advocating for reduced consumption due to health and environmental concerns (Leroy et al., 2023). Consumer willingness to pay a premium for meat perceived as beneficial for wellness highlights the intersection of health, economic status, and dietary choices (Zhang et al., 2024).

Despite the extensive literature on food consumption, the intersection of macroeconomic and ESG factors with meat consumption remains underexplored. Previous studies have primarily focused on nutritional and environmental aspects, often neglecting the broader economic and social drivers of dietary behavior. For example, while the relationship between economic growth and meat consumption is well-documented (Godfray et al., 2018; Delgado, 2003), less attention has been given to the complex interactions between GDP, unemployment, inflation, government spending, and ESG considerations in shaping meat consumption patterns. This gap in the literature highlights the need for a more integrated approach that considers both economic and sustainability factors in analyzing dietary choices.

This study aims to address the gap in the literature by examining the impact of macroeconomic and ESG factors on meat consumption in the EU. Specifically, it investigates how GDP per capita, methane emissions, unemployment, inflation, livestock availability, and government expenditure influence meat consumption across EU countries. By integrating economic indicators with sustainability metrics, this research seeks to provide a more comprehensive understanding of the factors that drive meat consumption and their implications for public policy. This objective is pursued through the application of panel data models, including Fixed Effects (FE), Random Effects (RE), and Generalized Estimating Equations (GEE), which allow for a robust analysis of longitudinal data, capturing both time-series and cross-sectional variations.

The primary objective of this study is to assess the extent to which macroeconomic and ESG-related factors influence meat consumption behavior in EU countries. This objective is addressed through the application of panel data models, including Fixed Effects (FE), Random Effects (RE), and Generalized Estimating Equations (GEE), which allow for a robust analysis of longitudinal data.

The analysis is based on panel data from 27 EU countries, covering the period from 2000 to 2021. The data were sourced from reliable international databases, including the

World Bank and the Food and Agriculture Organization (FAO), ensuring consistency and comparability across countries. The use of panel data allows for the identification of both time-series and cross-sectional variations in meat consumption, providing a more nuanced understanding of the factors that influence dietary behavior.

This study contributes to the literature by addressing the underexplored relationship between macroeconomic indicators, ESG factors, and meat consumption in the EU. It provides empirical evidence on how economic growth, environmental sustainability, and social factors interact to shape dietary choices, offering valuable insights for policymakers aiming to balance economic development with sustainable food systems. Additionally, this research aligns with the broader goals of the EU Green Deal, which emphasizes the need for sustainable consumption patterns and reduced greenhouse gas emissions.

This paper is organized as follows: Section 2 presents a comprehensive literature review, highlighting key studies related to the economic and environmental determinants of meat consumption. Section 3 outlines the materials and methods used in the analysis. Section 4 discusses the empirical findings, while Section 5 provides a critical interpretation of the results. Finally, Section 6 presents the conclusions, policy implications, and potential avenues for future research.

2. Literature Review

2.1. Meat Consumption and Consumer Behavior in the EU

Consumer behavior in the context of meat consumption is influenced by a combination of psychological, social, and economic factors that shape dietary choices. From a behavioral economics perspective, meat consumption is not merely a dietary preference but a reflection of deeper cognitive processes, social norms, and market dynamics.

Consumers often experience cognitive dissonance when confronted with the ethical implications of eating meat while simultaneously valuing animal welfare (Loughnan et al., 2014). To resolve this dissonance, individuals engage in moral disengagement strategies, such as perceiving meat consumption as natural or necessary (Piazza et al., 2015). This rationalization allows consumers to continue consuming meat without significant psychological distress. Meat consumption is strongly linked to social identity and cultural norms. Rozin et al. (2012) found that meat is often associated with masculinity, power, and status, reinforcing consumption patterns that align with traditional gender roles. Additionally, societal traditions, such as festive meals and family gatherings, contribute to the habitual nature of meat consumption, making it a socially reinforced behavior.

Consumer behavior in meat consumption is also driven by economic accessibility and purchasing power. Mathur et al. (2021) highlight that price sensitivity plays a crucial role, where consumers in higher-income groups are more likely to afford premium meat products, while those in lower-income brackets may opt for cheaper alternatives or plant-based substitutes. Economic fluctuations, such as inflation and unemployment, can significantly alter meat consumption patterns. In many societies, meat is perceived as a symbol of wealth and prosperity, particularly in emerging economies where rising incomes lead to increased demand for meat products (Nierenberg & Mastny, 2005). Eating meat is part of our evolutionary heritage, a symbol of affluence, well-being, and contentment, but it also contributes to environmental harm, social unrest, and health risks (Smil, 2002). This aligns with behavioral economic theories suggesting that consumption choices serve as signals of social and economic standing. Behavioral studies also indicate that meat consumption is driven by emotional and sensory satisfaction. Earle et al. (2019) found that the hedonic appeal of meat, including taste and texture, influences consumer preferences, often overriding ethical or health considerations. The “meat paradox” illustrates how

individuals reconcile their empathy for animals with meat consumption through self-deception, leading to a complex relationship with dietary choices (Hestermann et al., 2020).

The attitude–behavior gap in meat consumption presents a significant challenge to sustainability efforts, as individuals often express positive attitudes toward reducing meat intake but struggle to translate these intentions into action. Li (2024) highlights the psychological, social, and contextual factors that contribute to this discrepancy, including cognitive dissonance, habit formation, social norms, and perceived inconvenience. Despite increasing awareness of the environmental and health impacts of meat consumption, strong cultural attachments and economic accessibility perpetuate high consumption levels. This aligns with broader behavioral economics literature, which emphasizes the limitations of rational decision-making in dietary choices and the necessity of policy interventions that alter default options, improve availability of plant-based alternatives, and leverage social influence. For instance, according to Chan and Zlatevska (2019), individuals with low subjective socioeconomic status prefer meat-based foods due to a desire for status. Psychological Food Involvement (PFI) plays a crucial role in understanding the intention to reduce meat consumption, with consumers who use food to control their public image being more inclined to do so (Castellini et al., 2023).

With the theoretical groundwork in place, the discussion now turns to the practical evidence, demonstrating how these foundational ideas manifest in actual consumption behaviors and economic trends.

Global meat consumption has undergone significant transformations over the past decades, driven by economic development, shifting dietary patterns, and environmental concerns. Sans and Combris (2015) provide an overview of meat consumption trends from 1961 to 2011, highlighting a steady increase in per capita meat consumption, particularly in emerging economies. Similarly, Delgado (2003) describes how rising incomes in developing countries have fueled a “food revolution”, leading to greater demand for animal protein. However, Vranken et al. (2014) argue that global dietary habits are experiencing a “second nutrition transition”, where increasing awareness of health and environmental sustainability is beginning to curb excessive meat consumption in certain regions. This shift aligns with findings by Godfray et al. (2018), who emphasize the need for reduced meat consumption due to its impact on health and climate change. Meanwhile, Speedy (2003) underscores the disparities in meat consumption between high-income and low-income countries, illustrating how accessibility and affordability remain key determinants. Several countries have reached peak meat consumption, but emerging-economy countries continue to increase consumption due to greater affordability, while higher income countries show no relationship with meat consumption (Whitton et al., 2021).

Meat consumption patterns among older populations in Europe reveal significant socioeconomic and demographic variations, highlighting broader sustainability and health implications. Schütz and Franzese (2018) find that daily meat consumption is prevalent among individuals aged 50 and older across European countries, with gender playing a crucial role—men consistently consume more meat than women. Economic constraints appear to have a limited impact on dietary choices, as only a small fraction of respondents report reducing meat intake due to financial reasons. These findings align with the broader literature on meat consumption trends, suggesting that cultural and habitual factors may be stronger determinants of dietary behavior than economic affordability alone.

Meat consumption in the European Union has shown a gradual increase, with a noticeable shift from beef and lamb to poultry, largely influenced by consumer preferences and economic factors (Devine, 2003). Employment status also plays a role, as higher unemployment rates often lead to reduced disposable income, which in turn affects dietary choices and meat consumption patterns (Garcia & Quintana-Domeque, 2006). Additionally,

factors such as per capita income and urbanization significantly drive meat consumption, while cultural and economic elements—including Western dietary habits, religious beliefs, female labor participation, and globalization—also shape consumption trends (Milford et al., 2019). Notably, health awareness and price increases have been found to impact meat consumption more than environmental or animal welfare campaigns, with some environmental campaigns even leading to unintended increases in meat consumption (Scalco et al., 2019). These insights highlight the intricate balance between economic, social, and cultural influences in shaping meat consumption patterns across the EU.

The EU's commitment to the Green Deal necessitates a reduction in meat consumption, particularly red meat, to meet environmental targets and promote public health. This transition is influenced by consumer behavior, policy frameworks, and the agricultural sector's adaptability. According to Guillaume et al. (2024) the EAT-Lancet recommendations suggest an 80% reduction in red meat consumption to mitigate greenhouse gas emissions, which could lead to a 9% decrease in agricultural sector emissions, while shifting diets towards plant-based proteins can enhance environmental sustainability, although trade dynamics may offset local benefits. EU consumption, particularly meat and dairy products, contributes to environmental impacts such as acidification, eutrophication, land use, and water use, with total consumption expenditures per EU member state being a key factor (Beylot et al., 2019).

Current dietary guidelines in the EU recommend moderate meat consumption, yet actual intake often exceeds these recommendations, particularly in certain regions (Cocking et al., 2020). Consumer behavior regarding meat consumption is influenced by various psychological, economic, and social factors. Apostolidis and McLeay (2016) highlight that consumers' values and perceived benefits of meat substitutes play a crucial role in shaping dietary choices. Their study on Quorn, the largest manufacturer of meat substitutes in the UK, demonstrates that health, sustainability, and lifestyle alignment significantly impact consumer preferences. Despite the perception of meat substitutes being more expensive, many consumers associate them with positive health and environmental outcomes, driven by values such as security, benevolence, and universalism. Additionally, hedonism and social conformity influence purchasing decisions, suggesting that interventions like advertising, celebrity endorsements, and digital marketing could effectively promote meat-free alternatives. These findings suggest that while policy recommendations encourage reduced meat consumption, behavioral and market-driven strategies are equally essential in fostering sustainable dietary habits in the EU.

Meat consumption in EU countries has been linked to several negative outcomes, particularly regarding environmental impact, human health, and economic vulnerability. High meat consumption contributes to greenhouse gas emissions, health risks, and environmental degradation, while also facing growing consumer and policy scrutiny. Reducing meat consumption is seen as a key strategy to lower the EU's environmental footprint and help meet climate goals (González et al., 2020). Meat consumption is rising globally, affecting health and the environment, with potential health risks and environmental impacts (Godfray et al., 2018). A study found a significant positive association between meat consumption and increased BMI, indicating a link to obesity in European countries (Hasan, 2014). EU consumers consider meat reduction as part of a healthy and sustainable diet, with varying degrees of support across regions (de Boer & Aiking, 2022). There are distinct differences in meat consumption patterns across Europe, with variations in the types of meat consumed, such as red meat and processed meat, which have different health implications (Linseisen et al., 2002).

2.2. ESG and Macroeconomic Factors in Meat Consumption in the EU

The ESG (Environmental, Social, Governance) criteria serve as a comprehensive framework for evaluating businesses and investments based on sustainability, social responsibility, and governance transparency, aligning with the 17 goals of the 2030 Agenda for Sustainable Development (Poggi, 2024). Investing in ESG directs capital toward companies that prioritize environmental protection, social equity, and ethical governance, fostering a paradigm shift from a purely profit-driven economy to one that integrates justice, social responsibility, and sustainability. At the same time, ESG principles are closely tied to global efforts for carbon neutrality, recognizing that consumers play a vital role in reducing emissions. With the goal of reaching carbon peak by 2030 and carbon neutrality by 2060, individuals must adopt greener consumption habits, even if this transition entails higher costs and lifestyle adjustments. To support this shift, businesses must enhance economies of scale and improve the affordability and quality of green products, while governments should implement regulatory incentives, subsidies, and policies that encourage sustainable living (CICC Research & CICC Global Institute, 2022). Through a collective effort involving consumers, businesses, and policymakers, ESG can become the guiding force for a more equitable, resilient, and environmentally sustainable future.

The interaction between voluntary corporate ESG initiatives and public support for government regulation remains a contested issue in sustainability discourse. While some argue that corporate sustainability efforts reduce the perceived need for regulatory intervention by creating an illusion of self-regulation, others suggest that such efforts highlight the urgency of the problem, potentially increasing public demand for stricter policies. Kim et al. (2023) explore this tension through randomized controlled studies, finding no significant evidence that voluntary ESG actions either strongly encourage or dissuade public support for government regulation. Their findings suggest that the effects of corporate ESG initiatives on regulatory attitudes are highly context-dependent, shaped by competing mechanisms such as perceived industry progress versus the visibility of unresolved environmental and social challenges.

Recent discussions on ESG regulations highlight a growing divide between regulatory ambitions and economic concerns. While ESG frameworks aim to drive corporate accountability and sustainability, they have also raised significant debates about economic freedom and financial market stability. McPherrin (2023) critiques the European Union's proposed ESG regulations, arguing that they impose bureaucratic constraints that could stifle free-market principles and corporate autonomy. His analysis suggests that these policies may centralize economic power in supranational institutions, potentially leading to financial restrictions for businesses that fail to align with ESG standards. This contrasts with the literature that views ESG regulation as a necessary tool for mitigating environmental risks and ensuring long-term economic resilience. As the EU moves toward stricter ESG mandates, the debate underscores the need for a balanced approach that reconciles sustainability objectives with economic competitiveness.

Having established the theoretical foundations, the focus now shifts to practical observations, where the real-world data and empirical findings bring context and validation to these abstract concepts.

The impact of methane air pollution on meat consumption patterns in the European Union is multifaceted, encompassing environmental, health, and economic dimensions. Livestock, particularly ruminants such as cattle, are significant contributors to methane emissions, a potent greenhouse gas that accelerates climate change. To address this, the European Green Deal advocates for sustainable meat consumption by reducing intake to lower greenhouse gas emissions and improve public health. Studies indicate that cutting meat consumption could decrease overall greenhouse gas emissions, including methane, by

25–40%, while a shift toward plant-based diets could also reduce nitrogen emissions by 40%, improving air and water quality (Westhoek et al., 2014; Hawkes, 2014). Policy measures like a climate tax on meat have been proposed to incentivize reduced consumption, but cultural and economic resistance remains a significant barrier to widespread adoption (Nordgren, 2012).

Methane emissions are closely linked to livestock production, as the digestive processes of ruminants are a major source of this potent greenhouse gas. For instance, methane emissions have an inverted U-shaped relationship with meat consumption in the USA, reflecting the complex dynamics between production scale and environmental impact (Shafiullah et al., 2021). In China, livestock methane emissions have been increasing due to rapid urbanization and rising income levels, which drive higher meat demand (Du et al., 2024). In the EU, methane emissions from enteric fermentation are directly correlated with livestock numbers and meat consumption, highlighting the significant role of this sector in greenhouse gas emissions (Petrovic et al., 2015). Additionally, the EU livestock sector contributes substantially to global emissions, producing between 623 and 852 Mt CO₂-equivalent annually, with enteric fermentation being a primary source. This includes 28–29% from beef production, 28–30% from cow milk production, and 25–27% from pork production, reflecting the diversity of livestock systems across the region (Weiss & Leip, 2012). Furthermore, nutrient use efficiency varies significantly among EU countries, influencing the overall methane output of the livestock sector (Lesschen et al., 2011). These findings underscore the critical relationship between livestock production and methane emissions, emphasizing the need for targeted interventions to reduce the carbon footprint of the livestock industry.

As shown in the research by Sanchez-Sabate and Sabaté (2019), environmental concerns are influencing a growing number of Western consumers to reduce meat consumption, although those who have already made significant dietary changes for ecological reasons remain a minority. Individuals most likely to adopt meat curtailment strategies tend to be young women, environmentally conscious, and more commonly reside in Europe and Asia rather than in the U.S. While only a small fraction has already adjusted their diet, increasing awareness of meat's environmental impact continues to shape consumer behavior. Consumer awareness and intention to reduce meat consumption are often hindered by traditional practices and economic factors (Stubbs et al., 2018). The concept of consumption corridors promotes equitable meat consumption, ensuring that dietary changes do not compromise social equity (Cué Rio et al., 2022).

Social influence plays a crucial role in determining the spread of meat-eating behaviors, with individuals needing strong openness to influences from others with different meat-eating habits and a weak tendency to reinforce their current behavior when observing others in their social group (Ge et al., 2022). As the research of Horgan et al. (2019) shows, social, temporal, and situational factors influence meat consumption in the UK, with higher intake observed when eating with family, on Sundays, and in restaurants, compared to eating alone or with other companions. Meal type, day of the week, and location significantly influence meat consumption in Switzerland, France, and the Netherlands, with patterns varying across countries and consumer gender (Laffan, 2024).

As the population increases, global meat consumption is projected to rise by 15% by 2027 (Haddad et al., 2019), a trend particularly evident in the EU, where meat consumption has nearly doubled in some countries over the past four decades (Bansback, 1995). This growing demand is linked to higher disposable incomes and shifting consumer habits favoring meat-rich diets, particularly beef and poultry (Haddad et al., 2019). However, this rise in consumption also contributes to significant environmental concerns, with the livestock sector accounting for approximately 30% of total greenhouse gas emissions

in Europe (Petrovic et al., 2015). In response, the European Green Deal advocates for sustainable dietary patterns, promoting reduced meat consumption to mitigate ecological impacts (Cué Rio et al., 2022). While transitioning to lower meat consumption is essential for sustainability, it also presents economic challenges, as the livestock industry plays a crucial role in many European economies (Pais et al., 2020).

Additionally, population growth is a critical driver of increased meat demand, as highlighted by Keshari (2022), who projects a 25% rise in the global population by 2050, reaching 9.9 billion people. This demographic expansion is expected to drive a 60% increase in global meat consumption, potentially reaching 460 to 570 million tons annually. Such rapid growth in meat production and consumption is associated with severe environmental impacts, including higher greenhouse gas emissions, deforestation, water scarcity, and biodiversity loss. These challenges underscore the need for dietary shifts and sustainable consumption patterns to reduce the ecological footprint of the livestock sector.

The livestock sector significantly shapes meat consumption patterns in the EU, as its scale, production methods, and environmental footprint directly influence availability, pricing, and dietary choices. Livestock farming occupies 28% of the EU's land surface and accounts for 65% of total agricultural land use, demonstrating its central role in the food system (Leip et al., 2015). With the EU producing 35 million tons of meat annually, high demand for fodder and grain sustains intensive animal agriculture, reinforcing the cycle of production and consumption (aan den Toorn et al., 2020). However, this intensification also contributes to 81% of agriculture's global warming impact, exacerbating climate change, biodiversity loss, and resource depletion (Leip et al., 2015). While consumer choices drive livestock production levels, the environmental consequences of large-scale meat production raise concerns about sustainability. Shifting toward more efficient farming methods, alternative protein sources, and sustainable consumption habits could help mitigate these challenges while maintaining agricultural stability in the EU (Leip et al., 2015).

The relationship between GDP and meat consumption in the EU is complex, influenced by economic development, income distribution, and consumer preferences. As countries experience economic growth, particularly in the middle-income stage, meat consumption tends to increase. However, this trend may plateau at higher income levels, suggesting a tipping point around USD 40,000 per capita, beyond which meat consumption stabilizes or declines (Whitton et al., 2021; Schroeder et al., 1996). Countries transitioning through the middle-income stage see accelerated meat consumption due to skewed income distribution (Unnevehr & Khoju, 1991). In high-income nations, per capita meat consumption remains relatively constant despite income growth (Schroeder et al., 1996). The EU aims to reduce meat consumption to meet sustainability goals, necessitating stronger governance and consumer education on dietary habits (Cué Rio et al., 2022; Pais et al., 2020). While reducing meat consumption can mitigate climate change, it poses risks to economic growth, highlighting the need for balanced strategies that promote both sustainability and economic stability (Pais et al., 2020).

Government expenditure plays a crucial role in shaping meat consumption patterns in the EU, as fiscal policies, subsidies, and public health initiatives directly influence consumer behavior and market dynamics. Public subsidies for livestock farming have historically supported meat production, making it more affordable and accessible, thus driving higher consumption levels (Guillaume et al., 2024). However, as concerns over health and environmental sustainability grow, government spending is shifting toward promoting plant-based diets and sustainable food systems through subsidies, public awareness campaigns, and taxation policies (Thies, 2023). Health-related taxation on meat has been proposed as a strategy to reduce excessive consumption and lower healthcare costs

associated with diet-related diseases (Bonnet & Coinon, 2024). Additionally, public investment in research and innovation for alternative protein sources, such as lab-grown meat and plant-based alternatives, is gradually influencing consumer choices by expanding the availability of meat substitutes (Cué Rio et al., 2022). The economic impact of reducing meat consumption also affects agricultural trade and local economies, requiring governments to carefully balance policies that support both environmental goals and economic stability (Piekut, 2024).

The introduction of the euro has significantly influenced the European pig meat trade, shaping both supply-side dynamics and consumer behavior. Clot i Gallart et al. (2021) apply a gravity model to assess the effects of monetary integration, finding that intra-eurozone pig meat exports increased substantially post-adoption, driven by reduced transaction costs and enhanced market efficiency. However, they also highlight trade diversion effects, with non-eurozone EU exporters facing disadvantages, potentially affecting meat prices and availability across different regions. These trade shifts have implications for meat consumption patterns, as price stability and market accessibility play key roles in shaping consumer choices. Coupled with behavioral economics insights on price sensitivity and dietary habits, this suggests that macroeconomic policies, such as currency integration, indirectly influence meat consumption by altering affordability and supply chains. As the EU transitions toward sustainable food systems, understanding how trade policies interact with consumer behavior is critical for designing effective interventions that promote dietary shifts toward lower environmental impact foods.

The correlation between meat consumption and inflation rates in EU countries is influenced by various economic factors, including food price dynamics and income levels. Food price inflation, particularly for meat, follows diverse trends across EU nations, showing evidence of mean reversion and distribution shifts, with regional economic conditions playing a crucial role in shaping these variations (Liontakis, 2012; Liontakis & Papadas, 2010). While higher meat consumption is generally associated with increased income levels, which can indirectly impact inflation through demand pressures, the relationship is not linear. Akpan et al. (2024) highlight that factors such as inflation, nominal exchange rates, GDP per capita, credit to the agricultural sector, and capacity utilization in the meat industry can all affect per capita meat consumption over both short and long time horizons. In a similar vein, Santini et al. (2017) argue that shifts in meat consumption, particularly in high-income and emerging economies, can lead to substantial adjustments in agricultural markets. Their analysis suggests that lower domestic demand for meat, driven by changing dietary preferences or economic pressures, could reduce the profitability of meat production in the EU, despite potential benefits like lower feedstuff prices and improved trade balances with developing countries. This is particularly true for the European beef sector, which may face significant challenges in adapting to evolving market conditions.

Moreover, inflation synchronization within the EU has intensified following quantitative easing and recent high-inflation periods, reinforcing the interconnected nature of European economies (Budová et al., 2023). Additionally, Rokicki (2019) found that fluctuations in inflation can impact specific segments of the meat industry, such as the lamb market, where declining sheep populations and rising production costs have created significant pressures on supply and pricing across EU member states. Together, these studies illustrate the complex and multifaceted relationship between inflation and meat consumption, highlighting the need for targeted policies to stabilize production and support the long-term viability of the livestock sector.

An “animal welfare Kuznets curve” may exist, with harm to animals initially rising with economic growth, followed by improvement in treatment after a peak value (Frank, 2008). The “Animal Kuznets curve” suggests that meat consumption stabilizes at higher

income levels, implying that inflation may not have a direct effect on meat prices as consumer preferences evolve (Allievi & Vinnari, 2012). Additionally, as dietary habits shift toward alternative protein sources and plant-based diets, the long-term link between inflation and meat consumption may weaken (Devine, 2003).

The relationship between unemployment and meat consumption in the EU highlights significant economic and behavioral patterns, particularly during periods of financial distress. Rising unemployment typically reduces household disposable income, leading to shifts in dietary choices that prioritize affordability over quality. Studies indicate that while total food consumption may not drastically decline, households often substitute expensive protein sources, such as meat, with more affordable alternatives, reflecting a change in dietary preferences rather than outright food insecurity. Research across OECD countries has shown a negative elasticity of approximately 0.03 for protein intake, reinforcing the idea that economic downturns impact food quality rather than quantity (Been et al., 2024). Additionally, the Great European Recession demonstrated how unemployment-driven economic contractions contributed to declining meat consumption, particularly in regions with persistently high joblessness.

While previous studies have explored meat consumption trends through economic, nutritional, and environmental lenses, this study uniquely integrates macroeconomic and ESG factors within a behavioral economics framework. This approach allows for a deeper understanding of how financial stability, government policies, and sustainability concerns shape dietary choices across EU nations.

3. Materials and Methods

3.1. Variables of the Study

This study employs a structured econometric approach to examine the determinants of meat consumption in the European Union, integrating economic, demographic, and environmental variables within an ESG framework. The dataset consists of annual observations from 27 EU countries over a 22-year period (2000–2021), capturing a comprehensive range of macroeconomic and sustainability indicators. The data sources include the World Bank and the Food and Agriculture Organization (FAO), ensuring reliability and comparability across countries and years.

All statistical analyses, including panel data estimation, diagnostic tests, and descriptive statistics, were performed using IBM SPSS Statistics 23, a widely used software package known for its comprehensive range of statistical tools and robust data management capabilities.

The variables used in the analysis are presented in the following table (Table 1).

Table 1. Variables name and description.

Name of Variables	Description of Variables
MEAT	Per capita consumption of meat FAO kilograms per year per capita.
LIVESTOCK	Livestock production index (2014–2016 = 100). Livestock production index includes meat and milk from all sources, dairy products such as cheese, and eggs, honey, raw silk, wool, and hides and skins.
INFL	Inflation, consumer prices (annual %). Inflation as measured by the consumer price index reflects the annual percentage change in the cost to the average consumer of acquiring a basket of goods and services that may be fixed or changed at specified intervals, such as yearly. The Laspeyres formula is generally used.

Table 1. *Cont.*

Name of Variables	Description of Variables
UNEMPL	Unemployment, total (% of total labor force) (modeled ILO estimate). Unemployment refers to the share of the labor force that is without work but available for and seeking employment.
POPULATION	Population, total. Total population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship. The values shown are midyear estimates.
POP	Population growth (annual %). Annual population growth rate for year t is the exponential rate of growth of midyear population from year t – 1 to t, expressed as a percentage. Population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship.
GDP PPP	GDP PPP is gross domestic product converted to international dollars using purchasing power parity rates. An international dollar has the same purchasing power over GDP as the U.S. dollar has in the United States. GDP is the sum of gross value added by all resident producers in the country plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in constant 2021 international dollars.
GDP PPP CAPITA	It results from the quotient of dividing GDP PPP by the total population (GDP PPP/POPULATION). It shows the GDP per capita in purchasing power parity units.
METHANE	Methane (CH ₄) emissions from Agriculture (Mt CO ₂ e). Annual emissions of methane (CH ₄), one of the six Kyoto greenhouse gases (GHGs), from the agricultural sector. This includes emissions from livestock (IPCC 2006 codes 3.A.1 enteric fermentation, 3.A.2 manure management) and crops (IPCC 2006 codes 3.C.1 Emissions from biomass burning, 3.C.2 Liming, 3.C.3 Urea application, 3.C.4 Direct N ₂ O Emissions from managed soils, 3.C.5 Indirect N ₂ O Emissions from managed soils, 3.C.6 Indirect N ₂ O Emissions from manure management, 3.C.7 Rice cultivations). The measure is standardized to carbon dioxide equivalent values using the Global Warming Potential (GWP) factors of IPCC's 5th Assessment Report (AR5).
EXGOV	Expense (% of GDP). Expense is cash payments for operating activities of the government in providing goods and services. It includes compensation of employees (such as wages and salaries), interest and subsidies, grants, social benefits, and other expenses such as rent and dividends.
GDP	GDP per capita (constant LCU). GDP per capita is gross domestic product divided by midyear population. GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in constant local currency.

The inclusion of both GDP per capita (constant LCU) and GDP PPP per capita in the analysis is justified by their complementary roles in capturing economic performance. GDP per capita in constant LCU allows for an accurate assessment of a country's economic growth over time, free from the distortions of inflation, making it suitable for evaluating domestic economic trends. Meanwhile, GDP PPP per capita facilitates cross-country comparisons by adjusting for differences in price levels, providing a more accurate measure of purchasing power and living standards across nations. By incorporating both indicators, the analysis ensures a comprehensive understanding of how economic conditions influence meat consumption at both national and international levels.

The dependent variable is meat consumption (MEAT), while the independent variables include GDP per capita (GDP), GDP per capita PPP-adjusted (GDP PPP

CAPITA), unemployment (UNEMPL), population growth (POP), methane emissions (METHANE), government expenditure (EXGOV), inflation (INFL), and livestock availability (LIVESTOCK).

3.2. Main Research Hypotheses

To test the impact of these variables on meat consumption, we formulate a set of main research hypotheses that reflect the economic, environmental, social, and government dimensions of meat consumption patterns:

H1: *Higher GDP levels are associated with increased meat consumption.*

H2: *GDP PPP CAPITA positively influences meat consumption, reflecting the role of individual income levels in dietary preferences.*

H3: *Higher unemployment rates (UNEMPL) negatively affect meat consumption, as economic downturns limit household spending on higher-cost protein sources.*

H4: *Methane emissions (METHANE) are positively associated with meat consumption, given that livestock production is a key contributor to both meat supply and environmental externalities.*

H5: *Livestock availability (LIVESTOCK) positively impacts meat consumption, as greater local production leads to higher domestic consumption.*

H6: *Government expenditure (EXGOV) is expected to positively influence meat consumption, as fiscal policies and subsidies may affect food affordability and agricultural production.*

H7: *Inflation (INFL) negatively affects meat consumption, as higher prices reduce consumer purchasing power and shift dietary preferences toward alternative protein sources.*

H8: *Population growth (POP) has a positive impact on meat consumption, as an increasing population leads to higher aggregate demand for food products, including meat.*

3.3. Methodological Framework

Descriptive statistics provide an essential first step in any empirical analysis, offering a preliminary overview of the data distribution, central tendencies, and variability. This initial examination helps identify potential outliers, missing values, and data irregularities, which can significantly influence the reliability of econometric models. Presenting these statistics at the beginning of the analysis allows the reader to assess the quality and characteristics of the data before interpreting the empirical results, ensuring a more informed understanding of the underlying patterns and relationships within the dataset. This approach also helps justify the subsequent methodological choices, such as data transformations or the use of robust estimators, by clearly establishing the foundational structure of the data.

Panel data models are essential in econometric analysis when data are collected from multiple entities over time. These models capture both cross-sectional and time-series variations, allowing for a more comprehensive analysis of dynamic relationships. The primary advantage of panel data is its ability to control for unobserved heterogeneity, which can bias results if ignored. The Fixed Effects (FE) model is particularly useful when the unobserved characteristics of the entities are correlated with the explanatory variables. It effectively eliminates time-invariant factors by using within-group transformations, focusing solely on the variation within each entity over time. On the other hand, the Random Effects (RE) model assumes that the individual effects are uncorrelated with the independent variables, making it more efficient when this assumption holds true. The

choice between FE and RE models is often guided by the Hausman test, which statistically evaluates the presence of correlation between entity-specific effects and regressors. To determine whether the model's explanatory variables significantly impact the dependent variable, the Analysis of Variance (ANOVA) is used. This method tests the hypothesis that the group means are equal, helping to assess the overall model significance. However, a key methodological challenge in panel data analysis is the issue of autocorrelation, which can violate the assumption of independent residuals. To address this, the Durbin–Watson test is used in order to detect the presence of serial correlation. If positive autocorrelation is detected, this indicates the need for a more robust approach.

To address the limitations of FE and RE models in the presence of serial correlation, the analysis transitions to Generalized Estimating Equations (GEE). GEE provides a flexible framework for modeling correlated panel data, allowing for the inclusion of within-group correlation without relying on strict distributional assumptions. It estimates population-averaged effects, focusing on the overall impact of explanatory variables across the entire sample. Unlike FE and RE models, GEEs use a working correlation matrix to capture the dependence structure of the repeated observations, which can be specified as independent, exchangeable, or autoregressive, depending on the data characteristics. This flexibility allows GEE to produce more accurate and consistent parameter estimates even when the working correlation structure is misspecified. Additionally, GEEs utilize a quasi-likelihood estimation approach, providing robust standard errors that improve the reliability of statistical inferences in the presence of serial correlation.

3.4. Steps of the Methodological Framework

To examine the previous research hypotheses (H1–H8), this study employs three econometric models that progressively refine the analysis. The methodology follows a structured sequence of steps to ensure the selection of the most appropriate econometric model and the reliability of the results. Each step is designed to address potential biases, correct for data dependencies, and refine the estimation process. By systematically applying diagnostic tests and model specifications, it is ensured that the final model provides the most accurate and robust estimates for analyzing the determinants of meat consumption in the EU.

1. STEP 1: Conducting the Hausman Test to Choose Between Fixed Effects (FE) and Random Effects (RE) Models

To determine the appropriate econometric model for analyzing the determinants of meat consumption in the EU, the analysis first estimates the Fixed Effects (FE) model by incorporating country-specific dummy variables to control for unobserved heterogeneity across nations. The estimated coefficients from the FE model indicated the impact of economic and ESG factors on meat consumption.

Next, the Random Effects (RE) model is estimated under the assumption that country-specific differences are random and uncorrelated with the explanatory variables.

To formally test whether the FE or RE model is more appropriate, the Hausman test is conducted, which evaluates whether the differences in coefficients between the two models are systematic. This test examines whether unobserved individual effects are correlated with the independent variables, with the rejection of the null hypothesis favoring the FE model. Based on the results of the Hausman test, the Random Effects (RE) model is the preferred choice over the Fixed Effects (FE) model.

2. STEP 2: Estimation and Evaluation of the Random Effects Model

Following the selection of the Random Effects (RE) model, the analysis proceeds with its estimation to analyze the impact of economic and ESG factors on meat consumption

in the EU. The RE model is chosen under the assumption that country-specific effects are randomly distributed and uncorrelated with the explanatory variables, allowing for more efficient estimation while retaining variation both within and between countries. The results indicate that key economic indicators such as GDP, GDP per capita (PPP-adjusted), unemployment, and inflation, along with environmental factors like methane emissions and livestock availability, significantly influence meat consumption patterns.

To assess the potential for multicollinearity among the independent variables included in the regression models, Variance Inflation Factors (VIFs) were calculated. Multicollinearity occurs when two or more predictors are highly correlated, potentially distorting the estimated coefficients and reducing the statistical power of the model. In this study, a commonly used threshold of $VIF > 10$ was employed to identify variables with potentially problematic levels of multicollinearity, as this indicates a high degree of redundancy among the predictors. Additionally, tolerance values were examined, with values below 0.1 considered indicative of significant multicollinearity. These measures were used to ensure the stability and reliability of the estimated coefficients, supporting the robustness of the final model specification.

To ensure the statistical validity of the estimated models, a series of diagnostic tests were conducted, including the ANOVA F-test and the Durbin–Watson (DW) test. The F-statistic was used to assess the overall significance of the regression model by comparing the explained variance (regression sum of squares) to the unexplained variance (residual sum of squares). A statistically significant F-statistic indicates that the model provides a better fit than a model with no independent variables. The Durbin–Watson test was employed to detect the presence of autocorrelation in the residuals, with values close to 2 indicating the absence of first-order autocorrelation. These diagnostic tests are essential for validating the reliability and interpretability of the regression results, ensuring that the assumptions of the classical linear regression model are adequately met.

The ANOVA results confirm the statistical significance of the model, demonstrating that the independent variables collectively explain a substantial portion of the variation in meat consumption. However, the Durbin–Watson statistic indicates the presence of strong positive autocorrelation, suggesting that the residuals are not independently distributed. This violation of the independence assumption reduces the reliability of the parameter estimates in the RE model. To address this limitation and ensure more accurate inferences, the analysis transitions to the Generalized Estimating Equations (GEE) model, which accounts for serial correlation and provides a more robust framework for panel data analysis. Detailed statistical results are presented in the subsequent section.

3. STEP 3: Transition to Generalized Estimating Equations (GEE) for Robust Estimation

Given the presence of autocorrelation detected in the Random Effects (RE) model, as indicated by the low Durbin–Watson statistic, the analysis proceeds with the Generalized Estimating Equations (GEE) model to obtain more reliable estimates. The GEE framework is particularly suited for panel data with within-subject correlations, as it corrects for serial dependence by applying an autoregressive (AR1) correlation structure. This approach accounts for the time-dependent relationships between observations within each country, ensuring unbiased standard errors and more efficient coefficient estimates.

To evaluate the adequacy of the GEE model and determine the best specification, Goodness of Fit tests are conducted using the Quasi Likelihood under Independence Model Criterion (QIC) and the Corrected QIC (QICC). These information criteria, which follow a “smaller-is-better” rule, allow for a comparative assessment of model performance by penalizing complexity while rewarding improved fit. The model includes the following explanatory variables: GDP, livestock availability (LIVESTOCK), inflation (INFL), unem-

ployment (UNEMPL), GDP per capita (PPP-adjusted), methane emissions (METHANE), government expenditure (EXGOV), and population (POP).

Additionally, the Wald Chi-Square test is conducted to assess the joint statistical significance of all explanatory variables. Initially, the test is performed on the full model to identify statistically significant predictors. Subsequently, any variables found to be statistically insignificant are removed, and the model is re-estimated with only the significant variables. The Goodness of Fit (QIC and QICC) tests and Wald Chi-Square test are then re-run on the refined model, and the results of the two models are compared.

The objective of this process is to arrive at a final model with the highest predictive power, containing only the most statistically relevant variables. This ensures that the econometric model is both parsimonious and efficient, striking a balance between model complexity and explanatory capability while maintaining robustness in estimating the determinants of meat consumption in the EU.

The transition between econometric models follows a structured progression aimed at refining the accuracy and robustness of the analysis. The Random Effects (RE) model serves as an initial framework, providing a broad yet informative picture of the key economic, environmental, and policy-related factors influencing meat consumption in the EU. By allowing for both within- and between-country variation, the RE model enables a first-level hypothesis testing while incorporating critical ESG dimensions, including economic performance, environmental sustainability, and government policy. However, despite its explanatory power, the presence of serial correlation in the residuals raises concerns about the reliability of the standard errors, necessitating a transition to a more advanced method. To achieve a deeper, more precise understanding of the determinants of meat consumption, the analysis proceeds with the Generalized Estimating Equations (GEE) model, which corrects for autocorrelation and provides more statistically robust estimates. This methodological refinement aligns with the study's objective of developing an econometric framework that not only validates theoretical hypotheses but also ensures that the final model possesses the highest predictive power while maintaining parsimony and statistical validity.

To ensure the robustness of the analysis, first, the full model is estimated, incorporating all independent variables to capture the complete set of economic, and ESG factors influencing meat consumption. This initial estimation allows the study to assess the statistical significance of each variable using the Wald Chi-Square test. After identifying non-significant predictors ($p > 0.05$), the analysis proceeds by estimating a refined model, which includes only the statistically significant variables.

To determine which model provides a better fit, the analysis compares them using the Goodness of Fit criteria:

- Quasi Likelihood under Independence Model Criterion (QIC);
- Corrected Quasi Likelihood under Independence Model Criterion (QICC).

These measures follow a “smaller-is-better” principle, meaning that lower values indicate a more efficient model with improved predictive power. If the refined model exhibits lower QIC and QICC values, it suggests that excluding non-significant variables enhances model performance. Conversely, if these values increase, it implies that the removed variables contribute to overall model fit, even if they are not individually significant.

In this case, the full model outperforms the refined version, as evidenced by its lower QIC and QICC values. This indicates that even the statistically non-significant variables play a role in explaining meat consumption patterns, possibly by accounting for underlying relationships or mitigating omitted variable bias. As a result, the full model retains the most appropriate specification, ensuring a comprehensive and stable econometric framework for our analysis.

The decision to retain the full model, including both statistically significant and non-significant variables, is supported by multiple considerations. First, the Goodness of Fit criteria (QIC, QICC) indicate that the full model provides better predictive accuracy compared to the refined model, suggesting that the excluded variables, despite their lack of individual statistical significance, contribute to the overall explanatory power. Second, even non-significant variables can help reduce omitted variable bias, ensuring that key predictors are not misestimated due to missing relevant factors. Additionally, some variables may have indirect effects or interact with other predictors, influencing the dependent variable in ways not captured through simple significance testing. Retaining all variables also allows for a more comprehensive interpretation, reflecting the theoretical framework that incorporates economic, environmental, and policy-driven influences on meat consumption. Therefore, maintaining the full model is the optimal choice, as it preserves model stability, interpretability, and robustness while minimizing potential biases in estimation.

4. STEP 4: Examining Meat Consumption by Country Development Level

To investigate whether income level influences meat consumption patterns, countries were classified into income groups based on the World Bank's official income classifications, incorporated into the Generalized Estimating Equations (GEE) full model. According to the World Bank, economies are categorized into four income groups—low, lower-middle, upper-middle, and high—based on their Gross National Income (GNI) per capita. These classifications are updated annually on July 1, using conversion factors derived from the Atlas method, which adjusts for exchange rate fluctuations and aims to provide a more stable measure of income over time. Given that the present analysis focuses on EU member states, the low-income category is not represented, resulting in the following three groups: lower-middle-income (1), upper-middle-income (2), and high-income (3). This approach ensures consistency with internationally recognized economic frameworks and reflects the varying levels of economic capacity within the EU, providing a robust basis for examining the relationship between national income and meat consumption.

High-income countries were set as the reference category, allowing the study to analyze how meat consumption differs in lower-income groups relative to wealthier economies. Next, the study introduced income group as a categorical variable alongside macroeconomic and ESG predictors.

Specifically, the following three hypotheses were formed:

H9: *High-income countries consume significantly more meat than lower-income countries, supporting the hypothesis that economic prosperity increases meat demand.*

H10: *The impact of GDP PPP per capita on meat consumption is stronger in wealthier countries than in developing ones, as indicated by a significant interaction effect between GDP PPP per capita and income level.*

H11: *Income level moderates the relationship between GDP PPP per capita and meat consumption, providing a better predictive fit for the model.*

To test these hypotheses, a Generalized Estimating Equations (GEE) model is estimated, incorporating income group as a categorical factor and an interaction term between GDP PPP per capita and income group to determine if economic development moderates the impact of GDP PPP per capita on meat consumption:

$$\text{MEAT} = \beta_0 + \beta_1 \text{GDP PPP CAPITA} + \beta_2 \text{INCOME GROUP} + \beta_3 (\text{GDP PPP CAPITA} \times \text{INCOME GROUP}) + \sum \beta_i x_i + \varepsilon$$

where

- β_1 measures the effect of GDP PPP per capita on meat consumption in high-income countries. Since the reference group is high-income, β_1 measures how GDP per capita affects meat consumption only in high-income countries.
- β_2 captures the direct effect of being in a lower-income group. Since the reference category is high-income, the coefficient β_2 represents the difference in meat consumption between lower- and upper-middle-income groups relative to high-income.
- β_3 determines whether the impact of GDP on meat consumption varies by income level. β_3 tells us whether the impact of GDP per capita on meat consumption is different for lower and upper-middle-income countries compared to high-income countries.
- X_i includes other economic and ESG variables.

To evaluate the model, the analysis applies the following statistical tests:

- Wald Chi-Square test to assess the joint significance of the predictors.
- Goodness of Fit measures (QIC, QICC) to compare the performance of models with and without the interaction term.

This step enhances the understanding of how economic development shapes dietary choices, contributing to the broader discussion on income-driven food consumption patterns in the EU.

Finally, in order to enhance the reliability and robustness of the econometric analysis, additional statistical checks were conducted beyond the standard diagnostics. Specifically, a test for cross-sectional dependence among the panel units (countries) was performed to verify the independence of error structures, a critical assumption in panel data analysis. This was achieved through pairwise correlation analysis of the residuals, which indicated that the majority of country pairs exhibit non-significant correlations ($p > 0.05$), supporting the assumption of independent error structures. In addition, Clustered Standard Errors (CSEs) were applied to address potential within-group correlation, providing more accurate and reliable standard error estimates. This approach ensures that the estimated coefficients are robust to within-country heteroskedasticity and cross-sectional dependence, enhancing the credibility of the findings.

4. Results

4.1. Descriptive Statistics

Before presenting the econometric results, an overview of the descriptive statistics for the dataset is provided. This step allows for a clearer interpretation of the empirical findings by establishing the basic characteristics of the data, including the distribution, mean, standard deviation, and range of each variable, ensuring that the subsequent analysis is appropriately contextualized.

The descriptive statistics in Table 2 reveal a wide range of values across variables, reflecting the economic and structural diversity within the EU. Key economic indicators such as GDP, government expenditure (EXGOV), inflation (INFL), and GDP PPP per capita demonstrate varying levels of skewness and kurtosis, indicative of both the economic heterogeneity and the unique developmental trajectories of EU member states. For instance, the GDP distribution, with a skewness of 4.837 and a kurtosis of 22.861, captures the substantial economic differences between larger and smaller economies, while the INFL variable, with a kurtosis of 70.087, reflects periods of significant economic volatility. Despite these observed distributional variations, the full dataset was retained to preserve the representativeness of the analysis, ensuring that the models accurately reflect the complex economic landscape of the EU. This approach minimizes the risk of selection bias that

could arise from the exclusion of influential observations, thereby maintaining the external validity of the findings.

Table 2. Descriptive statistics.

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
YEAR	594	2000	2021	2010.50	6350	0.000	0.100	−1.205	0.200
GDP	594	5710.959	4,335,626.321	191,824.425	638,312.584	4.837	0.100	22.861	0.200
MEAT	594	35.08	119.22	77,366	13,807	−0.198	0.100	0.186	0.200
LIVESTOCK	594	61.82	188.44	101,292	13,170	1.861	0.100	7.971	0.200
INFL	594	−4447	45,666	2494	3254	6.468	0.100	70.087	0.200
UNEMPL	594	1805	27,686	8572	4327	1.473	0.100	2.545	0.200
GROWTH	594	−16,040	24,615	2513	3989	−0.274	0.100	4.249	0.200
GDP PPP	594	12,000,204,588.848	5,227,703,792,777.606	748,951,991,358.287	1,115,963,342,274.728	2.245	0.100	4.323	0.200
POPULATION	594	390,087	83,196,078	16,301,355.99	21,433,474.944	1.818	0.100	2.159	0.200
GDP PPP CAPITA	594	12,548.285	137,821.419	45,068.262	21,854.282	2.032	0.100	5.680	0.200
METHANE	594	0.0518	52.675	9.367	12.064	1.912	0.100	3.004	0.200
EXGOV	580	22,003	99,032	39,814	9141	2.969	0.101	15.003	0.203
POP	594	−3.847	3.931	0.221	0.867	0.140	0.100	1.948	0.200

Additionally, the robustness checks confirmed the stability of the regression results. The analysis of cross-sectional dependence indicated that most country pairs do not exhibit statistically significant residual correlations, validating the assumption of independent error structures across the EU panel. Furthermore, the application of clustered standard errors resulted in consistent and statistically significant coefficients for key variables, including GDP, methane emissions, and government expenditure, even after correcting for potential within-group correlation. These results reinforce the robustness of the model and provide confidence in the observed relationships between meat consumption and the selected macroeconomic and ESG factors.

4.2. Hausman Test Between Fixed Effects (FE) and Random Effects (RE) Models

In order to decide on the appropriate econometric model for analyzing the determinants of meat consumption in the EU, the Fixed Effects (FE) model is first estimated, by incorporating country-specific dummy variables to control for unobserved heterogeneity across 27 EU countries (Table 3).

In the Fixed Effects (FE) model (Table 3), country-specific dummy variables for 27 EU countries are included, omitting Greece to avoid the dummy variable trap—a situation where perfect multicollinearity arises if all categories are included. By excluding Greece, it serves as the reference category, meaning that the coefficients of the other country dummies indicate how meat consumption in each country deviates relative to Greece. A positive and significant coefficient suggests higher meat consumption compared to Greece, while a negative coefficient indicates lower consumption. The choice of Greece as the baseline may have been arbitrary or based on its economic and dietary characteristics, providing a meaningful point of comparison across EU countries.

Table 3. Coefficients of Fixed Effects model.

Variable	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	78.664	5.695	-	13.812	0.000	-	-
GDP	-5.357×10^{-6}	0.000	-0.261	-1.734	0.083	0.020	49.059
LIVESTOCK	0.100	0.030	0.100	3.315	0.001	0.509	1.963
INFL	-0.238	0.107	-0.059	-2.230	0.026	0.663	1.508
UNEMPL	-0.971	0.110	-0.315	-8.815	0.000	0.363	2.758
GDP PPP CAPITA	0.000	0.000	-0.195	-1.889	0.059	0.044	22.920
METHANE	1.559	0.492	1.405	3.167	0.002	0.002	425.262
EXGOV	0.022	0.049	0.015	0.454	0.650	0.411	2.433
POP	-0.926	0.696	-0.060	-1.330	0.184	0.225	4.445
DUMMY = Austria	5.699	2.595	0.082	2.196	0.028	0.329	3.039
DUMMY = Belgium	-15.300	2.844	-0.221	-5.379	0.000	0.274	3.651
DUMMY = Bulgaria	-27.936	3.056	-0.404	-9.141	0.000	0.237	4.215
DUMMY = Croatia	-13.112	2.784	-0.190	-4.709	0.000	0.286	3.499
DUMMY = Cyprus	1.276	3.438	0.018	0.371	0.711	0.187	5.334
DUMMY = Czechia	-4.180	2.638	-0.060	-1.585	0.114	0.318	3.140
DUMMY = Denmark	-9.028	2.891	-0.131	-3.122	0.002	0.265	3.773
DUMMY = Estonia	-12.584	3.076	-0.182	-4.090	0.000	0.234	4.272
DUMMY = Finland	-5.191	2.458	-0.075	-2.111	0.035	0.367	2.728
DUMMY = France	-59.470	21.921	-0.860	-2.713	0.007	0.005	216.882
DUMMY = Germany	-51.589	17.235	-0.746	-2.993	0.003	0.007	134.064
DUMMY = Hungary	15.193	10.665	0.220	1.425	0.155	0.019	51.336
DUMMY = Ireland	-8.019	6.564	-0.116	-1.222	0.222	0.051	19.443
DUMMY = Italy	-25.743	8.961	-0.372	-2.873	0.004	0.028	36.244
DUMMY = Latvia	-15.226	2.995	-0.220	-5.084	0.000	0.247	4.049
DUMMY = Lithuania	-7.115	2.801	-0.103	-2.540	0.011	0.282	3.541
DUMMY = Luxembourg	27.103	5.590	0.392	4.849	0.000	0.071	14.102
DUMMY = Malta	0.260	3.382	0.004	0.077	0.939	0.194	5.161
DUMMY = Netherlands	-21.873	5.034	-0.316	-4.345	0.000	0.087	11.438
DUMMY = Poland	-25.893	7.341	-0.374	-3.527	0.000	0.041	24.324
DUMMY = Portugal	7.075	2.202	0.102	3.213	0.001	0.457	2.189
DUMMY = Romania	-32.472	3.594	-0.469	-9.036	0.000	0.172	5.828
DUMMY = Slovakia	-20.345	2.904	-0.294	-7.006	0.000	0.263	3.805
DUMMY = Slovenia	-2.100	2.824	-0.029	-0.743	0.458	0.304	3.285
DUMMY = Spain	-8.566	11.470	-0.084	-0.747	0.455	0.036	27.569
DUMMY = Sweden	-4.318	2.584	-0.062	-1.671	0.095	0.332	3.013

The country-level coefficients presented in Table 3 reflect the relative differences in meat consumption across EU member states, with Greece serving as the baseline category. Positive coefficients for countries such as Austria (5.699), Luxembourg (27.103), Portugal (7.075), and Hungary (15.193) indicate higher average meat consumption compared to Greece. This likely reflects differences in economic prosperity, dietary preferences, and live-stock production capacity. In contrast, countries like Bulgaria (-27.936), France (-59.470), Germany (-51.589), Italy (-25.743), Poland (-25.893), and Romania (-32.472) have significantly negative coefficients, suggesting lower meat consumption relative to Greece. These negative coefficients may be associated with factors such as economic structure, cultural dietary habits, or stronger environmental awareness, which can influence meat consumption patterns. The large negative coefficients for France and Germany, for instance, could reflect the impact of mature economies with well-established sustainability initiatives and a higher awareness of the environmental consequences of meat consumption. The

variation in these coefficients highlights the importance of accounting for country-specific factors when analyzing meat consumption within the EU.

In the Fixed Effects model (Table 3), the results indicate that certain macroeconomic and environmental variables significantly influence meat consumption in the EU. Specifically, LIVESTOCK (livestock availability) shows a positive and statistically significant relationship ($\beta = 0.100, p = 0.001$), confirming that increased meat production is associated with higher consumption. Similarly, METHANE emissions ($\beta = 1.405, p = 0.002$) have a strong positive correlation, highlighting the environmental implications of meat production. In contrast, unemployment (UNEMPL) has a negative and highly significant effect ($\beta = -0.315, p = 0.000$), suggesting that economic difficulties, which come from unemployment, constrain meat consumption. Inflation (INFL) also negatively impacts consumption ($\beta = -0.059, p = 0.026$), as rising prices reduce consumer purchasing power. Meanwhile, GDP and GDP PPP CAPITA do not exhibit statistically significant relationships, which may be due to internal differences among EU member states. However, the high levels of multicollinearity (VIF) in certain variables, such as METHANE (VIF = 425.262) and GDP (VIF = 49.059), suggest possible interdependencies among independent variables, potentially affecting the accuracy of the estimates.

The estimated coefficients from the FE model were

$$\beta_{FE} = (\text{GDP, LIVESTOCK, INFL, UNEMPL, GDP PPP CAPITA, METHANE, EXGOV, POP}) = (-5.357 \times 10^{-6}, 0.100, -0.238, -0.971, 0.000, 1.559, 0.022, -0.926) \quad (1)$$

Next, the Random Effects (RE) model is estimated, under the assumption that country-specific differences are random and uncorrelated with the explanatory variables (Table 4).

Table 4. Coefficients of Random Effects (RE) model.

Variables	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	50.496	4.297	-	11.751	0.000	-	-
GDP	3.063×10^{-6}	0.000	0.149	4.521	0.000	0.951	1.052
LIVESTOCK	0.080	0.034	0.080	2.342	0.020	0.895	1.118
INFL	-0.311	0.140	-0.077	-2.219	0.027	0.866	1.155
UNEMPL	-0.287	0.115	-0.093	-2.488	0.013	0.741	1.350
GDP PPP CAPITA	0.000	0.000	0.297	6.804	0.000	0.547	1.828
METHANE	0.386	0.037	0.348	10.554	0.000	0.957	1.045
EXGOV	0.217	0.049	0.150	4.406	0.000	0.898	1.114
POP	2.952	0.650	0.192	4.544	0.000	0.580	1.724

The results in Table 4 provide the coefficients from the Random Effects (RE) model, offering a complementary perspective to the Fixed Effects (FE) results in Table 3. While the FE model isolates within-country variations, controlling for unobserved heterogeneity by assigning a unique intercept to each country, the RE model captures both within- and between-country effects, assuming that country-specific effects are uncorrelated with the independent variables. This broader perspective can lead to differences in coefficient estimates, as seen in the slightly altered significance levels and magnitudes for variables such as GDP PPP CAPITA and METHANE. For instance, while LIVESTOCK remains positively associated with meat consumption in both models, the influence of other macroeconomic factors varies, reflecting the different assumptions underlying each model. This comparison is essential, as it highlights the potential impact of model selection on the interpretation of relationships, emphasizing the need for careful consideration when choosing the most

appropriate specification. The subsequent Hausman test provides a formal assessment of whether the FE or RE model is more suitable for this analysis, ensuring that the chosen model accurately captures the true nature of the data.

The estimated coefficients from the RE model were

$$\beta_{RE} = (\text{GDP, LIVESTOCK, INFL, UNEMPL, GDP PPP CAPITA, METHANE, EXGOV, POP}) = (3.063 \times 10^{-6}, 0.080, -0.311, -0.287, 0.000, 0.386, 0.217, 2.952) \quad (2)$$

To formally test whether the FE or RE model is more appropriate, the Hausman test is conducted, which evaluates whether the differences in coefficients between the two models are systematic. The test statistic is computed as follows:

$$H = (\beta_{FE} - \beta_{RE}) - [\text{Var}(\beta_{FE}) - \text{Var}(\beta_{RE})]^{-1} (\beta_{FE} - \beta_{RE})$$

where

- β_{FE} and β_{RE} represent the coefficient vectors from the FE and RE models, respectively.
- $\text{Var}(\beta_{FE})$ and $\text{Var}(\beta_{RE})$ denote the variance–covariance matrices of the respective models.

Based on the results of the Hausman test, the Random Effects (RE) model is the preferred choice over the Fixed Effects (FE) model. The test indicates that there is no statistically significant difference between the estimators of the two models, implying that the assumptions of the Random Effects approach hold. Specifically, the absence of correlation between the individual-specific effects and the independent variables ensures that the RE model remains both consistent and efficient. Furthermore, the RE model allows for the estimation of time-invariant variables and provides greater generalizability beyond the sampled units. Given these advantages and the efficiency of the RE approach, it is deemed the most appropriate model for this analysis.

The selection of the Random Effects (RE) model over the Fixed Effects (FE) model is justified based on both the Hausman test results and the assessment of multicollinearity using Variance Inflation Factor (VIF) values. The VIF values indicate that the FE model suffers from extreme multicollinearity, particularly with GDP (VIF = 49.059), GDP PPP CAPITA (VIF = 22.920), and METHANE (VIF = 425.262), making coefficient estimates highly unreliable. Additionally, UNEMPL (VIF = 2.758) and POP (VIF = 4.445) further suggest a problematic correlation among predictors. In contrast, the RE model exhibits significantly lower VIF values, with GDP PPP CAPITA (VIF = 1.828) and POP (VIF = 1.724) staying within acceptable thresholds, with other variables such as GDP (VIF = 1.052), METHANE (VIF = 1.045), and LIVESTOCK (VIF = 1.118) showing minimal collinearity. The RE model is also more statistically efficient, as it does not remove time-invariant variables, ensuring that valuable information is retained. Since the Hausman test does not indicate a significant correlation between individual effects and regressors, the RE model is preferred for its greater efficiency, stability, and broader generalization potential. Consequently, the RE model is the optimal choice, providing more reliable coefficient estimates and a more meaningful interpretation of the data.

4.3. Analysis of Random Effects Model

The results of the Random Effects (RE) model reveal important insights into the determinants of meat consumption in the EU. The statistical significance (Sig.) and standardized coefficients (Beta) help assess the relative strength and direction of each variable's impact, allowing us to evaluate the research hypotheses.

Methane emissions have the strongest positive effect on meat consumption (Beta = 0.348, $p = 0.000$), confirming H4, which hypothesized a direct relationship between livestock

production and environmental impact. This result suggests that increased meat consumption is closely linked to methane emissions, reinforcing the environmental consequences of dietary choices. Similarly, GDP per capita (PPP-adjusted) has a strong and significant positive effect ($\text{Beta} = 0.297, p = 0.000$), supporting H2, as higher income levels enhance consumers' ability to afford meat products. Population growth also exerts a moderate but significant positive effect ($\text{Beta} = 0.192, p = 0.000$), validating H8, which expected a direct link between demographic expansion and higher meat demand.

Government expenditure on public services (EXGOV) has a moderate positive impact on meat consumption ($\text{Beta} = 0.150, p = 0.000$), confirming H6, as fiscal policies and subsidies can influence food affordability and agricultural production. Similarly, GDP exhibits a moderate but statistically significant positive relationship with meat consumption ($\text{Beta} = 0.149, p = 0.000$), supporting H1, which anticipated that economic growth would drive higher consumption. However, its effect is slightly weaker than GDP per capita, indicating that individual purchasing power plays a more direct role than aggregate economic expansion.

Livestock availability has a weaker but still positive effect ($\text{Beta} = 0.080, p = 0.020$), providing partial support for H5, which expected a strong relationship between livestock production and meat consumption. While significant, the relatively small Beta suggests that factors such as market demand, economic conditions, and trade dynamics may play a larger role in determining meat consumption levels than mere livestock availability.

In contrast, unemployment exerts a negative and significant effect on meat consumption ($\text{Beta} = -0.093, p = 0.013$), validating H3, as higher unemployment reduces household purchasing power and limits expenditures on more expensive food items. Inflation also has a negative and statistically significant impact ($\text{Beta} = -0.077, p = 0.027$), confirming H7, as rising prices erode consumer affordability and shift consumption toward alternative protein sources. However, the relatively weak coefficients for unemployment and inflation suggest that, while important, these economic conditions do not dominate meat consumption trends in the EU.

Overall, the findings provide strong empirical support for all the research hypotheses. The most influential factors driving meat consumption are methane emissions, GDP per capita, and population growth, while government expenditure and GDP also play important roles. The negative effects of inflation and unemployment align with theoretical expectations but appear to exert a weaker influence than income-related and demographic factors. These results highlight the complex interplay between economic development, environmental sustainability, and policy interventions in shaping dietary patterns across the EU.

The ANOVA results (Table 5) provide a statistical assessment of the overall explanatory power of the Random Effects (RE) model.

Table 5. ANOVA analysis of Random Effects (RE) model.

	Sum of Squares	df	Mean Square	F	Sig.
Regression	41,166.745	8	5145.843	48.890	0.000
Residual	60,100.276	571	105.254		
Total	101,267.021	579			

The regression sum of squares (41,166.745) represents the variation in meat consumption explained by the model's independent variables, while the residual sum of squares (60,100.276) accounts for the unexplained variance. The total variation in meat consumption, captured by the total sum of squares (101,267.021), indicates how well the model accounts for differences in consumption across EU countries. The F-statistic (48,890, $p = 0.000$)

confirms that the independent variables collectively have a statistically significant effect on meat consumption at a highly significant level ($p < 0.01$). This strong significance indicates that at least one of the predictor variables has a meaningful influence on the dependent variable, reinforcing the validity of the model. The degrees of freedom ($df = 8$ for regression and 571 for residuals) further validate the model's structure, confirming that it accounts for the appropriate number of explanatory factors while preserving sufficient variability for reliable inference. The high F-value suggests that the model performs well in explaining variations in meat consumption, justifying its use for further interpretation and policy analysis.

The model summary (Table 6) provides an overall evaluation of the Random Effects (RE) model in explaining meat consumption in the EU. The R-value (0.638) indicates a moderate correlation between the dependent variable (MEAT) and the independent variables included in the model. The R-Square (0.407) suggests that 40.7% of the variation in meat consumption is explained by the model, indicating reasonable but not exceptionally strong explanatory power. The Adjusted R-Square (0.398), which accounts for the number of predictors in the model, is slightly lower, reflecting some reduction in explanatory power when adjusted for the degrees of freedom.

Table 6. Model summary of Random Effects (RE) model.

R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin–Watson
0.638	0.407	0.398	10.259	0.331

A key diagnostic measure in the table is the Durbin–Watson statistic (0.331), which assesses autocorrelation in the residuals. A Durbin–Watson value significantly below 2.0, particularly close to 0, indicates strong positive autocorrelation, meaning that errors in one period are highly correlated with errors in the next. This violates the assumption of independent residuals, leading to inefficient estimates and potential overstatement of statistical significance. The presence of serial correlation in panel data suggests that the model's standard errors are likely biased, reducing the reliability of the conclusions drawn from the regression.

Given this issue, the Random Effects model is not fully adequate, and a more refined approach is required to correct for autocorrelation. The Generalized Estimating Equations (GEE) model is appropriate for handling such dependencies by explicitly accounting for within-panel correlation and ensuring more efficient standard errors. By using an autoregressive (AR1) correlation structure, the GEE model corrects for the time-dependent nature of the residuals, producing unbiased and reliable estimates. Therefore, based on the evidence of serial correlation, we proceed with the GEE model as the next step in the analysis to improve the robustness and accuracy of the results.

4.4. Generalized Estimating Equations (GEE) Model

This section presents the findings of the Generalized Estimating Equations (GEE) model, which refines the analysis by correcting for autocorrelation and ensuring robust standard errors. After identifying statistically significant predictors in the Random Effects (RE) model, the GEE model is applied to provide a more precise estimation of the relationships between economic, ESG factors and meat consumption in the EU. The results are assessed through Goodness of Fit measures (QIC, QICC) and Wald Chi-Square tests, allowing for a comparative evaluation of model performance. The following tables summarize the estimated coefficients, statistical significance, and overall model fit.

The Goodness of Fit results (QIC, QICC) provide a basis for evaluating the adequacy of the GEE model. Since these criteria follow a “smaller-is-better” rule, lower values indicate a better model fit. If the QIC and QICC values are relatively high, it suggests that the model may contain redundant variables, necessitating further refinement by removing non-significant predictors. Comparing these values between the full model and the reduced model (with only statistically significant variables) will determine whether simplification improves predictive accuracy.

The Goodness of Fit results provide an assessment of how well the Generalized Estimating Equations (GEE) model explains meat consumption. The key indicators used are

- Quasi Likelihood under Independence Model Criterion (QIC) = 65,751.291;
- Corrected Quasi Likelihood under Independence Model Criterion (QICC) = 65,689.971.

Since both QIC and QICC follow a “smaller-is-better” rule, lower values indicate a better-fitting model. However, these values alone do not provide an absolute measure of Goodness of Fit—they are most useful when comparing different model specifications.

In this case, the relatively high QIC/QICC values suggest that the model may contain non-significant predictors that do not contribute meaningfully to explaining meat consumption. To improve the model’s predictive accuracy, the next step involves analyzing the statistical significance of each independent variable in Table 7. Variables that are not statistically significant ($p > 0.05$ in the Wald Chi-Square test) will be removed, and the model will be re-estimated to assess whether a reduced version provides a better fit.

Table 7. Goodness of Fit initial model including all the variables.

Criterion	Value
Quasi Likelihood under Independence Model Criterion (QIC)	65,751.291
Corrected Quasi Likelihood under Independence Model Criterion (QICC)	65,689.971

The comparison of QIC and QICC values between the full and refined models will determine whether excluding non-significant variables enhances the model’s efficiency and predictive power. If the values decrease after refinement, it would confirm that the reduced model performs better by eliminating unnecessary predictors.

The parameter estimates (Table 8) provide insights into the significance of each independent variable in explaining meat consumption in the Generalized Estimating Equations (GEE) model. The Wald Chi-Square test is used to determine whether each predictor has a statistically significant effect, while the p -value (Sig.) indicates whether we can reject the null hypothesis (i.e., whether the variable has no effect).

Statistically Significant Variables ($p < 0.05$): To Be Retained.

The following variables are statistically significant and will be retained in the next step of the analysis:

- GDP ($p = 0.000$, Wald Chi-Square = 20.173): highly significant, confirming its strong effect on meat consumption.
- LIVESTOCK ($p = 0.032$, Wald Chi-Square = 4.618): statistically significant, indicating that livestock availability influences meat consumption.
- UNEMPL ($p = 0.032$, Wald Chi-Square = 4.575): significant negative effect, suggesting that higher unemployment reduces meat consumption.
- GDP PPP CAPITA ($p = 0.002$, Wald Chi-Square = 9.439): strongly significant, confirming its role in explaining consumption patterns.
- METHANE ($p = 0.000$, Wald Chi-Square = 21.372): highly significant, reinforcing the link between meat consumption and environmental impact.

- Non-Significant Variables ($p > 0.05$)—To Be Removed

Table 8. Parameter estimates and Wald Chi-Square test initial model including all the variables.

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test	
			Lower	Upper	Wald Chi-Square	Sig.
(Intercept)	48.722	8.091	32.864	64.581	36.259	0.000
GDP	3.215×10^{-6}	7.1590×10^{-7}	1.812×10^{-6}	4.619×10^{-6}	20.173	0.000
LIVESTOCK	0.146	0.067	0.013	0.279	4.618	0.032
INFL	−0.110	0.112	−0.331	0.111	0.947	0.331
UNEMPL	−0.338	0.158	−0.647	−0.028	4.575	0.032
GDP PPP CAPITA	0.000	6.7506×10^{-5}	7.509×10^{-5}	0.000	9.439	0.002
METHANE	0.435	0.094	0.251	0.620	21.372	0.000
EXGOV	0.048	0.049	−0.049	0.144	0.939	0.333
POP	0.038	0.351	−0.651	0.726	0.012	0.915

The following variables are not statistically significant and can be excluded from the refined model:

- INFL ($p = 0.331$, Wald Chi-Square = 0.947): no significant effect on meat consumption.
- EXGOV ($p = 0.333$, Wald Chi-Square = 0.939): insignificant, suggesting that government expenditure does not have a strong impact.
- POP ($p = 0.915$, Wald Chi-Square = 0.012): no statistical significance, implying that population growth alone does not explain meat consumption.

Implications for Model Refinement:

Since INFL, EXGOV, and POP are statistically insignificant, they do not contribute meaningfully to explaining meat consumption and will be removed in the next iteration of the model. The refined model will be re-estimated with only the significant variables (GDP, LIVESTOCK, UNEMPL, GDP PPP CAPITA, and METHANE).

After removing the non-significant variables (INFL, EXGOV, and POP), the Generalized Estimating Equations (GEE) model was re-estimated, and the updated Goodness of Fit results are presented in Table 9.

Table 9. Goodness of Fit refined model including only the statistically significant variables.

Criterion	Value
Quasi Likelihood under Independence Model Criterion (QIC)	77,208.937
Corrected Quasi Likelihood under Independence Model Criterion (QICC)	77,136.287

In Table 10, a comparison of the two models (Initial vs. Refined) is conducted. Since QIC and QICC values increased in the refined model, this suggests that removing the non-significant variables did not improve model fit and, in fact, may have led to a loss of explanatory power. Ideally, a refined model should produce lower QIC and QICC values, indicating a better balance between model complexity and predictive accuracy. The increase in QIC and QICC indicates that the removed variables, despite being statistically non-significant, may still have contributed to overall model performance. The initial model provided a better fit based on the Goodness of Fit criteria.

Table 10. Comparing the two models (Initial vs. Refined).

Model	QIC	QICC
Initial model (Table 5)	65,751.291	65,689.971
Refined model (Table 7)	77,208.937	77,136.287

4.5. Examining Meat Consumption by Country Income Group

This section presents the results of the Generalized Estimating Equations (GEE) model, examining how income classification influences meat consumption across European countries. By incorporating into the previous GEE model (see initial model) the income group as a categorical variable, the analysis assesses whether lower-income countries exhibit significantly different consumption patterns compared to high-income economies.

The categorical variable information in Table 11 provides insight into the distribution of countries across the three income groups used in the GEE model. The dataset is dominated by high-income (H) countries, which account for 80.7% of the observations (N = 468), while upper-middle-income (UM) countries represent 17.1% (N = 99), and lower-middle-income (LM) countries make up only 2.2% (N = 13). This unbalanced distribution has important implications for the interpretation of results. Since high-income (H) is the reference category, the estimated coefficients for LM and UM in the regression model reflect the difference in meat consumption relative to high-income countries. However, the low number of observations in the LM category may lead to high standard errors, making it difficult to detect statistically significant differences between LM and high-income countries. This means that if income group effects do not reach significance, it could be due to sample size limitations rather than the absence of a true economic effect.

Table 11. Categorical variable information.

INCOME GROUP		N	Percent
Lower-Middle-Income	1	13	2.2%
Upper-Middle-Income	2	99	17.1%
High-Income	3	468	80.7%
Total		580	100.0%

The next step is to analyze the Goodness of Fit and parameter estimates to determine whether income classification significantly improves model performance and provides meaningful insights into meat consumption patterns.

The Goodness of Fit criteria (Table 12) provide a quantitative measure of how well the GEE model fits the data. The Quasi Likelihood under Independence Model Criterion (QIC) is 63,264.195, and the Corrected Quasi Likelihood under Independence Model Criterion (QICC) is 63,199.304. Since lower QIC and QICC values indicate a better model fit, we compare these results to the initial and refined models (without income group) to determine whether the inclusion of income classification improves the predictive accuracy.

Table 12. Goodness of Fit.

Criterion	Value
Quasi Likelihood under Independence Model Criterion (QIC)	63,264.195
Corrected Quasi Likelihood under Independence Model Criterion (QICC)	63,199.304

The comparison of Goodness of Fit criteria (QIC, QICC) (Table 13) across the three models—Initial, Refined, and Final—demonstrates the evolution of model performance

as we adjusted the specification to better explain meat consumption in the EU. The initial model, which included all economic and environmental predictors, exhibited moderate predictive performance (QIC = 65,751.291). When a refined model was tested by removing statistically non-significant variables, the model fit worsened (QIC increased to 77,208.937), indicating that eliminating certain predictors reduced the explanatory power of the analysis. However, the final model, which reintroduced key variables—including income classification—and incorporated an AR(1) correlation structure, demonstrated the best model fit with the lowest QIC (63,264.195). This confirms that accounting for income classification, alongside economic and environmental determinants, improves the ability to predict meat consumption trends.

Table 13. Comparing the three models (Initial, Refined, Final).

Model	QIC	QICC
Initial model (Table 6)	65,751.291	65,689.971
Refined model (Table 8)	77,208.937	77,136.287
Final model (Table 11)	63,264.195	63,199.304

The results suggest that income group classification enhances model accuracy, even if individual income coefficients are not always statistically significant. Furthermore, the deterioration of model fit in the refined model highlights the importance of retaining even some non-significant predictors to capture the complexity of meat consumption patterns. The adoption of an AR(1) correlation structure in the final model successfully accounts for autocorrelation effects, making the estimates more robust and reliable.

The final model provides the most accurate and meaningful insights and should be used as the basis for policy recommendations. The inclusion of income classification in particular supports the notion that economic prosperity influences dietary habits, although further refinements—such as testing interaction effects between GDP and income level—could provide deeper insights into the relationship between economic development and meat consumption.

The tests of model effects (Table 14) assesses the overall significance of each independent variable in explaining meat consumption (MEAT). The results indicate that INCOME GROUP is statistically significant ($p = 0.032$), suggesting that income classification plays a role in explaining variations in meat consumption across countries. Additionally, GDP ($p = 0.000$) and GDP PPP per capita ($p = 0.004$) are highly significant, reinforcing the strong economic influence on dietary choices. Other significant factors include livestock availability ($p = 0.029$), unemployment ($p = 0.040$), and methane emissions ($p = 0.000$), suggesting that both economic prosperity and environmental considerations are crucial determinants of meat consumption patterns. In contrast, inflation ($p = 0.380$), government expenditure ($p = 0.322$), and population size ($p = 0.911$) are not statistically significant, indicating that price changes, fiscal policy, and population growth do not have a direct influence on national meat consumption levels.

In the tests of model effects in Table 14, most predictors have one degree of freedom ($df = 1$) because they are continuous variables in the regression model. For continuous variables (GDP, livestock, inflation, unemployment, GDP per capita, methane, government expenditure, population):

- Each of these variables is measured on a continuous scale, meaning they are treated as having one parameter to estimate in the model.
- The Wald Chi-Square test evaluates whether the estimated coefficient for each variable is significantly different from zero.
- Since only one parameter is being tested per variable, the degree of freedom (df) = 1.

Table 14. Tests of model effects.

Source	Wald Chi-Square	df	Sig.
(Intercept)	33.238	1	0.000
INCOME GROUP	6.882	2	0.032
GDP	19.934	1	0.000
LIVESTOCK	4.762	1	0.029
INFL	0.772	1	0.380
UNEMPL	4.198	1	0.040
GDP PPP CAPITA	8.440	1	0.004
METHANE	21.254	1	0.000
EXGOV	0.981	1	0.322
POP	0.013	1	0.911

For categorical variables (INCOME GROUP, $df = 2$):

- INCOME GROUP is a categorical variable with three levels (lower-middle-income, upper-middle-income, high-income).
- In the regression, the model includes two dummy variables (one for each of the first two income groups), while the third category (high-income) is the reference group.
- Since there are two dummy variables, the overall test for INCOME GROUP uses $df = 2$, testing whether the two income group coefficients differ significantly from zero.

Overall, the significance of GDP, GDP PPP per capita, and income group confirms that economic prosperity influences meat consumption, while environmental and agricultural factors contribute to explaining variations in dietary habits across countries. The next step is to analyze the parameter estimates to understand the magnitude and direction of these relationships in more detail.

The parameter estimates (Table 15) provide a breakdown of the effect of each variable, including the specific impact of income groups. While INCOME GROUP was significant in the overall effects test, the individual category coefficients (lower-middle-income and upper-middle-income) are not statistically significant at the 5% level ($p = 0.084$ and $p = 0.134$, respectively). This suggests that, although income classification as a whole contributes to model performance, the differences between individual income groups are not strong enough to be significant when analyzed separately. Meanwhile, GDP ($p = 0.000$), GDP per capita ($p = 0.004$), unemployment ($p = 0.040$), methane emissions ($p = 0.000$), and livestock availability ($p = 0.029$) remain significant, reinforcing their critical role in shaping meat consumption trends. The reduction in the significance of INCOME GROUP in the parameter estimates table compared to the overall effects test may indicate that economic and ESG factors explain a larger portion of the variance in meat consumption than income classification alone. This suggests that income group differences exist but may not be strong enough to independently predict meat consumption once other economic indicators are accounted for.

The above results provide partial support for the proposed (H9, H10, H11) hypotheses. H9 is not fully supported, as the individual coefficients for lower-middle- and upper-middle-income groups are not statistically significant at the 5% level ($p = 0.084$ and $p = 0.134$, respectively). This suggests that while income classification as a whole improves model performance, the direct effect of being in a lower-income group does not significantly reduce meat consumption compared to high-income countries. H10 is also not strongly supported, as there is no clear evidence from the interaction term ($GDP \times Income\ Group$) that GDP PPP per capita has a significantly stronger impact on meat consumption in wealthier countries. This indicates that economic prosperity alone may not drive higher meat demand or that the relationship is more complex than a simple income-based differentiation. H11 can only

be confirmed if the Goodness of Fit criteria (QIC, QICC) improve when including income level as a moderator. If the fit improves, it validates the role of income classification in refining the GDP–meat consumption relationship. According to the comparison of three models (Table 13), the final Goodness of Fit (lower QIC, QICC) validates the role of income classification in refining the GDP–meat consumption relationship. However, without a significant interaction effect, the moderating role of income level remains inconclusive.

Table 15. Parameter estimates.

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	49.296	8.089	33.441	65.150	37.137	1	0.000
LOWER-MIDDLE	−4.198	2.425	−8.951	0.556	2.995	1	0.084
UPPER-MIDDLE	−1.014	0.677	−2.342	0.314	2.241	1	0.134
HIGH-INCOME	0 *	−	−	−	−	−	−
GDP	3.121×10^{-6}	6.990×10^{-7}	1.751×10^{-6}	4.491×10^{-6}	19.934	1	0.000
LIVESTOCK	0.149	0.068	0.015	0.282	4.762	1	0.029
INFL	−0.092	0.104	−0.298	0.113	0.772	1	0.380
UNEMPL	−0.326	0.159	−0.639	−0.014	4.198	1	0.040
GDP PPP CAPITA	0.000	6.632×10^{-5}	6.269×10^{-5}	0.000	8.440	1	0.004
METHANE	0.430	0.093	0.247	0.612	21.254	1	0.000
EXGOV	0.049	0.049	−0.048	0.146	0.981	1	0.322
POP	0.041	0.362	−0.670	0.751	0.013	1	0.911

* Note: set to zero because this parameter is redundant.

5. Discussion

This study evaluates the determinants of meat consumption in EU countries by testing eleven (H1–H11) hypotheses using Random Effects (RE) and Generalized Estimating Equations (GEE) models. The findings confirm that economic factors play a crucial role in shaping meat consumption patterns in the EU. According to GEE model results, GDP per capita (H1) and GDP PPP per capita (H2) both exhibit strong positive relationships with meat consumption, indicating that economic growth and higher purchasing power increase meat consumption. Unemployment (H3) is negatively correlated, reinforcing the idea that financial constraints reduce meat consumption. However, inflation (H7) does not significantly impact consumption, suggesting that consumers may adjust their purchasing behaviors without necessarily reducing meat intake in response to price fluctuations. These results emphasize the importance of economic stability in influencing dietary choices, with GDP-related factors being the most significant drivers.

Environmental and supply-side factors also shape consumption trends. Methane emissions (H4) and livestock availability (H5) are positively associated with meat consumption, confirming that higher production levels drive both supply and demand. In contrast, government expenditure (H6) and population growth (H8) do not significantly influence meat consumption, suggesting that fiscal policies and demographic expansion alone do not dictate dietary habits. These findings highlight the dominant role of economic and environmental dynamics over policy-driven or population-based factors, indicating that market conditions and sustainability considerations should be central to policy interventions aimed at regulating meat consumption in the EU.

This study further examines the role of income classification. H9 suggests that high-income countries consume significantly more meat than lower-income countries, based on the assumption that economic prosperity expands dietary choices. While income classification is significant overall, individual income group coefficients (lower-middle- and

upper-middle-income) are not significant, implying that factors beyond income contribute to consumption patterns. H10 proposes that GDP PPP per capita has a stronger impact on meat consumption in wealthier countries, assuming economic growth intensifies dietary preferences. However, this is rejected due to the lack of a significant interaction effect between GDP PPP per capita and income group, indicating that GDP-driven meat consumption does not necessarily vary by income level. Lastly, H11 suggests that if model fit improves with income level included, it confirms that income moderates the GDP–meat consumption relationship. This is partially supported, as QIC/QICC values improve in GEE models, yet the absence of a statistically significant interaction effect prevents definitive conclusions about income’s moderating role.

The findings of this study align with and expand upon previous research examining the determinants of meat consumption in the European Union. The positive association between GDP per capita and meat consumption observed in our analysis supports the broader economic literature on dietary transitions, which suggests that economic growth enhances purchasing power and dietary choices. This is consistent with the findings of [Sans and Combris \(2015\)](#), who highlight that rising income levels correlate with increased per capita meat consumption, particularly in emerging economies undergoing a “food revolution”. Their study underscores how economic development influences consumer behavior, shifting diets toward higher animal protein intake as countries move through different stages of economic growth. The observed relationship between GDP and meat consumption in our study reinforces the notion that economic prosperity is a key driver of dietary preferences, although with potential saturation points in higher-income nations.

Similarly, the strong positive association between methane emissions and meat consumption in our study confirms the environmental impact of livestock production. [Gerber et al. \(2013\)](#) provide a comprehensive assessment of the global livestock sector’s contribution to greenhouse gas emissions, demonstrating that methane emissions are directly linked to meat production intensity. The positive correlation identified in our analysis reinforces their findings, suggesting that increased meat consumption contributes to higher methane emissions, reflecting the broader environmental trade-offs associated with dietary patterns. These results emphasize the critical role of sustainable agricultural practices and policy interventions in mitigating the environmental consequences of livestock production, particularly in the context of the European Union’s Green Deal and climate action goals.

The findings of this study further emphasize the role of economic conditions in shaping meat consumption patterns, particularly when analyzing the effects of income classification. While GDP per capita was found to be a significant determinant of meat consumption, the income classification analysis revealed that high-income countries do not necessarily consume more meat than lower-income nations. This contradicts the assumption that economic prosperity alone drives higher meat consumption, suggesting that other structural and behavioral factors influence dietary choices. This result aligns with the conclusions of [Mazzocchi et al. \(2008\)](#), who found that while diets in advanced economies are converging towards healthier patterns, developing countries remain further from achieving World Health Organization nutrition goals. Their research underscores the idea that economic drivers are more relevant than socio-cultural factors in determining the quality of diets.

However, this study indicates that beyond a certain income threshold, meat consumption does not necessarily increase, implying a saturation effect in wealthier nations where health consciousness, environmental awareness, and alternative dietary preferences may play a more prominent role. The lack of a significant difference between income groups in our analysis suggests that while economic development influences dietary patterns, it does not operate in isolation. Instead, it interacts with broader policy, cultural, and sustain-

ability considerations. These insights reinforce the need for policies that balance economic growth with public health and environmental sustainability, particularly in guiding food consumption patterns in both high- and low-income settings.

The integration of ESG criteria and the circular economy (CE) framework serves as a key driver of sustainability in the agri-food sector, as both approaches aim to reduce environmental impact and promote responsible business practices. However, as highlighted by [Khatami et al. \(2024\)](#), the implementation of circular economy practices remains low in many European countries due to insufficient policies and limited investment in renewable energy. At the same time, the present study emphasizes the role of consumers, government incentives, and corporate responsibility in fostering sustainable consumption patterns. Therefore, achieving meaningful progress in the sector requires a multi-level approach that combines ESG policies with circular business models to drive long-term sustainability.

The increasing emphasis on ESG reporting and environmental impact disclosure is transforming the agri-food sector, aligning with both consumer expectations and regulatory pressures. While ESG principles advocate for sustainable business practices, the rise of environmental impact reporting, as highlighted by [Deconinck et al. \(2023\)](#), underscores the complexity of implementing standardized methodologies across global food supply chains. The shift toward quantified environmental metrics, such as carbon footprint assessments and life-cycle analyses, can enhance transparency and drive more sustainable consumption patterns. However, both studies recognize the risks of fragmented methodologies and the potential for disproportionately higher costs for producers in low- and middle-income countries. Addressing these challenges requires a coordinated policy approach that integrates ESG frameworks with robust, science-based environmental reporting standards to ensure consistency, reduce compliance burdens, and promote fair trade practices.

This study identifies a strong positive correlation between methane emissions and meat consumption, indicating that increased demand for meat is directly linked to higher methane emissions due to intensified livestock production. This finding is consistent with previous research examining the environmental consequences of meat consumption. [Steinfeld et al. \(2006\)](#) highlight that the livestock sector is a major contributor to global methane emissions, primarily through enteric fermentation in ruminant animals. Their study underscores that as meat consumption rises, particularly in regions experiencing economic growth, methane emissions also increase due to expanded livestock farming. This aligns with the study's results, reinforcing the notion that dietary choices have significant environmental implications. The growing awareness of methane's role in climate change has led to calls for policy interventions aimed at reducing meat consumption and promoting sustainable alternatives. The findings support these discussions, emphasizing the need for integrated strategies that address both economic and environmental concerns in shaping future food consumption patterns.

The relationship between meat consumption and population growth is complex and influenced by multiple economic and social factors. While it might be expected that larger populations consume more meat in absolute terms, per capita meat consumption is shaped by variables beyond demographic expansion alone. Previous research suggests that economic growth, urbanization, and dietary transitions play a more substantial role in determining meat consumption patterns than population size itself. [Delgado et al. \(2001\)](#) argue that rising incomes and urbanization are the primary drivers of increased demand for animal products, while mere population growth does not necessarily lead to proportional increases in meat consumption. This aligns with our findings, indicating that the structural factors underlying food consumption patterns are more critical than demographic expansion alone. The results emphasize the need to consider broader economic and cultural

determinants when analyzing dietary shifts, particularly in the context of sustainable food systems and global nutrition policies.

This study revealed some unexpected findings, particularly the lack of a statistically significant impact of inflation and government expenditure on meat consumption in the EU. While economic theory suggests that rising prices should reduce demand due to decreased purchasing power, the results indicate that meat consumption remains relatively inelastic to inflation fluctuations. Possible explanations include the stability of demand for staple dietary choices or consumers' ability to adjust their purchases by opting for cheaper meat alternatives. Similarly, the absence of a significant relationship between government expenditure and meat consumption may suggest that public policies do not directly influence dietary choices or that subsidies are evenly distributed between the meat industry and alternative protein sources, thereby neutralizing any impact.

While the inclusion of income classification improved model fit, the individual coefficients for lower-middle-income and upper-middle-income countries were not statistically significant, suggesting that broad income categories alone do not strongly determine meat consumption. Instead, macroeconomic factors such as GDP per capita ($p = 0.000$), GDP PPP per capita ($p = 0.004$), and unemployment ($p = 0.040$) emerged as stronger predictors. This indicates that relative economic conditions within countries influence dietary choices more than categorical income levels. Additionally, the lack of significance could be due to shifting dietary trends in high-income nations, where environmental concerns and health awareness are reducing meat consumption despite economic prosperity. The results suggest that policymakers should focus on targeted fiscal measures, food pricing strategies, and sustainability policies, rather than assuming that economic growth alone will dictate consumption trends.

Furthermore, the small sample size for lower-middle-income countries ($N = 13$) and upper-middle-income countries ($N = 99$) (Table 10) may have limited the statistical power of the analysis, affecting the ability to draw definitive conclusions about the relationship between income levels and meat consumption. The European Union primarily consists of high-income countries, with most member states classified in the upper-income bracket based on global economic standards. While some nations historically fell into upper-middle-income classifications, economic convergence within the EU has led to a gradual alignment towards high-income status. Structural funding, economic integration, and policies such as the EU Single Market and Eurozone stability mechanisms have facilitated economic growth and reduced income disparities among member states. As a result, even countries that previously had lower income levels, such as some Eastern European nations, have experienced significant economic development, pushing them closer to the high-income category. Therefore, the EU's economic structure is predominantly characterized by high-income economies or countries converging towards that level.

Future research could apply our comparative methodology on income groups at a global scale to assess whether the observed relationships between economic factors and meat consumption hold beyond the European context. Given that the EU primarily consists of high-income countries or nations converging toward this status, our findings may not fully capture the variations present in lower-income regions. Expanding the analysis to include a more diverse set of economies—particularly those in low- and lower-middle-income categories—would provide deeper insights into how income disparities shape dietary patterns worldwide and whether economic development consistently drives increased meat consumption across different socioeconomic contexts.

Overall, the findings confirm that economic growth and livestock availability are primary drivers of meat consumption, while unemployment and methane emissions also play significant roles. However, inflation, government spending, and population growth appear

to have limited direct impact. While income classification enhances model performance, its role in shaping meat demand is more nuanced than initially expected.

Finally, the study of [Thom et al. \(2024\)](#) examines the structural vulnerabilities of EU agriculture under an import stop scenario, revealing how trade disruptions, particularly the restriction of soy imports, could lead to increased production costs, environmental burdens, and changes in meat production and consumption. Both studies highlight factors influencing meat consumption in the EU but from different perspectives. While the present behavioral study emphasizes consumer-driven changes in response to economic conditions, the trade policy study illustrates supply-driven constraints that affect market dynamics and consumption patterns. Both studies demonstrate that shifts in meat consumption in the EU are influenced by economic conditions and trade dependencies. While consumer behavior responds to affordability constraints during economic downturns, supply-side disruptions, such as an import stop on soy, reshape availability and pricing. Despite these different pathways, the outcome remains similar—a reduction in meat consumption driven by external pressures. This highlights the need for a dual approach in policy design, addressing both economic incentives for sustainable diets and trade resilience to ensure a stable and adaptable food system.

6. Conclusions

This study aimed to examine the extent to which macroeconomic and ESG (Environmental, Social, and Governance) factors influence meat consumption patterns in the EU, providing a comprehensive analysis through Random Effects (RE) and Generalized Estimating Equations (GEE) models. By integrating behavioral economics with econometric modeling, the research sought to uncover the economic, environmental, and policy-driven mechanisms that shape dietary choices across EU nations.

The findings highlight that economic prosperity is a key driver of meat consumption, with GDP per capita and GDP PPP per capita positively influencing dietary choices. Conversely, higher unemployment leads to reduced meat intake, suggesting financial constraints limit access to meat products. Unexpectedly, inflation does not significantly impact consumption trends, indicating that price fluctuations alone do not alter consumer behavior. On the environmental side, methane emissions correlate positively with meat consumption, reinforcing the link between livestock production and environmental impact, while livestock availability significantly affects demand. However, government expenditure and population growth appear to have no direct influence on meat consumption patterns.

This study's findings have important policy implications for balancing economic growth with sustainability goals. Given the strong link between meat consumption and methane emissions, policymakers should consider targeted interventions such as incentives for sustainable livestock farming, carbon taxes on emissions, and promoting plant-based alternatives. Additionally, as unemployment significantly reduces meat consumption, social policies supporting income stability and job creation could mitigate economic disparities in dietary access. Since inflation does not directly affect meat consumption, food policy should focus more on structural economic conditions rather than short-term price controls. These results emphasize the need for integrated policies that align economic development with sustainable food systems, ensuring both environmental protection and food security in the EU.

Moreover, given that GDP per capita and GDP PPP per capita are strong positive determinants of meat consumption, while country's income ranking does not significantly impact dietary choices, policymakers should consider targeted economic and food policies rather than relying solely on broad income classifications. Since higher GDP levels increase meat demand, sustainability strategies should be integrated into economic growth models,

such as implementing incentives for sustainable livestock farming, investing in alternative protein sources, and promoting consumer education on environmentally friendly diets. Additionally, progressive taxation on high-emission food products or subsidies for plant-based alternatives could help balance economic prosperity with environmental responsibility. Given that income ranking does not independently drive consumption, policies should focus on ensuring the affordability and accessibility of diverse protein sources across all income groups, rather than assuming that high-income countries will automatically consume more meat. Encouraging economic growth strategies that incorporate sustainability, job security, and equitable food policies can help mitigate the environmental impact of rising meat demand while maintaining economic stability.

This study contributes to the growing body of literature on the relationship between macroeconomic factors, ESG indicators, and consumer behavior, specifically focusing on meat consumption within the European Union. By integrating multiple econometric models, including Fixed Effects, Random Effects, and Generalized Estimating Equations (GEE), this research provides a comprehensive analysis of the economic and environmental drivers of dietary choices across 27 EU member states.

A key contribution of this study is the examination of how economic variables, such as GDP, GDP per capita, and unemployment, interact with environmental factors like methane emissions to influence meat consumption patterns. This approach goes beyond traditional economic analyses by incorporating sustainability metrics, offering a more holistic understanding of consumer behavior in the context of climate change and economic development.

Moreover, this research addresses a critical gap in the literature by explicitly considering the impact of income group classifications, based on World Bank standards, on dietary choices. This perspective allows for a more nuanced understanding of how economic development influences consumer behavior, highlighting the importance of tailored policy interventions.

Finally, this study contributes to the ongoing debate on the role of economic stability and environmental sustainability in shaping consumer preferences, providing valuable insights for policymakers seeking to balance economic growth with climate goals in the EU.

While this study provides valuable insights, future research should explore the role of psychological and cultural factors in shaping meat consumption patterns, as well as evaluate the long-term effectiveness of EU sustainability policies. Investigating variations across different types of meat, regional differences, and urban versus rural dietary behaviors would further enhance understanding.

There are some limitations to consider. The reliance on national-level data may overlook regional disparities, and while our models establish strong associations, they do not prove causality. Additionally, behavioral influences such as ethical concerns and dietary trends were not explicitly measured, though they likely play a role in consumer decision-making.

One limitation of this study is the potential influence of outliers on the empirical results. Although efforts were made to identify and address these outliers in the data preparation phase, their presence can still introduce bias and affect the robustness of the model estimates. Future research could benefit from the application of more advanced outlier detection and treatment methods, such as robust regression techniques or machine learning-based anomaly detection, to further minimize the impact of extreme values and enhance the accuracy of the findings.

Furthermore, a critical limitation is the use of aggregate inflation as a macroeconomic indicator. Although this approach captures general price trends, it does not differentiate between overall inflation and food-specific inflation, which may have a more direct impact

on meat consumption. Future research could benefit from incorporating more targeted measures, such as the Food Price Index (FPI), to isolate the specific influence of food price dynamics.

Additionally, the analysis does not account for potential lagged effects in the relationship between economic factors and meat consumption, despite the fact that consumer behavior often responds to economic changes over time. To address this, future studies could employ dynamic panel models such as the Arellano–Bond estimator, which is specifically designed to handle time-dependent effects and autocorrelation in panel data.

Moreover, while the current income classification approach based on the World Bank categories provides a standardized framework, it may oversimplify the diverse economic contexts within the EU. More sophisticated clustering methods or a more granular income classification could offer deeper insights into the impact of economic development on dietary behavior.

Finally, this study’s empirical strategy relies on cross-sectional and time-series data that may not fully capture the complex, multi-dimensional nature of consumer behavior. Future work should consider integrating behavioral and psychological factors to provide a more comprehensive understanding of the drivers of meat consumption.

Despite these limitations, this study offers a robust empirical foundation for understanding the interplay between economic growth, environmental sustainability, and consumer behavior. Policymakers should leverage these insights to develop targeted strategies that promote sustainable dietary shifts while considering both economic feasibility and social acceptance.

In conclusion, this study sheds light on the complex relationship between economic, environmental, and policy factors in shaping meat consumption trends across the EU. As dietary choices continue to evolve in response to economic growth and sustainability concerns, policymakers must strike a balance between promoting environmental responsibility and ensuring economic stability. While structural factors such as income and market supply play dominant roles, shifting consumer behavior through awareness and policy incentives remains crucial. Future efforts should build upon these findings to create a more sustainable and resilient food system that aligns economic development with environmental and public health goals.

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