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Drivers of a new dietary transition towards a sustainable and healthy future

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ABSTRACT

Given the impact of food consumption on climate change and the scarcity of natural resources, along with its effect on public health, a new dietary transition away from environmentally burdensome and unhealthy foods is needed. To promote such a transition in the dietary habits of consumers, it is crucial to understand what motivates their consumption habits. Therefore, this study seeks to assess potential drivers of a new dietary transition. Drivers such as income, prices, education, human development, and environmental awareness were assessed for 25 countries around the world over the last two decades. The panel-corrected standard errors estimator was computed to control for data specificities. Results revealed that prices, education and environmental awareness promote the new dietary transition, while income, human development, and globalization may act as barriers. Moreover, evidence of an Environmental Kuznets Curve was found. To meet sustainability targets, strategies that can help developing countries "tunnel" through this curve are recommended. Education and information campaigns, along with price mechanism strategies could be effective ways to promote the new dietary transition. Food policymakers need to understand what drives this transition, so they can design effective and efficient strategies that promote economic growth while guaranteeing sustainable development.

1. Motivation

Climate change and the sustainable management of natural resources are two of the main challenges of the 21st century, and there are many areas of intervention. Consumption habits are one of these areas, particularly when they involve natural resources and result in environmental externalities. According to the Intergovernmental Panel on Climate Change (IPCC), a shift in consumption habits is necessary to achieve the targets proposed to mitigate climate change and accomplish sustainable development (IPCC, 2019). Studies recommend a reduction in the consumption of foods with high ecological footprints, such as animal-based foods, to improve sustainability (e.g., Hedenus et al., 2014; McMichael et al., 2007; Springmann et al., 2018). However, according to data from the Food and Agriculture Organization (FAO[1]), and illustrated in Fig. 1, meat consumption has been increasing for the past fifty years, and has been higher in the developed world, i.e., high-income countries (HIC), than in the rest of the world (FAO, 2020).

Godfray et al. (2018) found that, although it has plateaued, the meat consumption of HICs (Europe and Northern America) is the highest in the world. In middle-income countries, meat consumption has risen dramatically, particularly in China, as the graph shows. The countries with the lowest meat consumption are mainly located in Africa, and are low-income countries. India's low meat consumption is largely explained by the country's long tradition of vegetarianism. However, while Fig. 1 shows the absolute values of meat consumption, Fig. 2 presents the per capita consumption of meat for the same regions.

One obvious difference between the two graphs are the values for Oceania which, in Fig. 1 are the lowest and in Fig. 2 are the highest. This is explained by the world's highest consumer of meat, Australia. While China is the highest meat consumer in absolute terms, consumers eat the most per capita in Australia. Although levels have plateaued in Europe, North America and Oceania, the World average is rising due to increases in emerging economies such as China and South America (which includes Brazil). Thus, in absolute and per capita terms, meat consumption has generally been increasing, leading to a variety of environmental and health-related externalities.

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[1] An abbreviation list concerning the abbreviations most used in the text is available at the end of the paper in the appendix section.

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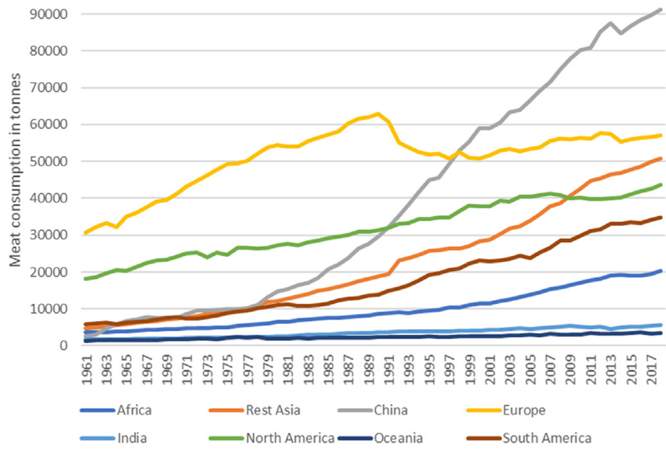

Fig. 1. Meat consumption (million metric tons) for different world regions.

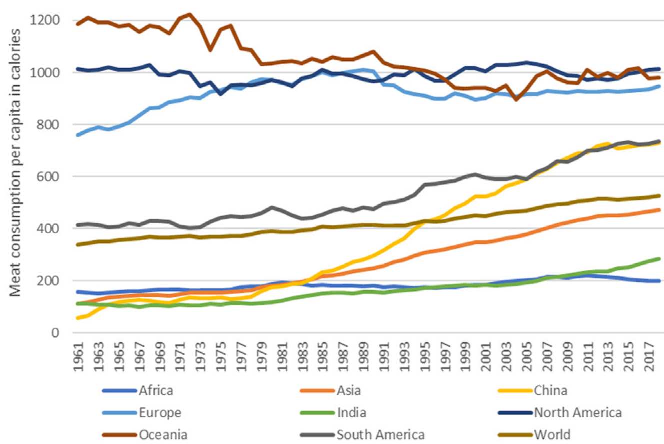

Fig. 2. Meat consumption per capita (calories) for different regions of the world.

1.1. On the characteristics of plant-based foods

A potential option to reduce the environmentally burdensome consumption of meat, is to shift diets from resource-intensive foods to more sustainable ones, such as plant-based foods, as discussed in the literature by Aiking and de Boer (2020), Jiang et al. (2020), Temme et al. (2020) and Springmann et al. (2018), among others. In accordance with Springmann (2019), Poore and Nemecek (2018) and Clune et al. (2017), conducting literature reviews on life-cycle assessments of foods, plant-based foods have smaller ecological footprints, in terms of natural resources and greenhouse gas emissions (GHGE), than animal-based foods and, thus, should be incentivised, to reduce the ecological impact of food consumption. A reduction of animal-based consumption could also have a positive effect on health (Micha et al., 2017; Tang et al., 2017) and biodiversity (Crenna et al., 2019; Machovina et al., 2015). According to the World Health Organization (Bouvard et al., 2015), processed meat was classified as "carcinogenic to humans" and red meat as "probably carcinogenic to humans" and therefore, the worldwide consumption of these types of meat should be reduced in favour of healthier foods. Additionally, the literature on the benefits of plant-based food has been increasing, suggesting positive impacts on cardiovascular diseases (Matsumoto et al., 2019), on some cancers (Dinu et al., 2017), and on all-cause mortality (Appleby et al., 2016), among others. This does not mean, however, that animal-based foods are all unhealthy, rather that excessive consumption of these foods, particularly processed and red meats, may contribute to health problems, as described above (Löfvenborg et al., 2020; Mota et al., 2019; Wolk, 2017).

Furthermore, Seconda et al. (2018) show that plant-based diets produce lower greenhouse gas emissions, are healthier, and provide high nutritional quality at a lower monetary cost. The authors, studying a cohort of 34,193 participants, assessed the environmental, nutritional, and economic components of different diets. The authors concluded that "*participants with low GHGE diets consumed more plant-based products*" (p. 14) and that these people with "*low GHGEs are characterized by a low intake of food from animal origin*" (p. 11). Additionally, diets mainly composed of plant-based foods "*were also characterized by a high nutritional quality and a higher proportion of organic food*" (p. 11). According to Table 4 (p. 13), these low GHGE and highly nutritional diets were the least expensive of all diets assessed by the authors. Melina et al. (2016) suggests that plant-based diets, if planned correctly, are nutritionally adequate and may provide health benefits, further suggesting that these diets are appropriate for all stages of the life cycle. Furthermore, Springmann (2019) and Clark et al. (2019) discuss the positive relationship between plant-based diets and their effects on health and the environment. The authors conclude that plant-based diets are generally both healthier and more sustainable.

However, one issue concerning plant-based diets that deserves detailed attention by consumers is the level of pesticides present in the foods eaten. The literature recommends that strict regulation on this matter should be the norm. Seconda et al. (2018) conclude that healthy and low GHGE diets be based on high levels of organic produce, and this could explain the lack of any pesticide-related side-effects. Organic foods should be prioritised in the dietary transition to more plant-based foods. However, these foods are generally more expensive compared to conventional produce, and thus the need for strict regulation, guaranteeing that recommended levels are not exceeded. According to Winter (2015), who analysed the risk of consuming fruit and vegetables that are exposed to higher levels of pesticides, "*chronic dietary exposure to pesticides continue to be at levels far lower than levels considered to be of health concern*" (p. 11). This finding is further corroborated by Jara and Winter (2019) who concludes that residual pesticide violations are rarely a health concern.

Moreover, Winter (2015) further warns that "*Consumer fears from pesticide residues provide the potential for consumers to reduce their consumption of fruits, vegetables, and grains, negating [its] positive health benefits*" (p. 11). The author also warns of the potential risk of not eating enough fruit and vegetables, which is a chronic consumer characteristic worldwide. Huang et al. (2016) warn that, among low-income individuals, messaging about pesticide residue in fruits and vegetables can make consumers less likely to buy these highly nutritional foods, regardless of whether they are conventional or organic. The literature suggests that the health benefits of a diet rich in fruit and vegetables far

Table 1
Variables, description, and sources.

Variables	Description	Measure	Source
DTRN	New dietary transition	Ratio	FAO
PIC	Producer price index for cereals	Index	FAO
PIF	Producer price index for fruits	Index	FAO
PIV	Producer price index for vegetables	Index	FAO
PIM	Producer price index for meat	Index	FAO
PICA	Producer price index for cattle	Index	FAO
PICH	Producer price index for chicken	Index	FAO
PIPO	Producer price index for pork	Index	FAO
LCU	GDP per capita constant LCU	LCU/cap	WDI
LCU2	GDP per capita constant LCU (squared)	LCU/cap	WDI
FP	Female population	%	WDI
HDI	Human development index	Index	UNS
KOF	Globalization index	Index	KOF
TRY	Tertiary education	%	OECD
EIC	Emission intensities for cereal incl. rice	CO2/kg	FAO
EICA	Emission intensities for cattle	CO2/kg	FAO
PST	Pesticides used	Kg	FAO

Notes: LCU denotes local currency units, cap denotes capita, CO2 denotes carbon dioxide, and kg means kilograms.

Table 2
Descriptive statistics.

Variables	Obs.	Mean	Std. Dev.	Min.	Max.
LDTRN	500	1.0083	0.3295	0.4687	2.2341
LPIC	500	4.7920	0.3279	2.6313	5.5904
LPIM	500	4.6528	0.2392	2.7829	5.6500
LPIF	500	4.6940	0.3121	2.5923	6.1712
LPIV	500	4.6520	0.2553	2.9104	5.6133
LPICA	500	4.6352	0.2955	2.7294	5.6479
LPICH	500	4.7006	0.2599	3.0983	5.6449
LPIPO	500	4.6294	0.2589	2.2900	5.4180
LLCU	500	11.4385	2.0987	8.5984	17.2245
LLCU2	500	135.2355	53.3589	73.9324	296.6819
LFP	500	3.9343	0.0195	3.9076	3.9929
LHDI	500	−0.1668	0.0762	−0.4541	−0.0587
LKOF	500	4.3722	0.1022	4.0276	4.5143
LTRY	500	3.2057	0.4411	2.0088	4.0380
LEIC	500	−1.5140	0.3737	−2.5195	−0.3179
LEICA	500	2.7867	0.3719	1.8438	4.0341
LPST	500	9.5168	1.6214	5.2311	12.9800

Table 3
Cross-section dependence and panel unit root tests.

Variables	Cross-Section Dep.	Panel Unit Root Tests	
	CD-test	Constant	Constant & Trend
LDTRN	1.61	84.23***	117.609***
LPIC	40.54***	−3.232***	−0.771
LPIM	31.62***	−1.788**	1.494
LPIF	45.31***	−3.806***	−1.448*
LPIV	42***	−1.702**	−2.57***
LPICA	36.48***	−2.075**	0.768
LPICH	32.05***	−1.425*	−0.347
LPIPO	29.75***	−1.62*	0.732
LLCU	58.09***	−2.211**	0.729
LLCU2	58.05***	−2.035**	0.678
LFP	−0.28	525.413***	889.293***
LHDI	73.97***	−1.569*	−0.826
LKOF	71.58***	−2.091**	−0.369
LTRY	71.77***	−1.557*	−0.562
LEIC	10.91***	−1.781**	−2.002**
LEICA	0.67	77.688***	98.856***
LPST	−0.71	128.944***	121.595***
DLDTRN	4.55***	−8.27***	−5.524***
DLPIC	33.23***	−5.948***	−3.704***
DLPIM	15.04***	−4.229***	−2.91***
DLPIF	12.81***	−9.511***	−6.749***
DLPIV	16.97***	−5.486***	−3.092***
DLPICA	4.64***	−5.448***	−4.842***
DLPICH	18.19***	−7.537***	−6.111***
DLPIPO	17.79***	−8.667***	−6.59***
DLLCU	43.55***	−2.535***	−0.261
DLLCU2	43.57***	−2.551***	−0.229
DLFP	1.36	448.781***	631.501***
DLHDI	11.53***	−5.3***	−2.46***
DLKOF	32.22***	−4.743***	−3.783***
DLTRY	2.72	−7.746***	−5.955***
DLEIC	10.47***	−9.831***	−6.851***
DLEICA	1.22	327.576***	233.866***
DLPST	3.77***	−7.346***	−5.753***

Notes: The first-generation panel unit root test Maddala and Wu and the second-generation test CIPS have the null hypothesis: series are non-stationary. The CIPS is robust to cross-section dependence. Significance levels of 1, 5 and 10% are denoted as ***, **, *, respectively.

outweighs the potential pesticide-related risks. According to the literature, consuming conventionally grown produce is better than skipping fruit and vegetables (Lozowicka, 2015; Reiss et al., 2012; Valcke et al., 2017). Reiss et al. (2012) conclude that approximately 20,000 cancer cases per year could be prevented by increasing fruit and vegetables consumption, compared to the 10 cancer cases resulting from pesticide consumption. However, further monitoring and more research is needed

Table 4
Specification tests.

Models	I – Commodity Groups	II – Single-items
Breusch-Pagan LM test (RE)	1928.36***	1717.97***
Hausman test	85.34***	91.61***
Wooldridge test	86.987***	86.222***
Bc Born and Breitung test	23.29***	18.8***
Modified Wald test	1534.83***	2101.57***
Pesaran CD-test	4.658***	6.396***
Frees CD-test	1.939***	52.461***
Friedman CD-test	42.122**	1.713***

Notes: The Breusch-Pagan LM test for RE tests H0: Var(v_i) = 0; The Hausman test has a $\chi 2$ distribution and tests H0: that unobservable individual effects are not correlated with the explanatory variables; The Modified Wald test has $\chi 2$ distribution and tests H0: no heteroscedasticity; The Wooldridge test is normally distributed N(0,1) and tests H0: no first-order autocorrelation; The Bias-corrected Born and Breitung test has a Q distribution and tests H0: no serial autocorrelation; The Pesaran CD-test is a parametric testing procedure and follows a standard normal distribution, while the Frees and Friedman CD-tests are semi-parametric testing procedures and follow a Q and $\chi 2$ distribution, respectively. Significance levels of 1% are denoted as ***.

to guarantee that pesticide levels are not exceeded, to ensure the benefits of plant-based consumption, namely fruit and vegetables.

With regard to the economic component of plant-based diets, namely the cost of foods, the literature has recently shown that plant-based diets are generally cheaper than average omnivorous ones. For example, Lusk and Norwood (2016), using data on the expenditure of 24,537 consumers, concluded that "true vegetarians" (who do not buy animal-based foods) spend less money on food than their omnivorous counterparts. Moreover, according to Reynolds et al. (2019) it is "*possible to create diets with a 57% reduction in GHGE that met dietary and cost restraints in all income groups*" and further argues that changes are needed "*reducing animal-based products and increasing plant-based foods*" (p. 1). However, Hirvonen et al. (2020), analysing the cost of the EAT-Lancet reference diet, which is based mainly on plant-based foods, concludes that "*this diet costs a small fraction of average incomes in high-income countries, but is not affordable for the world's poor*" (p. 1). The authors further suggest that high-income countries should have no affordability problems in transitioning diets from animal-based to more plant-based. However, the authors also highlight that low-income countries will require some combination of higher income, nutritional assistance, and lower prices to guarantee the success of the dietary transition.

Nonetheless, considering the complexity of economic and social systems, and of human behaviour, it is often observed that changes aimed at reducing a specific type of consumption (e.g., animal-based consumption) do not necessarily lead to the intended outcome when net effects are considered, as the Jevons Paradox describes (Paul et al., 2019; Polimeni et al., 2015). This means that policymaking might produce counterproductive results if not all the information is accounted for.

1.2. Summary of objectives and methods

It is extremely urgent to understand what drives food consumption and, particularly a new dietary transition away from environmentally burdensome foods such as animal-based foods towards more plant-based foods, and this understanding is key to effectively promoting more sustainable food choices. This new dietary transition that is proposed here is not to be confused with the "nutrition transition" described by Popkin (1993), which has been observed throughout the last half of the 20th century, according to the author. The "nutrition transition" is described as a shift from staples rich in carbohydrates (cereals, roots and tubers) to foodstuffs derived from animal sources, vegetable oils and sugar-rich foods.

Considering the disparity between what is recommended by scientific literature and actual levels of consumption succinctly reviewed in Godfray et al. (2018), the present paper addresses the structure of dietary habits, exploring the possibility of a new dietary transition as an option to mitigate the environmental challenges faced. Thus, the main objective of this paper is to identify and understand the drivers of a potential new dietary transition. Potential drivers addressed range from: i) economic factors such as commodity food prices and income; ii) social factors such as education, level of development, globalization, and population and; iii) environmental factors such as emission intensities and chemical usage in agriculture. Thus, the contribution of this paper to the literature is to provide comprehensive knowledge on what motivates the new dietary transition. Only by understanding it, will policy makers be able to act effectively, and reduce the risk of potential unwanted spill over effects.

The novelty of this paper's analysis lies in its use of a world panel dataset to study a diverse group of potential drivers, in particular, the effect of prices, which has been extensively explored, and the role of higher education that is a new approach in the literature involving econometric models. Furthermore, assessing the new dietary transition, by itself, is also a novelty, because the existing literature has only focused on specific types of consumption such as the consumption of meat. The new dietary transition evaluated here, is represented by the ratio between plant-based consumption and meat consumption in calories. It estimates models using econometric techniques and guaranteeing their robustness, for a sample of 25 countries around the world during a period of 20 years (1998–2017). The analysis reveals that income, level of development, and globalization are barriers to the new dietary transition, whereas food prices, higher education and environmental awareness could be potential drivers to promote the transition. The analysis also shows that an inverse-U-shaped curve similar to the Environmental Kuznets Curve (EKC) is evident between income and the new dietary transition.

The paper is organized as follows: in addition to the motivation in section 1, section 2 briefly presents the literature. Data and methods are examined in section 3. Results are examined and discussed in sections 4 and 5, respectively. Lastly, section 6 concludes and suggests future research.

2. Literature review

While there have been some studies over the last two decades, analysing potential drivers of meat consumption, to the best of our knowledge, a dietary transition analysis has never been developed along the lines of the present study. Recent examples of analysis exploring determinants of food consumption, rather than dietary transition, are Milford et al. (2019), Janssen (2018) and Vranken et al. (2014). While the literature has assessed consumption of a specific food, such as meat, the current study is focused on the analysis of the dietary transition, specifically the ratio between plant-based and animal-based foods, which will be described in detail later. The use of robust and less-used econometric techniques is also a novel feature of the paper in comparison to other literature on the subject.

Nevertheless, the literature has suggested several factors that might influence this transition. The most commonly mentioned are population and income. With the increase of consumers and their purchase power, over the last 50 years an increase in consumption, specifically, meat consumption has been observed. Schmidhuber and Shetty (2005) outline two effects. The first, the “expansion” effect in which the total food consumed per capita increases, and the second, the “substitution” effect, in which there is a clear change in dietary composition from staples rich in carbohydrates (cereals, roots and tubers), to foodstuffs derived from animal sources, vegetable oils and sugar-rich foods. Popkin (1993) describes this change as the “nutrition transition”, which has been observed in the past in now developed economies, and is currently happening in the developing world.

The impact of income is consistent, as the literature reveals, but the intensity of the impact varies between countries and levels of income. The possibility of an Environmental Kuznets Curve (an inverted U-shape) has also been discussed. In terms of regions, according to York and Gossard (2004), Middle Eastern and African countries show a stronger positive effect of income growth on meat consumption, compared to Western countries. Furthermore, Regmi & Meade (2013) also show that the effect of economic growth on spending on meat and dairy is stronger in the poorer countries of Sub-Saharan Africa and South Asia than in wealthier countries, such as the United States. Cole and McCoskey (2013), Vranken et al. (2014) and Bodirsky et al. (2015) identify an EKC for the relationship between income and meat consumption, in which, as income increases so does meat consumption eventually reaching a peak after which meat consumption reduces.

Commodity food prices are also suggested as having a significant effect on food consumption, whether to increase or decrease certain types of consumption. Due to technological advances, economies of scale, and cheaper inputs in the food sector, the price of animal-based foods has been decreasing for the past 50 years relative to the price of other foods. Meat has become more affordable for consumers, even those who have not experienced an increase in their incomes (FAO, 2009). Many studies on food price elasticities have been carried out and Cornelsen et al. (2015), conducting a meta-analysis, found that, although meat consumption is negatively associated with prices, it is often inelastic, that is, the change in consumption is lower than the change in price for the specific meat. The study distinguishes between aggregated meat and single items, as well as by countries. Besides meat prices, prices of meat substitutes (cross-price) may also influence meat consumption. Wong et al. (2015) and Şahinli and Fidan (2012), computing food cross-price elasticities found that vegetables and pulses may act as substitutes for meat.

Social factors such as urbanization, education, gender, and age also have significant effects on meat consumption. According to Gossard and York (2003), all social factors, with the exception of urbanization, have a negative effect on meat consumption. However, Milford et al., (2019) show that urbanization is positively associated with meat consumption. This can be explained by the intrinsic characteristics of the urban population relative to the rural population, such as higher consumptions of food away from home and pre-cooked convenience foods (Schmidhuber and Shetty, 2005).

However, the availability of plant-based alternatives as pre-cooked and easy to deliver foods has been increasing in the market and may, in the future, revert the effect of urbanization seen in the literature. Better accessibility, higher exposure to advertising, better transport systems, and the larger supermarkets better able to refrigerate foods which have been promoting meat consumption (Popkin, 2006), might also be a potential driver to promote a new trend of plant-based foods. Thus, the effect of urbanization, if associated with other behavioural and individual-choice drivers, might be reversed.

The literature suggests that religion has influenced the consumption of meat as well. Vranken et al. (2014) and Milford et al. (2019) conclude that the effect is significant for major religions groups such as Christians (positive) and Muslims (negative), which is expected as Muslims are forbidden to eat pork, as are Jews. The same can be said for Hindus with respect to beef, and to branches of Buddhists forbidden to eat meat altogether.

According to Popkin (2006), globalization, which might imply an increase in cross-border movement of not only goods and services but also technology, information and cultural habits, could be a potential driver of food consumption. The “westernization” effect felt in developing countries, might be a result of this broadening globalization. Trade and foreign direct investment (FDI), according to Oberlander et al. (2017), lead to a convergence of domestic food systems, further contributing to dietary changes, much like the “nutrition transition” in which meat consumption is expanding. This is also suggested by Garciá-Dorado et al. (2019).

Therefore, there is a clear gap in the literature considering the drivers of a new dietary transition that support a more plant-based than animal-based consumption. Up to now, the literature has mainly focused specifically on meat consumption alone, and has not pursued a more holistic perspective of the interaction of other main food groups. Thus, this paper intends to contribute to the literature by filling this gap.

3. Data and methods

3.1. Data

In order to understand the potential drivers of this new dietary transition, the present analysis focuses on a panel dataset of 25 countries around the world over a 20-year time period (1998–2017). This dataset was chosen to obtain a balanced panel, as data on education is scarce, and the latest data on food consumption dates from 2017. Also due the availability of data, the countries assessed are geographically disperse. The majority is from Europe: Czech Republic, Denmark, Estonia, France, Germany, Greece, Hungary, Italy, Latvia, the Netherlands, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland and the United Kingdom, while there are also countries from other regions: Australia, Canada, Costa Rica, Japan, South Korea, Mexico, Turkey and the United States. However, only three are upper middle-income (Costa Rica, Mexico, and Turkey), whereas the rest are high-income countries.[2] Table 1 presents a summary of the variables used, including their description, measurement unit and source. The dataset is available online for download.[3]

To understand what drives the new dietary transition, a ratio was computed as the dependent variable (*DTRN*). It is the ratio between plant-based consumption and animal-based consumption as presented in Eq. (1):

$$DRTN = \frac{plant\ (kcal)}{livestock\ (kcal)}. \tag{1}$$

The higher the ratio, the greater the consumption of plant-based food compared to animal-based food (the desired transition). The lower the ratio, the greater the share of animal-based consumption relative to plant-based consumption. Rather than examining the absolute contribution of a given food group to caloric supply, the level of the new dietary transition of a country was assessed. This makes it possible to focus on the effect of transitioning from animal-based to plant-based sources.

For the drivers to be assessed, some followed those used in the literature, while others represent a new and novel approach. A bundle of price indices was assessed, both commodity group indices (cereals, fruits, vegetables, and meat) and single-item indices (cattle, chicken, and pig). Income was assessed via GDP per capita in constant local currency units. A squared version of the latter was also used to assess the possibility of an EKC, also discussed in the literature.

Social variables, such as the female population, HDI, and globalization were also computed. One innovation of this analysis was the assessment of the effect of education on food consumption, based on the number of all adults (25–65) who have completed at least tertiary level education. Also novel in this type of analysis, was the inclusion of environmental variables, specifically, emission intensities from cereal and cattle, and pesticide use. It is important to note that by considering a broader range of potential drivers, the possibility of biases from the omission of important variables was reduced. Extrapolations were computed for meat prices for the year 2017, for some countries. Food-related variables were collected from the Food and Agriculture Organization (FAO, 2020), while the economic and social variables came from World Development Indicators (WDI, 2020), United Nations Statistics (UNS, 2020), KOF Swiss Economic Institute (Gygli et al., 2019) and Organization for Economic Co-operation and Development Statistics (OECD, 2020). Therefore, the drivers of dietary transition are shown in Eq. (2). and Eq. (3):

$$DTRN = f(PIC, PIF, PIV, PIM, LCU, LCU2, FP, HDI, KOF, TRY, EIC, EICA, PST) \tag{2}$$

$$DTRN = f(PICA, PICH, PIPO, LCU, LCU2, FP, HDI, KOF, TRY, EIC, EICA, PST) \tag{3}$$

Following the equations, two models were computed, namely model I (Eq. (2).) with the commodity group indices and model II (Eq. (3).) with the single-item indices.

3.1.1. Descriptive statistics

Before the empirical analysis, an initial description of the data was carried out. Table 2 shows the descriptive statistics of all variables assessed. All variables were assessed in natural logarithms (*L*) to avoid scale issues with the coefficients and to facilitate their interpretation and make the relationships between variables linear.

To understand the trajectory of the new dietary transition, Fig. 3, composed of 2 subpanels, captures the dietary transition trends of 16 of the countries assessed, for the year 2017. The first subpanel shows the countries where a positive trend is observed, that is, where the ratio of dietary transition (more plant, less animal) increased throughout the period. In contrast, the second subpanel shows the countries where a negative trend is observed. For example, central European countries such as France, Germany and the Netherlands show a positive while eastern Europe countries such as Estonia, Latvia, Slovakia and Poland show a negative one. All three upper middle-income countries (Costa Rica, Mexico, and Turkey) show a negative dietary transition trend. Turkey and South Korea are not shown in the subpanels because they have large changes of dietary transition throughout the period which would make the graphical analysis difficult if included with the other countries. Nonetheless, these countries also show negative trends. For a complete analysis, the dataset assessed here is available online for download, as mentioned earlier.

Moreover, for the countries showing a positive trend throughout the period, some show a negative regression, such as Spain and Italy in the last two years of the timespan, and others show it earlier, such as France and Germany. Overall, only the Netherlands, Switzerland and the United Kingdom show a steady positive trend in the dietary transition, that is, a growing share of plant-based foods (numerator) compared to animal-based foods. These trends reflect the recommendations from environmental and health institutions such as the IPCC (IPCC, 2019), the WHO (Bouvard et al., 2015) and the EAT-Lancet commission (Willett et al., 2019), which advise that animal-based foods should be reduced in favour of more plant-based foods. Another insight that can be observed in the figure is the recurrent effect of westernization on diet in Eastern Europe countries. The same can be said about Japan and South Korea. It is possible that the high animal-based consumption of western culture is influencing eastern countries. Besides cultural influences, income also appears to influence food consumption. Whereas the less economically favourable countries show steady negative trends (less plant-based and more animal-based), the most economically favoured exhibit an unchanged or even positive trend (increasing ratio). The effect of income is further discussed in the analysis of the inverse-U-shaped curve similar to the EKC.

3.2. Methods

In order to accomplish the objective of understanding the drivers of the new dietary transition, coefficients were estimated using econometric panel data techniques. The advantage of using panel data is that it covers

[2] According to the World Bank classification, as of 1 July 2020, upper middle-income economies are those with a GNI per capita between $4046 and $12,535; and high-income economies are those with a GNI per capita of $12,535 or more.

[3] Original dataset can be found in: Pais, Daniel (2021), Mendeley Data, V1, doi: 10.17632/cf2gn7w8cm.1.

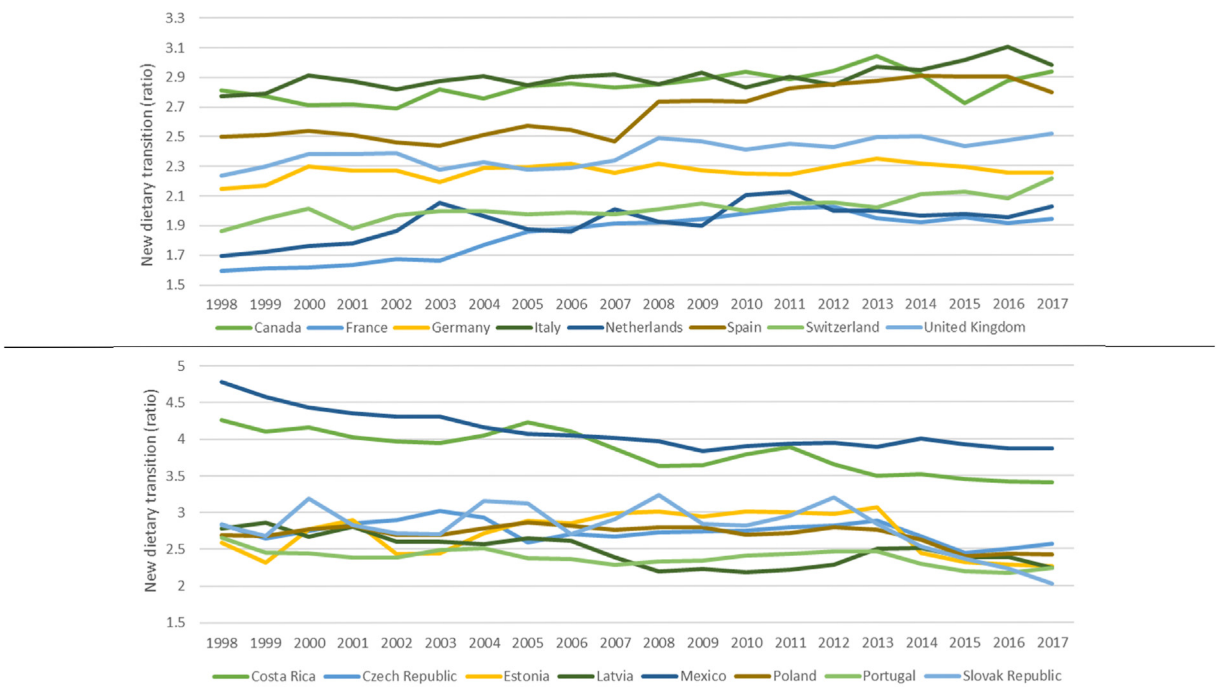

Fig. 3. Trends of the new dietary transition (ratio) for assessed countries.

more information, since it includes more countries and their specific effects, rather than a pooled dataset in which countries are aggregated. Before the models are estimated, a battery of diagnostic tests needs to be run to ensure the validity of the models and to act as blueprints for their elaboration. The econometric analysis in this study was conducted using the STATA 15 statistical software.

The analysis was made as follows: (i) a preliminary inspection was made of the data using the descriptive statistics (see section 3.1.1.); (ii) tests were undertaken to detect cross-section dependence, panel unit roots, panel autocorrelation, heteroskedasticity, contemporaneous correlation, and multicollinearity; (iii) the results obtained provided the basis for choosing the most suitable estimator, such as the Panel Corrected Standard Errors (PCSE) estimator; (iv) lastly, the robustness of the results was validated through comparing different estimators.

The PCSE estimator is well suited when there is autocorrelation, heteroskedasticity and contemporaneous correlation among the panels. Another suitable estimator for data with these characteristics is the Feasible Generalized Least Squares (FGLS) estimator. However, due to its prerequisite that $T \geq N$, which was not met in the study sample since the number of years ($T = 20$) was smaller than the number of countries ($N = 25$), the FGLS was abandoned. The models were estimated as follows:

$$Y_{it} = \alpha + \sum_{k=1}^{j} \beta_k X_{it} + D_t + \varepsilon_{it}, \tag{4}$$

where Y represents the dependent variable (*DTRN*), and X represents a vector of independent variables. The constant is represented by α, and ε is the error term. The subscripts i and t denote country and year, respectively, while j is the number of independent variables (drivers). D denotes a dummy. In the following tables, the natural logarithms are denoted as L and first differences as D before the variables.

4. Results

4.1. Diagnostic tests

To assess the data characteristics mentioned above, a battery of diagnostic tests was applied. First, the presence of cross-section dependence among the variables was assessed by applying the CD-test. Table 3 shows the results.

As can be seen, cross-section dependence is present for the majority of the variables with the exception of *LDTRN*, *LFP*, *LEICA*, *LPST*, *DLFP*, *DLTRY* and *DLEICA*. Since these variables did not show cross-section dependence, the first-generation panel unit root tests Maddala and Wu was used. At the same time, the second-generation CIPS test was applied to the rest of the variables. The results, also shown in Table 3, reveal that all variables were stationary in levels without constant, that is, none of the variables had a unit root, I(1), all were I(0). First differences validated the results. Since not all the variables were stationary with a trend, the variable was not applied in the models.

To choose the most suitable estimator among the pooled OLS and the Random Effects (RE) estimators, the Breusch-Pagan LM test was applied with the null hypothesis indicating the pooled OLS. The result, displayed in Table 4, rejects the null hypothesis. This rejection of the pooled OLS further confirmed the suitability of the panel methods proposed. Comparing the Fixed Effects (FE) and RE estimators, the Hausman test validated the suitability of the former, by rejecting the null hypothesis of RE, also shown in Table 4.

Table 4 shows the results of tests to detect the presence of panel autocorrelation, heteroskedasticity and contemporaneous correlation among the countries studied. The Wooldridge test for panel autocorrelation and the bias-corrected Born and Breitung test were calculated. Both tests rejected the null hypothesis of no autocorrelation. The modified Wald statistic for heteroskedasticity in the residuals was also carried out, and rejected the null hypothesis of homoskedasticity. The Pesaran, Frees, and Friedman tests for contemporaneous correlation were then computed. The presence of contemporaneous correlation was validated, with the rejection of all null hypotheses. To test for multicollinearity between the variables and, particularly, between HDI, tertiary education, and income, the Variance Inflation Factor (VIF) test was conducted. Since the HDI incorporates both an education index and an economic index, overlaid effects might have been an issue. The results from the VIF test revealed that all VIF values were under 10, and the mean VIF was 2.94. The highest value was 8 for the HDI, but the values for tertiary education and income were below 3, suggesting that multicollinearity is not a concern. Nonetheless, the indexes included in the HDI, although representing educational and economic perspectives are different from the proxies used in this study.

Results from the specification tests confirmed that the panel dataset was autocorrelated, heteroskedastic, and contemporaneously correlated. The FE estimator is not robust when handling data with these characteristics, so another more suitable estimator was needed. As mentioned before, the PCSE estimator is capable of handling these characteristics, so long as the respective specifications are considered when estimating the models. We opted to specify contemporaneously correlated AR(1) autocorrelation structures (AR1), and panel-specific AR(1) autocorrelation structures (psAR1) for both models.

4.2. Model results

After confirming the diagnostic tests, four estimations were computed, two for each model (I.1, I.2, II.1 and II.2). The results are displayed in Table 5. To also reveal where variables had no impact on the new dietary transition, the estimated models did not follow the parsimonious principle.

Overall, the results revealed strong consistency in econometric terms, with similar values and levels of statistical significances, irrespective of the correlation structure specified or model (for the variables which are common to both models). The Wald test was statistically significant, which also indicates the consistency of the models. The shift dummy *D2013* was applied from 2013 onwards to accommodate a breakpoint in FAO's methodology in the dependent variable. Its non-significance means that this breakpoint did not influence the analysis and thus remained in the model to validate this. Furthermore, the high R^2 supports the consistency of the models.

From examining Table 5, in terms of prices, only the commodity group indices of cereal and meat are statistically significant, whereas the price of fruit and vegetables does not affect the dietary transition. The same can be said about the single-item indices for cattle and chicken, which are statistically significant compared to pork. The highest effect is from meat, but even here, following a 1% increase in the meat price index, the dietary transition increases no more than 0.1%. This effect is smaller than the one observed for higher education. Following a 1% increase in tertiary education, the dietary transition increases a maximum of 0.14% (model II.2). Of all the drivers, higher education is the most effective in promoting the new dietary transition. Environmental factors, such as the emission intensities of cattle and the use of pesticides, also appear to promote the transition.

From the coefficients, it is possible to identify an inverse U-shaped curve for income, that is, higher income reduces the dietary transition (less plant-based food, more meat) until a certain point beyond which this reverses, and the dietary transition increases (more plant, less meat). In other words, a Kuznets curve is revealed. If the quotient for the dietary transition, with plant-based consumption as the numerator and meat the denominator, were inverted (meat/plant), the shape of the curve would also invert, showing a U-shaped curve.

The index for human development, globalization, and the female population, all appear to be barriers to the new dietary transition, with the highest being the female population. Following a 1% increase in the female population, the dietary transition reduces more than 5%. The same can be said about the development index (−1.70%) and globalization (−0.75%).

To check for robustness, a comparison was made between the most suitable estimators, and the classic pooled OLS, FE, and RE estimators. The robust option was computed for the latter two to correct for heteroskedasticity. Table 6 shows the results for all estimators.

As can be seen, all the coefficients maintain the same signs, when statistically significant, independent of the estimator used. Although both FE and RE estimators control for heteroskedasticity with the *robust* option, the coefficients are still biased in terms of significance levels since

Table 5
Results.

Dependent Variable *LDTRN*				
Independent Var.	Model I – Commodity Groups		Model II – Single-items	
	I.1	I.2	II.1	II.2
LPIC	0.0511**	0.0430		
LPIM	0.0872***	0.0918**		
LPIF	−0.0133	−0.0291		
LPIV	0.0028	0.0020		
LPICA			0.0500**	0.0475*
LPICH			0.0625**	0.0646*
LPIPO			0.0078	0.0023
LLCU	−0.7298***	−0.6675***	−0.6659***	−0.6498***
LLCU2	0.0295***	0.0269***	0.0267***	0.0261***
LFP	−5.4093***	−4.7049***	−4.4633***	−4.5473***
LHDI	−1.6756***	−1.7083***	−1.6833***	−1.7460***
LKOF	−0.7625***	−0.7404***	−0.8140***	−0.7756***
LTRY	0.1125***	0.0628**	0.1382***	0.0652**
LEIC	−0.0154	−0.0040	0.0012	0.0124
LEICA	0.0602**	0.0085	0.0665**	0.0014
LPST	0.0429***	0.0371***	0.0415***	0.0379***
D2013	0.0129	0.0144	0.0127	0.0143
CONS	28.0928***	25.3622***	24.2183***	24.7956***
Obs.	500	500	500	500
R^2	0.9243	0.7545	0.9110	0.7547
Wald ($\chi2$)	971.96***	369.65***	961.81***	444.98***

Notes: The Wald test has $\chi2$ distribution and tests H0: non-significance of all coefficients of the explanatory variables. Model I.1 denotes psAR1, while model I.2 denotes AR1, the same applies for model II.1 and II.2, correspondingly. ***, **, * denote statistical significance at 1, 5 and 10% levels, respectively.

Table 6
Robustness of results.

	Model I – Commodity Groups				Model II – Single-items			
	PSCE I.1	OLS	FE ROB.	RE ROB.	PCSE II.1	OLS	FE ROB.	RE ROB.
LPIC	+ (**)	+ (***)	+ (**)	+ (**)				
LPIM	+ (***)							
LPIF								
LPIV								
LPICA					+ (**)	+ (**)		
LPICH					+ (**)			
LPIPO						- (***)	- (***)	- (**)
LLCU	- (***)	- (**)			- (***)	- (*)		
LLCU2	+ (***)	+ (**)			+ (***)	+ (**)		
LFP	- (***)	- (***)	- (**)	- (*)	- (***)	- (***)	- (**)	- (**)
LHDI	- (***)	- (***)	- (*)	- (**)	- (***)	- (***)		- (***)
LKOF	- (***)				- (***)			
LTRY	+ (***)	+ (***)	+ (**)	+ (***)	+ (***)	+ (***)		+ (***)
LEIC		- (***)	- (*)	- (**)		- (***)	- (**)	- (**)
LEICA	+ (**)	+ (***)			+ (**)	+ (**)		
LPST	+ (***)	+ (**)				+ (***)	+ (**)	
D2013		+ (*)	+ (**)	+ (***)		+ (**)	+ (***)	+ (***)
CONS	+ (***)	+ (***)	+ (**)	+ (**)	+ (***)	+ (***)	+ (**)	+ (*)
Obs.	500	500	500	500	500	500	500	500
F-test		***	***	***				
Wald	***				***	***	***	***

Notes: Model I.1 and II.1 denote psAR1. ***, **, * denote statistical significance at 1, 5 and 10% levels, respectively.

contemporaneous correlation is not controlled. Thus, some coefficients do not appear to be statistically significant when, in fact, they could be. Furthermore, although the signs are maintained, the robustness check suggests the need to apply other estimators, such as the PCSE, when there is panel autocorrelation and contemporaneous correlation. If only the FE and RE results are considered, they might lead to biased conclusions and erroneous implications.

5. Discussion

This section discusses the results, with the objective of understanding which factors promote or hinder the new dietary transition. Beyond merely analysing the impacts of each of the drivers, it is even more important is to deduce from them effective policies to promote the dietary transition needed to safeguard public health and planetary sustainability.

5.1. The policy implications of effectively promoting a new dietary transition

Both economic theory and the literature, which will be described in detail below, suggest that meat prices have a negative effect on meat consumption and, therefore, were expected to have a positive effect on the new dietary transition. Following individual consumer theory, as prices increase (or decrease), consumption decreases (or increases), *ceteris paribus*. Moreover, as the cross-price increases (or decreases), consumption increases (or decreases), i.e., if the price of meat substitutes increases, the consumption shifts away from that specific food, and meat consumption may increase. These substitutes are represented in this study by the commodity group prices of cereals, fruit, and vegetables. However, contrary to expectations, only the price of cereals had a statistically significant effect.

The absence of a statistically significant effect by fruit and vegetables could be explained by the fact that neither is essential to consumers seeking to satisfy caloric needs. Fruit and vegetables have low caloric density and are more valued for their micronutrients such as vitamins and minerals. The price of cereals was expected to be negative to dietary transition as consumers tend to shift away from cereal-based foods when their price increases, as pointed out by Cornelsen et al. (2015). However, our results show a positive and significant effect. This might be because most cereal is harvested to feed animals and, thus, any price increase also affects the price of feed and, consequently, the price of meat. It seems that the impact of price increases for cereals has a greater impact on animal feed than on direct human consumption. Therefore, a policy merely intended to alleviate cereals prices might be ineffective in promoting the new dietary transition.

A tax on meat, on the contrary, thereby, making it more expensive, might promote a reduction in consumption and thus boost the dietary transition. For single-item foods, the consumption of chicken is more elastic than that of cattle, although, overall, meat is the most elastic and has the greatest impact. The dietary transition increases more from an increase in the price of chicken than from an increase in the price of cattle ($0.063 > 0.05$). However, the impact is still very low compared to the other drivers. Academic studies on food price elasticities are scarce, particularly when assessing single-item foods. Gallet (2010), presenting the most comprehensive meta-analysis on price elasticities of meat to date, shows more elastic effects for overall meat and specific meats compared to the results shown here. It is important to note that the current study does not analyse price elasticities directly, but looks at the effect of prices on the transition, rather than the consumption level of any specific food. Nevertheless, Gallet (2010) suggests that the price elasticity of poultry is lower than that of beef, in contrast to the values observed here. This could be due to the different study samples and dependent variables used. Again, our analysis is concerned with the dietary transition and not specific consumption. Nonetheless, the differences are not significant. Moreover, our findings corroborate those observed by Green et al. (2013) in respect to overall meat price elasticities.

With regard to the impact of income, there is evidence of an EKC phenomenon. With increases in income, consumers initially tend to consume more meat and/or less plant-based food, reducing the dietary transition. However, once they reach a certain income level, consumers begin to choose less animal-based and/or more plant-based food. These findings are corroborated in the literature, namely by Vranken et al. (2014) and Cole and McCoskey (2013) with respect to high-income countries. This introduces a dilemma, as it is expected that lower-income countries will increase their per capita income over time, which is undoubtedly desirable. However, with this increase, the consumption of environmentally burdensome products such as animal-based food also increases. Therefore, it is important to define strategies that guarantee economic prosperity without risking the environment and public health. Such strategies could employ a "leapfrogging" framework to "tunnel" through the EKC (Munasinghe, 1999), thereby avoiding the worst effects at the peak of the curve. "Tunnelling" strategies have been investigated for other areas where the EKC has been identified, such as deforestation (Culas, 2012), energy (Lu et al., 2015), and health (Brajer et al., 2008), among others. Developing countries could learn from the experiences of more developed countries and benefit from new technologies and a better understanding of food consumption to meet sustainability targets. However, asking lower-income economies not to make the same mistakes as high-income economies, raises a moral dilemma as to why the former should restructure their dietary habits to repair the potentially irreversible environmental damage caused by developed countries. In reality, this restructuring is not occurring, because developing countries are eagerly adopting the consumption habits of the developed world.

This effect is further exacerbated by globalization. A more globalized world tends to promote a less desirable "nutrition transition" towards a diet high in foodstuffs derived from animal sources, and the effect of "westernization" is evident in this study. According to its results, the proxy used to assess globalization (*LKOF*) has a negative effect on the dependent variable (*DTRN*). This means that higher levels of globalization correspond to a decrease in the new dietary transition. This negative effect is in line with the findings of other scientific studies, particularly the "nutrition transition" mentioned in the literature (Oberlander et al., 2017; Popkin, 2006; Sievert et al., 2019). There are several explanations for this phenomenon. Firstly, increased globalization means a greater variety of food products are traded internationally. Secondly, with greater incomes, consumers have more to spend and a greater variety to choose from, and tend to prefer animal-based foods. According to García-Dorado et al. (2019), economic globalization, particularly FDI, could be associated with increases in overnutrition and a greater number of the overweight and obese. Another possible economic factor is the reduction in the average cost of production from the economies of scale provided by a more globalized market. Once again, this reinforces the idea of the "nutrition transition" introduced by Popkin (2006), who postulates that there is a positive relationship between globalization and animal-based consumption. With higher levels of globalization, production costs are likely to fall, decreasing the price of foodstuffs that were once expensive, such as animal-based products. Further evidence of all these explanations is the fact that one of the variables used to compute the KOF indicator is the number of McDonalds in a country. More McDonalds means a higher KOF.

If meat consumption and overall consumption needs to be reduced, in favour of a more plant-based diet, the developed world needs to take the lead so that developing countries can be persuaded to follow their example. Technology innovations need to be transferred to boost efficiency and bring new products to the market. Campaigns also need to be held to raise awareness among the general population about sustainable and healthy food consumption. Education is a more effective tool than price mechanisms, to promote the new dietary transition, as our results show ($0.1125 > 0.0872$). This means that consumers with higher levels of education tend to consume less meat and/or more plant-based foods. This finding is in accordance with those of Koch et al. (2019), who, in a study of 12,915 participants, found that consumers of plant-based food tended to be more educated (see also Lacour et al., 2018). This only illustrates that more highly educated consumers tend to absorb and develop better dietary habits. Therefore, policymakers should develop strategies that ensure the dissemination of knowledge on food consumption and focus on higher-risk groups, such as the economically and educationally disadvantaged. The proportion of females in a population also appears to be a significant factor hindering the new dietary transition, so further detailed study is required to understand why this is the case. Pais et al. (2020) summarize some of the policies discussed in the literature, focusing on the role of education.

Another important finding is that the HDI does not consider the role of ecological sustainability in its analysis. According to our results, the HDI is a barrier for the new dietary transition, i.e., higher levels of development in a country tend to inhibit its dietary transition. This suggests that the index may need to be restructured to incorporate the aspect of ecological sustainability.

Furthermore, environmental factors were shown to have a positive effect on the new dietary transition. Some explanations can be suggested. With respect to the emission intensities of cattle (the highest among food types), in countries with higher intensities (low efficiencies), consumers tend to eat less meat and/or more plant-based food. On the one hand, this could be explained by the fact that countries with low efficiencies tend to import cattle, making it more expensive and, thus, reducing its consumption. This finding is new to the literature, and caution is needed regarding its interpretation. On the other hand, the variable may be understood as a proxy for environmental awareness, in that consumers aware of the higher emission intensities of cattle and the consequently higher pollution levels, may opt to consume less. However, this finding is not confirmed in the literature, namely Macdiarmid et al. (2016), who suggest that environmental awareness, although it is still poor among consumers, does not stop them from increasing animal-based consumption. Moreover, according to Chekima et al. (2016), environmental advertising is the main driver of green purchasing intentions, while environmental knowledge is not significantly related.

With regard to pesticides, if consumers know their agriculture sector uses high doses of pesticides, they may opt for alternative food sources, such as organically-certified or home-grown foods. According to Huang et al. (2016), messaging about pesticide residue in fruits and vegetables can make consumers less likely to buy these foods, regardless of whether it is conventional or organic. Nonetheless, although the use of pesticides is more associated with the cultivation of plant-based foods, the feed used for livestock may also contain high quantities of pesticides, as well as antibiotics and growth hormones, which also represent a potential threat to human health (Ferri et al., 2017). Considering the innovative nature of the environmental variables used in this study, more research is needed to secure a stronger consensus. Nevertheless, overall, consumers may opt for organic certification, which is more common among plant-based foods than animal-based ones (Lacour et al., 2018).

6. Conclusions and future research

The analysis conducted here focused on the drivers of a potential new dietary transition away from environmentally damaging products such as animal-based foods, and towards more plant-based foods. Potential drivers such as income, price, education, human development and environmental awareness were assessed for 25 countries around the world over the last two decades. In view of the data's characteristics, panel-corrected standard errors estimators were used. Results suggest that, in campaigns to promote the new dietary transition, policymakers should complement price mechanism strategies with educational initiatives. Environmental awareness and low efficiencies regarding emissions, also need to be incorporated in the discussion to devise better policies. Another barrier in the short-term is income, but, if properly handled, it could be an advantage. If policy makers can encourage developing countries to make better ecological decisions, irreversible environmental damage can be avoided, but only if developed countries set an example by following a sustainable path.

This area of research is relatively new, and there are few studies, particularly recent ones, compared to other fields of investigation into public health and environment sustainability. Consequently, comparing the study's results with the literature proved challenging. Nonetheless to devise policies on food consumption that will be effective and efficient, it is crucial to understand what motivates consumers. Hence, the innovative approach taken in this paper in addressing the impact of higher education, prices, and environmental awareness on the new dietary transition, and in analysing this dietary transition, rather than the consumption of a specific food type, as is common in the literature.

Further research is needed, particularly to understand the role of institutions and advertising in influencing food consumption. Other areas could not be fully explored here and deserve further study. The urban population encompasses a broad array of potential effects that may be important to analyse individually, but the effect of urbanization was not analysed here, due to methodological issues, specifically, the stationarity of the variable. Similarly, the effect observed for the female population requires a more detailed analysis to understand the intrinsic characteristics of this group that lead to the impact observed here. Moreover, this is only possible if the data is available, a persistent issue in empirical studies such as this.

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Appendix

Table A.1
List of abbreviations

CAP	Per capita	*KOF*	*Globalization index*
CO2	Dioxide carbon	*LCU*	*GDP* per capita *constant LCU*
DTRN	*Dietary transition*	*LCU2*	*GDP* per capita *constant LCU (squared)*
EIC	*Emission intensities (cereal)*	PCSE	Panel corrected standard errors
EICA	*Emission intensities (cattle)*	*PIC*	*Producer price index (cereals)*
EKC	Environmental Kuznets Curve	*PICA*	*Producer price index (cattle)*

(*continued on next column*)

Table A.1 (*continued*)

CAP	Per capita	*KOF*	*Globalization index*
FAO	Food and Agriculture Organization	*PICH*	*Producer price index (chicken)*
FDI	Foreign direct investment	*PIF*	*Producer price index (fruits)*
FE	Fixed effects	*PIM*	*Producer price index (meat)*
FGLS	Feasible generalized least squares	*PIPO*	*Producer price index (pork)*
FP	*Female population*	*PIV*	*Producer price index (vegetables)*
GNI	Gross national income	*PST*	*Pesticides used*
HDI	*Human development index*	RE	Random effects
HIC	High-income countries	*TRY*	*Tertiary education*
IPCC	International panel on climate change	UNS	United Nations Statistics
KG	Kilograms	VIF	Variance inflation factor

Notes: the variables assessed in the models are in *italic*.

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