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Drivers of Protein Consumption: A Cross-Country Analysis

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Abstract: Consumption and production of proteins derived from animals have more significant environmental and health impacts than proteins derived from plants. This raises concerns mainly in consideration of the predictable increased consumption of animal proteins at the expense of vegetal ones due to growing income, especially in developing countries. Animal protein consumption, and particularly meat consumption, seems to start to decrease at a high level of income, which may suggest that economic growth solves or attenuates the environmental and health problems of animal food consumption. To test this possibility, the relationship between per capita income and animal and vegetal protein consumption is explored. Using a cross-country regression for 142 countries in 2017, animal-based protein, meat protein, and vegetal-based protein consumption are specified as dependent variables. In addition to per capita income, other potential drivers of protein choices, including ecological, demographic and social factors are controlled for. Apart from income, which still seems to be the most important driver of any type of protein consumption, the results suggest that protein consumption from animal sources and meat sources have different determinants. Though there is actually some evidence of an inverted U-shaped relationship between per capita income and animal protein consumption, the peak is at such high levels as to make economic growth irrelevant to curb animal protein consumption.

Keywords: protein transition; animal protein; vegetal protein; meat consumption; income; consumption drivers; regression analysis; Environmental Kuznets Curve

1. Introduction

Throughout the world, as affluence grows, significant shifts in dietary patterns appear to suggest a move toward a diet dominated by higher intake of animal proteins [1,2]. Food consumption patterns, particularly of animal-derived foods, have severe consequences for environmental sustainability. It is well documented that their production contributes to several environmental problems [3–5], and their increasing consumption is linked to obesity and other pathologies [6,7]. At the same time, scientists agree on vegetal foods' environmental and health advantages [8–11]. In developed regions, it would be beneficial for the long-term sustainability of the environment and the health systems to shift from diets based on animal proteins towards diets based on plant proteins [8,12]. On the contrary, most people in developing regions would benefit from increasing protein consumption to achieve food security [1,13].

Increasing the knowledge of drivers of protein choices is necessary to find different measures that decrease the demand for animal proteins and encourage their substitution with plant-based protein. It has been hypothesized that animal food consumption increases along with income up to a peak, then it begins to decline, following an inverted U-shape curve usually known as an Environmental Kuznets Curve (EKC) because of its similarity to the results obtained by Kuznets [14] in his analysis of the inequality at different stages of development. The first studies on EKC, conducted by Grossman and Krueger [15,16],

Panayotou [17,18], Grossman [19], Kaufmann et al. [20], Torras and Boyce [21] and Islam and Vincent [22], were focused on pollutants. In that case the inverted-U relationship is due to the shift of prevalence in the economy from agriculture to industry to services; in high-income countries, technical progress reduced per unit output pollution, and increasing preference was given to environmental issues. For animal-based foods, the reason for the increasing trend is the lower budget constraints of higher incomes, and the related shift to more costly food (animal-based), while the inversion is related to increasing awareness of the health and environmental problems connected with high consumption levels of animal proteins. Some studies [23,24] have investigated the relationship between meat consumption and income, suggesting that per capita meat consumption follows an EKC, though other studies do not find the same result (e.g., [25]). To our knowledge, this has never been applied to animal protein consumption in a cross-country regression analysis. As well, models that assess different drivers than income [24–27] have considered only meat consumption, leaving aside other sources of protein (eggs, cheese, milk and seafood), even though the literature [28–30] indicates that they too could have significant health and environmental impacts.

For this reason, the intent of this paper is to verify if the Environmental Kuznets Curve hypothesis applies to animal, meat and vegetal proteins. The issue is whether protein consumption follows an Environmental Kuznets Curve, and whether there are differences between different protein types. To this purpose, in this paper, multi-national regression models on the consumption of animal proteins, meat proteins and vegetal proteins are estimated, using a combination of explanatory variables that, together with income, try to explain the consumption of the different proteins. The goal is to assess if there is evidence of an inverted U-shaped curve relative to income for animal protein and meat protein consumption, and a U-shape for vegetal proteins. Using proteins as indicators is recommended, because they are nutritionally crucial, and they have a pivotal role in the food system and food security, as a lack of protein is one of the primary causes of malnutrition [31]. Furthermore, reducing overconsumption of proteins and replacing animal proteins with plant proteins are ranked as the first and fourth most urgent changes to improve the sustainability of the Western food supply system [8]. This study explores economic (income), environmental (temperature), demographic (age of the population) and social factors (urbanization and religion). Investigation of several drivers may help policymakers promote a transition towards a plant-protein-rich diet. Only a combination of models can capture the complexities of a protein transition and may help to understand present and future trends Here, three models of consumption, which differ according to protein type (animal-based, meat and vegetal-based), are presented to highlight the possible differences among them.

In terms of sustainability, the food system is a crucial driver of environmental change, and understanding the factors that affect eating habits is essential for promoting more sustainable food consumption patterns. This study is the first step in identifying possible interventions towards more sustainable and healthier food choices. This is especially urgent because the destructive environmental consequences of the food system are expected to intensify as the population grows.

The paper is organized as follows: after summarizing the impacts of protein consumption (Section 2), we give an overview of the drivers of consumption that have been identified in the literature (Section 3). Then we detail the data and methodology used (Sections 4 and 5), and finally we present and discuss the results (Sections 6 and 7).

2. Protein Consumption Impacts

Proteins in foods and beverages can originate from animals (meat, poultry, seafood, eggs and dairy products) or from plants (legumes, vegetables, grains, nuts and seeds). There are substantial differences between animal and plant proteins. Recently, the discussion on animal and plant proteins has become crucial because of their different impact on the food system's long-term sustainability. Consumption projections [32] have shown a continued

shift in dietary patterns away from staples and towards animal products. Worldwide, the consumption of meat, dairy and eggs is increasing [33].

Figure 1a portrays the evolution of animal protein consumption, measured in g/cap/day, from 1961 to 2017. The panel shows the differences in geographic locations. Asia and Latin America are characterized by a rapid increase in the consumption of animal proteins, while in North America consumption seems to stabilize. In Europe, protein consumption rose dramatically until the 1990s, and then the rate of increase seemed to slow down. Figure 1b, with data from 2017, shows that most countries consume more protein than required. The average protein intake in many Western countries is 150–200% of recommended values [3]. In Europe, the total per capita protein consumption (including vegetable sources) is about 70% higher than recommended [34].
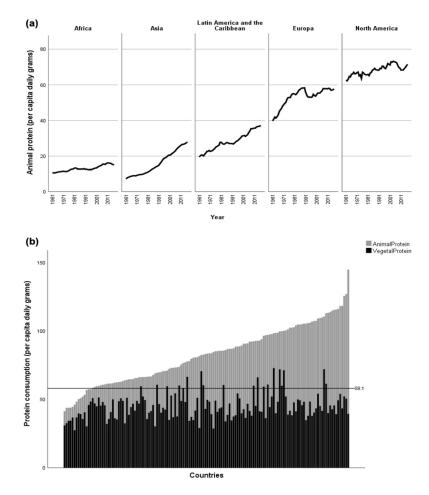

Figure 1. (**a**) Daily protein consumption (g/capita), 1961–2017; (**b**) total protein consumption by country. The line at 58.1 g corresponds to the recommended protein intake for a male adult of 70 kg [35]. Source: elaborations on [36].

The dietary changes associated with the consumption of animal products have important implications. Excess consumption of animal proteins, particularly if derived from meat, is linked to a rise in several pathologies and, as a result, in health system costs. Epidemiological studies suggest that the increasing amounts of red meat and processed meat consumption are associated with a higher risk of total mortality, cardiovascular disease, colorectal cancer and type 2 diabetes [6] and correlated with worldwide obesity [7]. There is controversial evidence about the role other animal proteins play in health. For example, according to Lu et al. [37], several studies suggest that dairy products' nutrients are beneficial for chronic diseases such as cancer, but other studies draw opposite conclusions. From their meta-analysis, the authors conclude that total dairy product intake has no significant

impact on increased cancer mortality risk. Still, whole milk intake in men significantly contributes to elevated prostate cancer mortality risk. Wang et al. [38], in their study on a sample in China (where there is much lower milk consumption than in the West), show evidence of how moderate milk consumption is correlated to a lower risk of cardiovascular disease mortality, but high milk consumption has a higher risk of total cancer mortality. The study by Fraser et al. [39] on 52,795 North American women, followed for 7.5 years, determines that higher intake of dairy milk is associated with a greater risk of breast cancer, when adjusted for soy intake.

Similarly, whether the consumption of eggs is detrimental to health is highly debated. In the recently published study by Zhuang et al. [40], the intake of eggs is associated with higher rates of cardiovascular disease and cancer mortality, mainly due to eggs' influence on cholesterol intake.

As for seafood, even though several studies suggest that in many developing regions and emerging economies fisheries can address malnutrition with local supplies of critical nutrients, and the regular consumption of fish may reduce the risk of all-cause mortality compared with a standard omnivorous diet [41], Rizzo et al. [29] explain that fish eaters have a higher risk when compared to people on a plant-based diet, mainly because of the lipophilic properties of the pollutants present in the fish flesh.

Recent analyses have valued the health benefits of a transition towards plant-based diets. Springmann et al. [11] calculated it would reduce global mortality by 6–10%. The authors project that adopting a vegan diet would result in 8.1 million avoided deaths and 129 million life-years saved compared with the reference scenario. In addition, Song et al. [42] show that replacing animal protein of various origins with plant protein is associated with a lower mortality. Tilman et al. [10] illustrate the magnitude of the health benefits associated with widely adopted alternative diets (vegetarian, pescatarian and Mediterranean) relative to conventional omnivorous diets. Across the three alternative diets, incidence rates of type 2 diabetes are reduced by 16–41% and cancer by 7–13%; relative mortality rates from coronary heart disease are 20–26% lower, and overall mortality rates for all causes combined are 0–18% lower. The study of Foscolou et al. [43] suggests that the consumption of a plant-based protein-rich diet is a beneficial nutritional choice for older people, since it may both benefit individual health and prolong successful ageing.

In addition to the health impacts from consumption, health impacts also result from emerging zoonotic diseases (including Bovine Spongiform Encephalopathy, avian influenza, Q fever and enterohemorrhagic Escherichia coli), which have been linked to livestock products. Resistant bacteria (e.g., methicillin-resistant Staphylococcus aureus, extended-spectrum b lactamase) are another effect due largely to antibiotics used in intensive livestock production. Globally, antimicrobial use in pig and poultry production is expected to double. Research by the European Medicines Agency shows that, in the EU, antibiotic resistance kills 25,000 people and costs €1.5 billion per year [3,8].

Increasing animal protein production has been identified as one of the most significant contributors to environmental pressures. According to Aiking [3], protein production is linked to the top three ecological impacts, for which we have already overstepped the planetary boundaries, i.e., climate change, biodiversity loss and nitrogen cycle disruption. Meanwhile, it has been suggested that the environmental burden of plant-based foods is lower than for animal products. This is because meat production is inherently resource-inefficient, with cattle being the least efficient converters of feed to meat: on average, 6 kg of plant protein is required to yield 1 kg of meat protein [3].

Perhaps the most significant impact is on global warming, because animal protein production results in carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) emissions. Using the composite measure of CO_2 equivalents (CO_2e), livestock production is responsible for ~15% of all anthropogenic emissions [2], with the dairy industry accounting for 2.9% [44]. Multiple life-cycle analysis studies have assessed the GHG emissions of different types of protein and protein production systems. Swain et al. [5] calculated that pork and poultry emissions intensity is much lower than beef; however, plant-based

proteins outperform all animal sources. There is extensive literature demonstrating how reducing animal protein consumption could lower GHG emissions. Results from a review paper by Chai et al. [9] suggest that the vegan diet is the optimal diet for the environment because, out of all the compared diets, its production results in the lowest level of GHG emissions. Springmann et al. [11] find that dietary changes toward fewer animal-sourced foods can help mitigate an expected growth in food-related GHG emissions. They estimate a GHG emissions reduction of 29–70% compared with a reference scenario by 2050. This is in line with other studies; for example, Tilman et al. [10] determine that three alternative diets low in animal protein could reduce emissions from food production below those of the projected 2050 income-dependent diet, with per capita reductions being 30%, 45% and 55% for the Mediterranean, pescatarian and vegetarian diets, respectively. Hedenus et al. [45] conclude that reduced ruminant meat and dairy consumption will be indispensable for reaching the two degree target with a high probability, unless unprecedented advances in technology take place.

Livestock farming uses 70% of agricultural land overall and one-third of arable land [9]. Land requirements for animal-based protein are 6–17 times higher than for soybeans [9]. This is because plant-based proteins have a lower land intensity than meat since they use the crop directly [5]. Livestock must be fed, and therefore livestock production results in land use competition, or food vs. feed production: one-third of the world's cereal is used as livestock feed each year [13]. This quantity contains energy to feed more than three billion people [46]. The study of Tilman et al. [10] suggests that shifts towards healthier diets could substantially decrease future agricultural land demand and clearing. According to the authors, the income-dependent diet, characterized by high animal protein consumption, requires 370 to 740 million hectares more cropland than the alternative low animal protein diets. Land conversion to agriculture is the most substantial direct way for the animal-based protein production chain to affect biodiversity. This involves converting natural habitats to grassland for grazing and to arable land, to produce grain and soybeans for livestock consumption [2]. Nearly one-third of global biodiversity loss is attributable to livestock production. According to Machovina et al. [4], reducing demand for animal-based food products and increasing proportions of plant-based foods in diets (the latter ideally to a global average of 90% of food consumed) will reduce the ecosystem and biodiversity impacts of animal product consumption, while meeting the nutritional needs of people.

Protein production is also responsible for large-scale fertilizer application, which contributes to the nitrogen cycle disruption. In fact, the current fertilizer output far exceeds the formation of reactive nitrogen by natural processes. Because nitrogen cycle disruption has substantial impacts on biodiversity and on the carbon cycle, protein production is the pivotal link between the top three environmental issues in the Rockström et al. ranking [3].

Agriculture uses more freshwater than any other human activity, and nearly one-third of this is required for livestock [2]. One kilogram of edible beef requires 20 tonnes of water [46]. In addition, water often ends up contaminated and, together with the waste generated by animals, represents a major source of regional and local environmental pollution (through eutrophication, acidification, leaching of nitrate and accumulation of phosphorus and heavy metals). More water is used for meat production than for plant protein production. One study finds that the difference between water input for animal protein vs. plant protein is generally around a factor of 26; even when intensive irrigation is needed for plant-based protein, animal protein production requires 4.4 times as much water [9].

Likewise, the global demand for seafood is constantly growing, and many marine fish populations are overexploited [34]. Global fisheries catches have been declining since the mid-1990s by approximately 1% per year, primarily due to overfishing. In 2017, fish accounted for 17% of animal protein and 7% of all protein consumption globally [41]. Fish production also relies on aquaculture, which can cause antibiotic resistance, biodiversity loss and death of the underlying seabed [29].

3. Income and Other Drivers of Protein Choices

There are many food choice drivers, but budget constraints have received the most attention in the literature. It is well known that income affects dietary changes [47], although the effect of income differs among developed and developing countries. According to Regmi et al. [48], low-income countries spend a greater portion of their budget on food and are more responsive to income change than middle- and high-income countries. Furthermore, low-income countries spend a more significant portion of their budget on staple food products, such as cereals, and when income increases, greater budget adjustments are made to higher-value food items such as dairy and meat. In general, as income increases, the tendency is to move up in the food chain [46]. Popkin coined the term "nutrition transition" in the early 1990s to describe dietary changes that occur in response to economic development [49].

Historically, a close relationship between income and meat consumption has been observed: as a country becomes richer, meat consumption increases. Delgado [50] suggested the existence of a "livestock revolution" in developing countries, where, as income rises above the poverty line, people eat more animal products at a faster rate than in developed countries. More recently, the intent is to see whether meat consumption decreases when a certain level of wealth is reached. Vranken et al. [24] suggest evidence of a second nutrition transition. In fact, an inverted U-shaped relationship between meat consumption and income indicates that average meat consumption reaches a maximum and then declines at a certain level of income. Depending on the specifications, the turning point identified by Vranken et al. [24] varies between Int$35,035 and Int$52,661 per capita. Cole et al. [23], in a cross-section sample of high-income countries, find a potential Kuznets relationship and a decrease of meat consumption at a per capita income of US$49,848. In their full panel-data sample, combining high- and low-income countries, their results suggest an inflection point in meat consumption at an income of US$36,375 p.c. This value is much higher than US$15,000 per capita indicated by Vinnari et al. [51] for bovine meat consumption in EU-15 countries. To our knowledge, this investigation has never been done on animal protein consumption at a global level.

The choice and the quality of the protein appear to be driven not only by economic factors but also by geography, religion and culture [1]. In the literature, other drivers have been included in regression analysis to explain meat consumption. Milford et al. [25] find that income per capita and urbanization rates are the two most important drivers of total meat consumption per capita; religion is also a significant variable. In comparison, income per capita and natural endowment factors are major drivers of ruminant meat consumption per capita. Vranken et al. [24] propose a regression model to explain meat consumption, where religious persuasions, masculinity index, and trade (a proxy for a country's openness) play an essential role. Cole et al. [23], in addition to income, find urbanization and land availability to be significant determinants.

4. Data

In this study, three different dependent variable are used, for which a series of drivers are tested. The dependent variables are "animal proteins" consumption, which indicates the daily per capita consumption (in grams) of proteins coming from any animal sources (meat, offal, seafood, dairy and eggs), "meat proteins" consumption, which indicates the daily per capita consumption (in grams) of proteins coming only from a source of meat (bovine meat, mutton, goat meat, pig meat, poultry meat, and other), and "vegetal proteins" consumption, which denotes the share of daily per capita consumption of proteins that are sourced from plants (cereals, vegetables, fruit, beans, nuts, seeds, roots and spices). Protein consumption data are taken from FAO [36]. FAO new food balance sheets are the most useful available proxy for consumption. The quantities of protein in the data set reflect only the quantities reaching the consumer. The actual amount consumed may be lower (due to waste, losses in preparation, rotten food).

The cross-country regression models for protein consumption comprise a series of selected drivers. These independent variables are income (GDP per capita PPP), temperature, population age (share of the population more than 65 years old), religion (share of population adhering to Islam) and urbanization (share of population living in cities). The models include 142 countries—all of the nations for which necessary data are available. Data are for 2017, except for the share of the Muslim population, for which the latest available data are for 2015 (it is assumed that the Muslim population share isn't significantly changed in two years). The data of per capita GDP (PPP in constant 2017 international dollars) are from the World Bank Indicators of Development [52].

The annual average temperature of each country was taken into consideration under the hypothesis that temperature influences the conditions for production (and hence consumption via relative prices). In particular, it is expected that the lower the temperature, the higher the animal-based and meat-based protein consumption, while the consumption of vegetal protein would be lower due to the unfavorable conditions for production, leading to lower supply and higher relative prices.

The age of the population can be considered as playing a role in the decision to consume more or less animal protein and vegetal protein. Gossard et al. [27] found that people eat less meat as they grow older. This may be due to physiological changes and/or to differences of dietary norms of people from different age cohorts. Therefore, the percentage of the population over 65 years old was included.

From the literature, religion is known to play an important role in influencing meat consumption, in particular, the adherence to Islam, which forbids the eating of pork [25]. Therefore, the Muslim population's share was included in our models.

Urbanization, together with income, is the driver that has attracted the most attention for affecting meat consumption. Previous studies [26] have found that the more urbanized the population, the more meat that is consumed. According to Popkin [53], this may be due to higher exposure to globalized trends, such as Western diets. In addition, cities have a better transportation system and larger supermarkets, and thus present better possibilities for maintaining the cold chain for animal products. In the model, the share of the urban population is used to test whether this affects the choices of consumption. Including an education variable was also considered, since, as suggested by Milford et al. [25], a higher level of education could possibly be correlated with lower meat consumption levels. Education is also linked to the third stage of the "nutritional transition", leading to healthier diets [54]. Nevertheless, education was highly correlated to per capita income, and eventually this variable was dropped.

Sources of all data are provided in Table A1 in Appendix A. Summary statistics for all the variables are specified in Table 1.

Table 1. Summary statistics of the variables.

	Mean	Std. Deviation	Minimum	Maximum	Cases
Animal protein	37.07	20.65	6.62	105.31	142
Meat protein	16.80	10.18	1.39	44.90	142
Vegetal protein (%)	57.94	15.88	27.28	90.01	142
GDP p.c. PPP (000 Int$)	20.56	19.64	0.91	112.82	142
Temperature	19.37	8.55	−3.54	30.10	142
Pop. > 65 (%)	9.22	6.49	1.03	27.11	142
Muslim (%)	24.50	35.43	0.00	99.65	142
Urban_pop. (%)	59.63	21.32	16.35	100.00	142

5. Method

This paper has the goal of assessing the relationship between income and animal protein consumption, controlling for other determinants. Scatterplots seems to suggest the existence of a Kuznets curve (inverted U-shape) in the relationship between per capita income and both all-animal and meat proteins, while the relationship with the share of

vegetal protein is still quadratic but U-shaped. A model for the share of vegetal protein consumption was included because, as explained earlier in the text, not only is it essential to find measures that decrease the demand for animal proteins and meat, but also to encourage their substitution with plant-based protein. Knowing what drives consumption of different types of protein can help decisionmakers decide how to intervene.

For our purposes, an Ordinary Least Square regression model is suitable. The main explanatory variable of interest is GDP per capita. However, different relationships can be modelled between this variable and protein consumption. The EKC hypothesis predicts that animal and meat consumption grows with income up to a peak, then starts to decline, which implies a quadratic function, leading to an inverted U-shaped curve. The equation of consumption (C) can therefore be written as a quadratic model in income:

$$C = \alpha + \beta1\,(GDP) + \beta2\,(GDP)^2 + \beta3\,(Temperature) + \beta4\,(Population\_old) + \beta5\,(Muslim) + \beta6\,(UrbanPopulation) + \varepsilon \quad (1)$$

where C is daily per capita consumption of animal proteins and meat proteins, with β1 predicted to be positive and β2 to be negative. According to the same EKC hypothesis, the share of vegetal protein over total daily protein consumption is predicted to be U-shaped; hence, when C represents the share of vegetal proteins, β1 is predicted to be negative and β2 to be positive. Following the pioneering study of Shafik and Bandyopadhyay [55] and many other studies (among others [56–59]), this model was confronted with two competing ones. The linear model implies that animal and meat consumption monotonically increase with income (β1 positive for models of animal and meat, negative for the model of vegetal protein share):

$$C = \alpha + \beta1\,(GDP) + \beta3\,(Temperature) + \beta4\,(Population\_old) + \beta5\,(Muslim) + \beta6\,(UrbanPopulation) + \varepsilon \quad (2)$$

A second alternative sometimes tested is the cubic model:

$$C = \alpha + \beta1\,(GDP) + \beta2\,(GDP)^2 + \beta7\,(GDP)^3 + \beta3\,(Temperature) + \beta4\,(Population\_old) + \beta5\,(Muslim) + \beta6\,(UrbanPopulation) + \varepsilon \quad (3)$$

If confirmed, the quadratic model (Equation (1)) also allows for calculation of the inflexion point, i.e., the amount of per capita income at which the consumption of the three different kinds of proteins start to increase/decrease. The inflexion income for each model is computed from the polynomial regression output by solving for, and setting to zero, the first derivative of C (Equation (1)) with respect to income:

$$d(C)/d(GDP) = 0 \Rightarrow GDP = -\beta1/2\beta2 \quad (4)$$

With the predicted GDP p.c. at the peak, the predicted consumption at that level was also calculated, using the estimated parameters of Equation (1). The values of GDP and GDP^2 are those at the peak; the values of the other explanatory variables were set at their mean and to other statistics of interest, specifically, the means and the means $+/-$ the Standard Deviation.

6. Results

The results of the models of animal and meat consumption, estimated with OLS, are shown in Tables 2 and 3. In the tables, models are presented with the income per capita variable introduced linearly (linear model), with the variable squared (quadratic model) and raised to the cube (cubic model). All models are overall highly significant, as shown by the F statistics, and the coefficients of determination, R^2, are high across the three models, suggesting a good overall fit.

Table 2. Results of the models of animal proteins.

	Linear			Quadratic			Cubic		
	Coeff.	White Robust St. Err.	Stand. Coeff.	Coeff.	White Robust St. Err.	Stand. Coeff.	Coeff.	White Robust St. Err.	Stand. Coeff.
Constant	13.634 ***	5.180		15.866 ***	4.94		15.112 ***	4.782	
GDP p.c. PPP	0.399 ***	0.086	0.379	0.995 ***	0.152	0.947	1.523 ***	0.274	1.449
GDP p.c. PPP^2				−0.006 ***	0.001	−0.467	−0.02 ***	0.006	−1.434
GDP p.c. PPP^3							0.000 **	0.000	0.571
Temperature	−0.298 **	0.168	0.123	−0.313 *	0.161	−0.129	−0.324 **	0.155	−0.134
Pop. > 65 (%)	1.026 ***	0.293	0.322	0.611 **	0.292	0.192	0.506 *	0.278	0.159
Muslim (%)	−0.029	0.022	0.049	−0.034	0.022	−0.058	−0.031	0.022	−0.052
Urban_pop. (%)	0.206 ***	0.056	0.212	0.121 **	0.055	0.124	0.087	0.059	0.090
R^2	0.804			0.827			0.833		
Adj. R^2	0.797			0.819			0.824		
F	111.83 ***			107.40 ***			95.39 ***		
Obs.	142			142			142		

Note: *, **, *** indicate significance at the 90%, 95% and 99% level, respectively.

Table 3. Results of the models of meat proteins.

	Linear			Quadratic			Cubic		
	Coeff.	White Robust St. Err.	Stand. Coeff.	Coeff.	White Robust St. Err.	Stand. Coeff.	Coeff.	White Robust St. Err.	Stand. Coeff.
Constant	4.484	3.183		5.883 *	3.001		5.187 **	2.813	
GDP p.c. PPP	0.158 **	0.047	0.304	0.532 ***	0.103	1.026	1.020 ***	0.185	1.967
GDP p.c. PPP^2				−0.004 ***	0.001	−0.594	−0.016 ***	0.004	−2.406
GDP p.c. PPP^3							0.000 ***	0.000	1.069
Temperature	−0.068	0.105	−0.057	−0.078	0.098	−0.065	−0.087	0.093	−0.073
Pop. > 65 (%)	0.245	0.166	0.156	−0.015	0.159	−0.009	−0.113	0.154	−0.071
Muslim (%)	−0.058 ***	0.013	−0.200	−0.061 ***	0.012	−0.211	−0.058 ***	0.013	−0.200
Urban_pop. (%)	0.160 ***	0.042	0.335	0.107 **	0.044	0.223	0.076 **	0.044	0.159
R^2	0.649			0.685			0.706		
Adj. R^2	0.636			0.671			0.691		
F	50.18 ***			48.88 ***			46.02 ***		
Obs.	142			142			142		

Note: *, **, *** indicate significance at the 90%, 95% and 99% level, respectively.

The fits for animal protein specifications are higher than the ones for meat protein. Heteroskedasticity was detected for all the models by implementing the Breusch-Pagan test and F-test. The tests jointly rejected the null hypothesis of homoskedasticity, and thus White robust standard errors [60] were estimated. Despite descriptive statistics suggesting some mild correlations between the variables, the presence of multicollinearity was excluded by controlling for the variance inflation factors.

The first focus is on the quadratic model, which is crucial for verifying the EKC hypothesis. When confronting the linear and the quadratic models, the results actually support the hypothesis of a curvilinear rather than linear relationship between per capita income and animal and meat consumption. Both the linear (+) and quadratic (−) terms are significant and of the predicted sign, implying an inverted U shape, whereby per capita income influences the consumption of animal and meat proteins at a decreasing rate. In addition, the adjusted R^2s are higher in the quadratic models. The quadratic models are definitely statistically superior to the linear ones.

The results also show that the share of the urban population is significant and positive for both animal and meat protein consumption. By contrast, the share of Muslims in the population negatively and significantly affects meat protein consumption but not animal protein. Both results are consistent with the literature [23,25]. The aged population share is significant and positive for animal proteins, contrary to what was found by Gossard [27] for meat for the USA, but the parameter for our cross-country regression on meat proteins is not significant. Average temperature is significant and negative for animal proteins, but not significant for meat proteins. People in temperate areas may eat more animal proteins

than tropical regions because the temperate zone is more conducive to grain production, and surplus grain is necessary for intensive feedlot production. Therefore, as confirmed also by York et al. [26], people in tropical regions may eat less meat due to the nature of tropical soil and other ecological factors that inhibit grain production. According to our results, the same applies to all animal-sourced protein.

Following the example of Milford et al. [25], the absolute values of standardized beta coefficients are used to rank the drivers according to their explanatory power. Since each variable is standardized, these coefficients are used to compare the effect that different predictor variables have on a dependent variable, and thus which variable has the greatest influence. As expected, per capita income is ranked first for importance across all models (except for urban population in the linear model of meat proteins). The share of aged population follows in the animal protein consumption models, while urbanization occupies the same position in the models of meat proteins.

To check for robustness of our results, two approaches were explored. One involved considering introducing a cubic term for income per capita (third columns in Tables 2 and 3). The parameter of the cubic income term is significant in both, and the adjusted R^2s are slightly higher than in the quadratic functions. However, the determinant of the first derivative of the animal protein function is negative, implying that its consumption is monotonically increasing with income, with an inflection point at Int\$76,466 p.c. As to meat proteins, the estimated function implies a N-shaped curve, with a high turning point at Int\$47,917 p.c. and a lower one (after which the curve increases again) at Int\$88,972 p.c. Though some improvement was therefore found in goodness of fit when introducing a cubic income term, the evidence is weak, and more importantly, there is no evident theoretical economic reason for an N-shaped curve relating income per capita and animal and meat protein consumption. It was suspected that the cubic function was due to the existence of some outlier that "forced" a shift to the cubic form.

A further control was therefore performed on the existence of outliers. It is well known that the existence of outliers is dubious for some authors (for a review see [61]); however, when it is accepted, different approaches are used to identify them so as to drop them from estimations. One is the Inter-Quartile Range (IQR) method, whereby, a priori, observations lower than the first quartile −1.5* IQR and greater than the third quartile +1.5* IQR of a variable of interest (in our case, Income p.c.) are dropped. The second, based on the Cook's Distance (CD), identifies a posteriori the influential points by combining the observation's leverage and the residual value; the higher the leverage and the residuals, the higher the CD [62]. The outliers were identified with both methods, and the regressions were re-estimated after dropping them. The outliers according to the IQR criterion were Luxembourg and Ireland. The outliers according to the CD (the cutoff level is based on the standard rule: CD > 4/(n−k−1)) were Luxembourg, Iceland and Mongolia for animal proteins, Luxembourg, St. Lucia and Mongolia for meat proteins (and share of vegetal proteins). The results of the regressions after dropping the outliers are shown in Appendix B (Tables A2–A7). In qualitative terms, the signs of the parameters never change (one exception is temperature in the CD model, but it is never significant), and income and income squared always remain significant. The significance of the cubic income term is lower in the IQR model for animal proteins, and its parameter is not significant in the IQR model for meat proteins. The standardized coefficients indicate that the most important variable is income, without exceptions.

Regardless, what is important is the level of the turning point that the estimated functions indicate, i.e., the income level at which the consumption starts to decline. From the regression estimates, the turning points were calculated. With the estimated functions, the consumption at those points were also calculated. Since they depend not only on income levels but also on the levels of the other independent variables, to have an appreciation of the possible variation, they were set at their mean, and to have an appreciation of the possible range, they were set at their mean plus and minus their standard deviations. The results are shown in Table 4.

Table 4. Income per capita and consumption at the estimated turning points: full sample and samples without outliers.

	GDP p.c. at the Turning Point (Int$ PPP)	Consumption (g/day) at the Turning Point with the Other Variables at Their:		
		Mean	**Mean − SD**	**Mean + SD**
Animal proteins				
All sample	77,229	60.2	57.6	62.9
IQR sample	56,809	55.9	54.3	57.6
CD sample	60,157	56.1	51.4	60.8
Meat proteins				
All sample	65,808	26.6	27.3	26.0
IQR sample	46,108	26.0	27.9	24.1
CD sample	50,154	26.8	27.6	26.0

The turning points for the full sample are located at about Int$77,000 per capita income for animal proteins and at about Int$66,000 for meat. These income levels are very high, since they are over the 99th and the 97.5th percentiles, respectively. They are much larger than those estimated for meat by Cole et al. [23] (US$36,375–49,848 per capita), by Vranken et al. [24] (Int$35,035 to Int$52,661 p.c.), and rather in line with the one that can be calculated from the results by Milford et al. [25] (about $100,000, according to the shown parameter estimates, but they reported few decimals and the quadratic term was not significant). When eliminating the outliers, the turning points are located at about Int$57,000 and Int$60,000 p.c. for animal proteins and Int$46,000 and Int$50,000 p.c. for meat proteins. Though these are lower levels, they are nevertheless high in income p.c. ranking. The lowest one for animal proteins (Int$57,000) is located at the 96th percentile, and the lowest one for meat proteins (Int$46,000) at the 88th percentile.

The corresponding consumption levels of animal proteins at the estimated turning point for the full sample is 60.2 g/day, with limits ranging from 58–63 g/day. The consumption of meat protein is 26.6 g/day (26–27.3 g/day). For comparison, these values are 62 and 58% higher than the average consumption levels in the sample for animal and meat proteins, respectively (37.1 and 16.8 g/day) and are located at the 84th and 81st percentiles, respectively. Again, dropping candidate outlier observations leads to lower estimated consumption levels at the turning points. The lowest consumption level of animal proteins (51.4 g/day) is located at the 71st percentile, and the lowest for meat proteins (24.1 g/day) at the 73rd. All these values can also be compared to the Safe Level of Protein Intake recommended by the WHO [35] of 0.83g/kg/day of overall proteins (not only animal or meat), which translates into 62 and 46 g/day for adults of 75 and 55 kg, respectively.

The unavoidable conclusion is that, if a turning point exists at all, it is located at such high levels that, for all practical purposes, animal and meat consumption are strictly increasing with per capita income.

The results of the model concerning the share of vegetal proteins are reported in Table 5.

Not surprisingly, the determinants of the share of vegetal protein are symmetric to the ones of meat proteins. Again, the quadratic model is statistically superior to the linear one, since the quadratic income term is significant and the adjusted R^2 is larger. The signs indicate a U-shaped curve. The share is also negatively driven by urban population and positively by the share of Muslim population. The ecological factor (temperature) doesn't seem to affect the share of vegetal protein consumption.

Examination of the standardized coefficients suggests that, in this case as well, income is the most important driver, except for the linear model, where the share of aged population is ranked first. In the quadratic and cubic models, the share of Muslims is second in ranking.

Table 5. Results of the models of the share of vegetal proteins.

	Linear			Quadratic			Cubic		
	Coeff.	**White Robust St. Err.**	**Stand. Coeff.**	**Coeff.**	**White Robust St. Err.**	**Stand. Coeff.**	**Coeff.**	**White Robust St. Err.**	**Stand. Coeff.**
Constant	78.074 ***	5.142		75.924 ***	4.859		77.281 ***	5.266	
GDP p.c. PPP	−0.217 ***	0.059	−0.268	−0.791 ***	0.156	−0.978	−1.741 ***	0.405	−2.152
GDP p.c. PPP^2				0.006 ***	0.002	0.584	0.030 *	0.016	2.846
GDP p.c. PPP^3							0.000	0.000	−1.334
Temperature	0.111	0.163	0.059	0.126	0.154	0.067	0.145	0.158	0.078
Pop. > 65 (%)	−0.709 ***	0.235	−0.289	−0.309	0.233	−0.126	−0.120	0.241	−0.049
Muslim (%)	0.087 ***	0.022	0.194	0.092 ***	0.021	0.205	0.086 ***	0.023	0.191
Urban_pop. (%)	−0.225 ***	0.051	−0.302	−0.143 ***	0.051	−0.192	−0.083	0.053	−0.111
R^2	0.737			0.772			0.806		
Adj. R^2	0.728			0.762			0.795		
F	76.27 ***			76.29 ***			79.27 ***		
Obs.	142			142			142		

Note: *, *** indicate significance at the 90% and 99% level, respectively.

Comparison with a cubic function shows little evidence of a better fit. Though there is a small improvement in the adjusted R^2, the cubic income parameter is not significant, and even the quadratic one is only weakly significant. If a cubic function is adopted, the lower turning point (after which the share begins to grow) is Int\$43,227 p.c., and the following one (after which the curve decreases again) is Int\$86,556 p.c.

The results of the estimates from the samples dropping the outliers according to the IQR and Cook Distance rules are reported in Appendix B (Tables A6 and A7). Again, the signs do not change and the significance of the parameters does not change sensibly when dropping the outliers.

Nevertheless, dropping the outliers entails some changes in the turning point. In the case of the share of vegetal proteins, the lowest point for the full sample occurs at an income p.c. of about Int\$64,000 (Table 6), again a very high level (over the 95th percentile). The corresponding share (Table 5) is 44%, ranging from about 42 to 45% according to the assumed values of the other explanatory variables. The turning point according to the estimates based on outlier exclusion are at lower income levels (Int\$44,000 or Int\$48,500 p.c.), corresponding to the peak of meat protein consumption. Nevertheless, the share of vegetal proteins at the low inversion point is in the same range as the full sample.

Table 6. Income per capita and share of vegetal protein at the estimated turning point.

	GDP p.c. at the Turning Point (Int\$ PPP)	Share (%) at the Turning Point with the Other Variables at Their:		
		Mean	**Mean − SD**	**Mean + SD**
All sample	63,762	44.0	44.7	43.3
IQR sample	44,336	44.3	42.9	45.6
CD sample	48,509	43.4	44.0	42.9

7. Discussion

In this study, a multiple regression analysis was performed to investigate the protein consumption of a cross-country sample for the year 2017. To our knowledge, it is the first time that a regression analysis has been applied to the total animal protein consumption and vegetable consumption. Few studies have investigated meat consumption before, with the latest being Milford et al. [25] using data from 2005 and 2011, where for the first time a broad combination of explanatory variables was used in an analysis of total meat consumption. Even though our combination of explanatory variables isn't as large as that study, they were tested not only on per capita meat protein consumption, but also on animal and vegetal protein consumption. Our results indicate that protein consumption from animal sources and meat sources have different explanatory variables; however, in

all cases, income is the most important driver. The issue is the extent to which and the modalities by which it does affect consumption. A quadratic relationship between meat consumption and income has been previously presented in the literature. Results of this study show evidence of the same relationship where meat proteins are concerned, but also for all animal protein consumption. Though some improvement in goodness of fit was found when introducing a cubic income term, the evidence is weak, and considering the lack of theoretical economic reasons for an N-shaped curve relating income per capita and animal and meat protein consumption, the quadratic function is preferred.

Both models predict that animal and meat protein consumption grow with income per capita up to a turning point, after which they start to decrease. Accordingly, the share of vegetal proteins decreases to a lower limit, then increases, with a U shape. For the policy implications, however, the income level at which the turning point is located is crucial, given the negative health and environmental impact of animal protein consumption. Unfortunately, our results suggest that, if any turning point exists, it corresponds to a high level of income, suggesting that a deceleration in meat and animal protein consumption will not happen unless a country reaches a per capita income of Int$77,000 and of Int$66,000, respectively. Our estimates are at a higher level than some previous studies on meat consumption [23,24] and are more in line with a more recent one [25]. Given that many countries are far away from this level of income, and given the environmental and health concerns associated with the production and consumption of animal proteins, these results are not encouraging. Even though the Kuznets relationship seems to be confirmed from our data analysis, the Kuznets theory specification for which the demand should bring environmental and health advantages as income grows is not realistic in the case of protein consumption. This is confirmed also by the proposed vegetal protein consumption model, characterized by a U-shaped relationship with income: the share of vegetal protein consumption re-increases only when a per capita income of about Int$64,000 is reached.

Further research might go in two directions. One is introducing dynamics in the analysis by using panel data. This might shed more light on the evolution over time of protein consumption in the different countries, thus considering the possibility of different trajectories across countries. The second is analyzing the relationship between income and protein consumption within single countries. Cross-country analyses use national average income and consumption, thus disregarding the variability within each country. Analyzing the relationship within countries could better control for specific national characteristics influencing protein consumption. Income distribution within countries can be skewed, and thus national averages can hide different reactions to income growth.

8. Conclusions

In this paper, the relationship between income and protein consumption, specifically meat, animal and vegetal protein, was analyzed through a cross-country regression, including several drivers in addition to income. The results suggest some evidence of an inverted U-shaped relationship between animal and meat protein consumption and per capita income as well as a U-shaped relationship between per capita income and vegetal protein consumption. Nevertheless, the inversion of the trends is predicted at very high income levels. Taken together, in terms of policy implications, these results suggest that one cannot count on income growth to curb the negative health and environmental impacts of animal food consumption. The market alone fails to show signs of externalities associated with unsustainable protein consumption. This study provides new insight into the fact that economic development alone won't, at least in the short run, bring a solution, and actions on different levels are needed to address this market failure. Given the scale of the challenges that the food system has to face in the context of sustainability, it is important to understand protein consumption trends and drivers, especially since different protein sources differ in terms of their environmentally damaging potential. Assessments of the effects of economic, social, ecological and cultural factors on all protein sources are essential to understand what and who can be targeted to shift consumption away from animal

proteins and encourage substitution with plant-based proteins. This is crucial to make the food system more sustainable, particularly as the continuation of current trends of eating habits can cause considerable environmental pressures. Unfortunately, the other variables that are found to have an effect at a macro level, whether positive or negative, on animal and meat consumption (temperature, urbanization, population age and religion) are hardly under government influence. Policy intervention should take into consideration these findings and act with respect to cultural values and spreading consciousness of the environmental and health impacts of personal consumption habits as well as providing economic incentives that shift the relative cost of alternative food.

Appendix A

Table A1. Variables selected for regression and their sources.

Variables	Unit	Year	Source	Link
Per capita consumption of protein (animal, from meat, vegetal)	g/capita/day	2017	FAO New Food Balance Sheets	http://www.fao.org/faostat/en/#data/FBS (accessed on 25 January 2021)
GDP per capita PPP	Constant 2017 International $	2017	World Development Indicators Database, World Bank	https://data.worldbank.org/indicator/NY.GDP.PCAP.PP.KD (accessed on 20 January 2021)
12-months average temperature	Celsius	2017 *	Berkley Earth	http://berkeleyearth.lbl.gov/country-list/ (accessed on 10 March 2021)
Population over 65	Share of total population	2017	World Development Indicators Database, World Bank	https://data.worldbank.org/indicator/SP.POP.65UP.TO.ZS (accessed on 1 February 2021)
Population adhering to Islam	Share of total population	2015	Association of Religion Data Archive	https://www.thearda.com/internationalData/index.asp (accessed on 1 February 2021)
Urban population	Share of total population	2017	World Development Indicators Database, World Bank	https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS (accessed on 25 January 2021)

* when not available Jan. 1951–Dec. 1980 estimated absolute temperature + latest year available anomaly.

Appendix B. Estimates without Outliers

Table A2. Results of the models of animal proteins. Sample without IQR outliers.

	Linear			Quadratic			Cubic		
	Coeff.	White Robust St. Err.	Stand. Coeff.	Coeff.	White Robust St. Err.	Stand. Coeff.	Coeff.	White Robust St. Err.	Stand. Coeff.
Constant	14.872 **	5.288	0.431	15.519 **	4.887		13.133 **	4.912	
GDP p.c. PPP	0.504 ***	0.084		1.295 ***	0.219	1.107	1.848 ***	0.359	1.578
GDP p.c. PPP^2				−0.011 ***	0.003	−0.567	−0.036 **	0.013	−1.767
GDP p.c. PPP^3							0.000	0.000	0.765
Temperature	−0.298	0.167	−0.124	−0.324 *	0.157	−0.135	−0.314 *	0.154	−0.131
Pop. > 65 (%)	0.874 **	0.295	0.278	0.518	0.288	0.165	0.575 *	0.285	0.183
Muslim (%)	−0.033	0.022	−0.058	−0.031	0.022	−0.054	−0.028	0.022	−0.048
Urban_pop. (%)	0.177 **	0.056	0.185	0.101	0.059	0.105	0.089	0.058	0.092
R^2	0.807			0.825			0.830		
Adj. R^2	0.800			0.817			0.821		
F	112.3 ***			104.70 ***			92.05 ***		
Obs.	140			140			140		

Note: *, **, *** indicate significance at the 90%, 95%, and 99% level, respectively.

Table A3. Results of the models of animal proteins. Sample without CD outliers.

	Linear			Quadratic			Cubic		
	Coeff.	White Robust St. Err.	Stand. Coeff.	Coeff.	White Robust St. Err.	Stand. Coeff.	Coeff.	White Robust St. Err.	Stand. Coeff.
Constant	9.579 *	4.665		11.190 *	4.305		7.938	4.057	
GDP p.c. PPP	0.473 ***	0.061	0.428	1.222 ***	0.220	1.108	1.898 ***	0.285	1.721
GDP p.c. PPP^2				−0.010 ***	0.003	−0.564	−0.037 ***	0.008	−2.042
GDP p.c. PPP^3							0.000 ***	0.000	0.922
Temperature	−0.111	0.143	−0.046	−0.141	0.131	−0.059	−0.131	0.124	−0.055
Pop. > 65 (%)	1.158 ***	0.258	0.381	0.777 **	0.269	0.255	0.822 **	0.254	0.270
Muslim (%)	−0.019	0.021	−0.034	−0.019	0.020	−0.034	−0.013	0.020	−0.023
Urban_pop. (%)	0.158 **	0.051	0.169	0.072	0.056	0.077	0.062	0.054	0.066
R^2	0.827			0.845			0.855		
Adj. R^2	0.820			0.838			0.847		
F	127.10 ***			120.50 ***			110.00 ***		
Obs.	139			139			139		

Note: *, **, *** indicate significance at the 90%, 95%, and 99% level, respectively.

Table A4. Results of the models of meat proteins. Sample without IQR outliers.

	Linear			Quadratic			Cubic		
	Coeff.	White Robust St. Err.	Stand. Coeff.	Coeff.	White Robust St. Err.	Stand. Coeff.	Coeff.	White Robust St. Err.	Stand. Coeff.
Constant	5.175	3.215		5.704 *	2.862		4.884	2.793	
GDP p.c. PPP	0.212 ***	0.053	0.366	0.857 ***	0.144	1.467	1.047 ***	0.245	−2.413
GDP p.c. PPP^2				−0.009 ***	0.002	−0.932	−0.018 *	0.008	3.337
GDP p.c. PPP^3							0.000	0.000	−1.503
Temperature	−0.068	0.104	−0.057	−0.090	0.093	−0.075	−0.086	0.093	0.070
Pop. > 65 (%)	0.167	0.163	0.107	−0.124	0.158	−0.079	−0.105	0.156	−0.087
Muslim (%)	−0.060 ***	0.013	−0.201	−0.058 ***	0.013	−0.204	−0.057 ***	0.012	0.185
Urban_pop. (%)	0.14 **	0.04	0.304	0.082	0.04	0.172	0.078	0.04	−0.112
R^2	0.650			0.698			0.700		
Adj. R^2	0.637			0.685			0.685		
F	49.79 ***			51.32 ***			44.13 ***		
Obs.	140			140			140		

Note: *, **, *** indicate significance at the 90%, 95%, and 99% level, respectively.

Table A5. Results of the models of meat proteins. Sample without CD outliers.

	Linear			Quadratic			Cubic		
	Coeff.	White Robust St. Err.	Stand. Coeff.	Coeff.	White Robust St. Err.	Stand. Coeff.	Coeff.	White Robust St. Err.	Stand. Coeff.
Constant	2.801	2.886		4.166	2.566		2.778	2.544	
GDP p.c. PPP	0.214 ***	0.046	0.387	0.820 ***	0.139	1.483	1.125 ***	0.204	2.034
GDP p.c. PPP^2				−0.008 ***	0.002	−0.907	−0.020 ***	0.006	−2.229
GDP p.c. PPP^3							0.000 *	0.000	0.821
Temperature	0.023	0.096	0.019	0.001	0.082	−0.001	0.005	0.082	0.004
Pop. > 65 (%)	0.298	0.154	0.193	−0.007	0.148	−0.004	0.011	0.144	0.007
Muslim (%)	−0.054 ***	0.012	−0.191	−0.055 ***	0.012	−0.193	−0.052 ***	0.012	−0.184
Urban_pop. (%)	0.130 **	0.043	0.272	0.058	0.043	0.121	0.053	0.042	0.110
R^2	0.664			0.710			0.718		
Adj. R^2	0.651			0.697			0.703		
F	52.54 ***			53.98 ***			47.67 ***		
Obs.	139			139			139		

Note: *, **, *** indicate significance at the 90%, 95%, and 99% level, respectively.

Table A6. Results of the models of the share of vegetal protein. Sample without IQR outliers.

	Linear			Quadratic			Cubic		
	Coeff.	White Robust St. Err	Stand. Coeff.	Coeff.	White Robust St. Err.	Stand. Coeff.	Coeff.	White Robust St. Err.	Stand. Coeff.
Constant	77.126 ***	5.206		76.264 ***	4.517		79.896 ***	4.851	
GDP p.c. PPP	−0.293 ***	0.060	−0.323	−1.345 ***	0.194	−1.484	−2.187 ***	0.354	−2.413
GDP p.c. PPP^2				0.015 ***	0.003	0.975	0.052 ***	0.012	3.337
GDP p.c. PPP^3							0.000 **	0.000	−1.503
Temperature	0.111	0.163	0.060	0.146	0.145	0.078	0.131	0.155	0.070
Pop. > 65 (%)	−0.601 *	0.234	−0.247	−0.126	0.221	−0.051	−0.212	0.234	−0.087
Muslim (%)	0.090 ***	0.022	0.203	0.087 ***	0.021	0.196	0.083 ***	0.023	0.185
Urban_pop. (%)	−0.204 ***	0.05	−0.275	−0.102 **	0.05	−0.137	−0.084	0.052	−0.112
R^2	0.739			0.799			0.810		
Adj. R^2	0.729			0.782			0.800		
F	75.88 ***			84.28 ***			80.46 ***		
Obs.	140			140			140		

Note: *, **, *** indicate significance at the 90%, 95%, and 99% level, respectively.

Table A7. Results of the models of the share of vegetal protein. Sample without CD outliers.

	Linear			Quadratic			Cubic		
	Coeff.	White Robust St. Err.	Stand. Coeff.	Coeff.	White Robust St. Err.	Stand. Coeff.	Coeff.	White Robust St. Err.	Stand. Coeff.
Constant	80.901 ***	4.686		78.745 ***	4.088		82.548 ***	4.322	
GDP p.c. PPP	−0.296 ***	0.051	−0.341	−1.253 ***	0.198	−1.444	−2.088 ***	0.326	−2.407
GDP p.c. PPP^2				0.013 ***	0.003	0.914	0.046 ***	0.011	3.222
GDP p.c. PPP^3							0.000 **	0.000	−1.436
Temperature	−0.022	0.146	−0.012	0.012	0.125	0.006	0.001	0.130	0.000
Pop. > 65 (%)	−0.787 ***	0.212	−0.325	−0.306	0.200	−0.126	−0.356	0.202	−0.147
Muslim (%)	0.081 ***	0.021	0.183	0.082 ***	0.020	0.185	0.075 ***	0.021	0.169
Urban_pop. (%)	−0.187 ***	0.05	−0.249	−0.073	0.05	−0.098	−0.059	0.049	−0.078
R^2	0.755			0.802			0.826		
Adj. R^2	0.746			0.793			0.816		
F	82.13 ***			89.43 ***			88.80 ***		
Obs.	139			139			139		

Note: **, *** indicate significance at the 95%, and 99% level, respectively.

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