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JEL Codes: C13; F61; I12

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Globalisation and national trends in nutrition and health - a grouped fixed-effects approach to inter-country heterogeneity*

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October 2016

Abstract

Using a panel dataset of 70 countries spanning 42 years (1970-2011), we investigate the distinct effects of economic and social globalisation on national trends in markers of diet quality (supplies of animal protein, free fat and sugar, prevalence of diabetes, average body mass index). Our key methodological contribution is the application of the grouped fixed-effects estimator, which extends linear fixed-effects models to include both time-invariant and time-varying unobserved heterogeneity, under the assumption that both the latter and the former follow group-specific patterns. We find that increasing social globalisation has a significant impact on the supplies of animal protein and sugar available for human consumption. Specific components of social globalisation like personal contacts with foreigners and above all information flows drive these results. Economic globalisation has no effect on dietary outcomes, and has a negative impact on health. These findings suggest that the social and cultural aspects of globalisation should deserve greater attention in studies of the nutrition transition.

Keywords: nutrition transition; obesity; economic globalisation; social globalisation; grouped fixed-effects; panel data.

JEL Codes: C13; F61; I12.

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1 Introduction

High- and middle-income countries have experienced a profound shift in their population diet over the past decades. Food supply as measured by calories available for human consumption¹ has significantly increased, which has improved food security (Thompson et al., 2012). Yet, while a large share of the population in middle-income countries has escaped from hunger, the nutrition composition of national diets has also changed. The supply of carbohydrates² other than sugar has moderately increased, while in contrast, the supplies of animal protein, free fat,³ and sugar have experienced a significant growth. Popkin (1993) has introduced the concept of nutrition transition to describe these dietary changes.

Countries at different stages of economic development are also at different stages of the nutrition transition. While high-income countries are reaching a new historical equilibrium characterized by high levels of fat, animal protein and sugar supply, middle-income countries are still experiencing important changes.⁴ Since the 70s, the amounts of energy in kilocalories per capita per day (kcal/capita/day) derived from animal protein, free fat and sugar has risen much faster in middle-income countries than in high-income countries (cf. *infra*). Thus, the nutrition patterns observed in middle-income countries may converge to those achieved in high-income countries, even if diets remain heterogeneous at the world level.

The nutrition transition poses important policy challenges for health. Epidemiological data collected in high-income countries show that diets rich in sugar, free fat and animal protein constitute important risk-factors for non-communicable diseases such as cardiovascular diseases (CVD), diabetes, obesity and a number of cancers (WHO, 2015*b*). In 2012, 17.5 million people died from CVD ranking them as the number one cause of death globally. More than three

¹ Due to data availability, we use food supply available for human consumption as a proxy for calorie intake. This approach may overestimate actual calorie intake as food waste is ignored.

² Carbohydrates are sugar, and starches found in fruits, grains, and vegetables. Products rich in carbohydrates are cereals, pasta, rice, bread, corn, peas, and lentils.

³ We group in the 'free fat' category, all fats available from oil, butter, and cream. These food items are used by individuals and firms essentially for the taste and chemical properties of their fats.

⁴ This paper focuses on high- and middle-income countries and leave aside low-income countries. Among middle-income countries, a distinction is made between upper- and lower-middle-income countries. This distinction follows the World Bank classification: <https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups>.

quarters of CVD deaths takes place in low- and middle-income countries, causing substantial economic and welfare losses (WHO, 2015a). As a consequence, the World Health Organisation (WHO) regards food-related chronic diseases as a growing threat all over the world, replacing traditional public health concerns such as undernutrition and infectious diseases (WHO, 2000).⁵

Globalisation of national economies is usually seen as a key driver of the nutrition transition (Hawkes, 2006; Popkin, 2006; Bishwajit et al., 2014). The existing evidence for this claim, however, consists mostly of case studies that link observed changes in diets to substantial alterations of national food system following trade openness (Hawkes and Thow, 2008; Thow and Hawkes, 2009; Thow et al., 2011) and significant foreign direct investments (FDI) in the food industry (Hawkes, 2006). These case studies typically focus on the economic aspects of globalisation, and fail to take into account the multifaceted nature of globalisation.

Olivier et al. (2008) propose a theoretical model, which shows that the economic and the social dimensions of globalisation can have opposite effects on the inter-country heterogeneity in (food) cultures. In their model, consumers have to choose between a domestic cultural good (e.g. national cuisine) and a foreign cultural good. In addition to a private hedonic value, a cultural good has a cultural externality. Consumption signals membership in a cultural group (domestic vs. foreign). The cultural externality increases with the share of individuals affiliated to the cultural group, as a larger group reinforces the sense of belonging and facilitates social exchange. An overlapping generation model then describes the dynamic transmission of cultural preferences between generations. Parents have more incentives to transmit their own culture, when the domestic good has a high cultural externality (e.g. high market share) or when its price is relatively low. If the world integration of the domestic market induces a fall in the market price of the domestic good, then its consumption is associated with larger cultural externalities and becomes more attractive. Hence, economic globalisation will *preserve (food) cultures* across countries, and even lead to cultural homogeneity within a country and to cultural divergence across countries. This prediction has to be somewhat nuanced when considering nutrition

⁵ While this paper focuses on inter-country heterogeneity in population-average diet, we do not forget that under- and over-nutrition coexist in many places: as for income distribution, a rise in the average food supply may be accompanied by increasing inequalities within countries.

outcomes and food supply. First, two distinct food cultures may be associated with similar nutrition patterns (e.g. same supplies of protein, fat and sugar). Second, the prediction does not hold if returns to scale are increasing, which is likely to happen in food markets dominated by very large multinational firms (Maystre et al., 2014). With such a market structure, economic integration implies a larger decrease in the prices of the cultural goods produced by the largest firms. These firms thus have a dynamic advantage in terms of preference transmission in the integrated market (for example, as illustrated by the market penetration of Coca-Cola in many emerging countries). Hence, while economic globalisation may preserve food culture, we remain cautious about its effect on nutrition patterns.

The model prediction regarding the effect of social globalisation on nutrition is more clear cut. When countries become socially integrated, the worldwide share of the population consuming the domestic good mechanically decreases, inducing a reduction in its cultural externality. Consequently, domestic demand declines, which weakens the dominance of the domestic food culture. As the same process takes place simultaneously in all countries, cultural heterogeneity across countries decreases. Therefore, social globalisation causes a *convergence of (food) cultures* across countries, and therefore a convergence of nutrition patterns.

We empirically test for these theoretical predictions by analysing trends in nutrition and food-related diseases in a panel of 70 high- and middle-income countries observed between 1970 and 2011. We expect social globalisation to have a higher predictive power than economic globalisation. Our paper contributes to the burgeoning literature on globalisation and health. Using a fixed-effect approach, Vogli et al. (2014), Goryakin et al. (2015) and Miljkovic et al. (2015) investigate the impact of globalisation on overweight and obesity. The economic and social aspects of globalisation are measured by the KOF index, and health and nutrition data are provided by international institutions.⁶ Goryakin et al. (2015) highlight a positive effect of social globalisation and a small negative effect of economic globalisation on female overweight.

⁶ Vogli et al. (2014) use data from 128 countries, 1980-2008; Goryakin et al. (2015) pool Demographic Health Surveys (on women) from 56 countries, 1991-2009; Miljkovic et al. (2015)'s sample consists of 79 countries, 1986-2008. In addition, a study by Costa-i-Font and Mas (2014) uses an instrumental variable approach (without controlling for country fixed-effect) to examine the link between globalisation and obesity. They find a positive effect of globalisation on obesity.

Miljkovic et al. (2015) report also a positive impact of social globalisation on obesity. Yet, unlike Goryakin et al. (2015), they find that a sub-dimension of economic globalisation, trade openness, has a positive impact on country obesity, while foreign direct investments have no effect. One explanation for these contradictory results is that Miljkovic et al. (2015) do not control for the income effect of economic globalisation (variations in economic globalisation and in GDP are very collinear in their data).

We add to this literature by studying the effects of both economic and social dimensions of globalisation (measured with the KOF index) on three key indicators of nutrition transition, e.g. the supplies of animal protein, free fat, and sugar available for human consumption. These nutrients experienced the largest growth rates over the past 40 years and are strongly correlated with negative health consequences.⁷ We also examine the impact on two health outcomes associated with nutrition transition, e.g. the BMI and diabetes prevalence. We provide results for a long time period (1970-2011) and for each subcomponent of the KOF index. Our empirical analysis is based on the theoretical model developed by Olivier et al. (2008), which proposes testable predictions regarding the separate effects of social and economic globalisation through well-specified *cultural* mechanisms. All regressions control for the income effects of economic globalisation. Importantly, we use the Grouped Fixed-Effects (GFE) estimator developed by Bonhomme and Manresa (2015) to control for time-invariant *and time-varying* unobserved heterogeneity across countries under the assumption that the latter follows grouped patterns. This innovative estimation technique accounts for trends in potential unobserved confounders of globalisation, which is not the case for usual country fixed-effect models. Thus, it greatly reduces the potential for omitted variable bias in the identification of the globalisation effect. Thereby, the GFE estimator permits long-term analyses when additional control variables are not available for a long time period.

Our results suggest that the effect of economic globalisation is somewhat over-estimated by food experts. Estimations for the 1970-2011 period show that social globalisation has a positive

⁷ High intake of sugar increases the risk of overweight and type 2 diabetes (Te Morenga et al., 2013; Imamura et al., 2015). Free fat is associated with increased risk of coronary heart disease mortality (Leren, 1968; de Souza et al., 2015) and animal protein elevates the risk of type 2 diabetes (Malik et al., 2016).

and substantial effect on animal protein supply, and a milder significant impact on sugar supply. The magnitude of this effect is large, as a one standard deviation increase in the index of social globalisation is associated with a 20% increase in energy (kcal/capita/day) derived from animal protein sources. Social globalisation has no significant impact on the supplies of free fat. Additional GFE regression results show that the effect of social globalisation comes from personal contacts with foreigners (e.g. through telephone, tourism, migrations) and more importantly from information flows (e.g. internet, television, newspapers). Social globalisation has no effect on health, while economic globalisation has a negative impact on BMI and diabetes. From an econometric perspective, our results also suggest that GFE models perform better than usual fixed-effect models when variations in the dependent variable have a strong time component. This is the case here for nutrition outcomes but not for health outcomes. If the dependent variable is strongly determined by time-invariant components (e.g. genotypes), then fixed-effect models remain more appropriate.

The rest of the paper proceeds as follows. Section 2 describes the data used in the empirical analysis. Section 3 presents the estimation strategy. Results are reported in Section 4. Finally, Section 5 concludes.

2 Data

Our empirical analysis focuses on five key outcomes that, following the literature, characterize nutrition transition: the supplies of animal protein, free fat and sugar; the country-average BMI and national diabetes prevalence, whose trends may reflect changes in nutrition intakes.

2.1 Nutrition outcomes

The nutrition outcomes are computed at the country-year level from raw food supply data of the Food and Agriculture Organization (FAO).⁸ The FAO provides the amounts of fat and protein for each food item in its nomenclature, so that the raw data expressed in gram/capita/day can be converted into kcal/capita/day. We then determine for each food item its dominant type of fat and protein. We proceed as follows:⁹

- We differentiate between sources of animal protein and sources of vegetable protein;
- We differentiate between sources of animal fat and sources of vegetable fat, and distinguish these from free fat (e.g. fat available from oil, butter, and cream);
- We separate sugar from the other carbohydrates.

Figures 1-3 respectively show the trends in the composition of protein, fat, and carbohydrates supplies between 1970 and 2011. The amount of energy (kcal/capita/day) derived from animal protein sources rose by 70% in upper- and by 33% in lower-middle-income countries, as compared to 25% in high-income countries (Figure 1). Similarly, the supply of free fat doubled in upper-middle-income countries and rose by 78% in lower-middle-income countries, while it only rose by 30% in high-income countries (Figure 2). Last, the supply of sugar grew by 25% in lower-middle- and by 23% in upper-middle-income countries, but did not change in high-income countries (Figure 3).

Insert Figures 1, 2, and 3 here

2.2 Health outcomes

BMI is calculated as the weight in kilograms divided by the square of height in meters squared (kg/m^2). This individual index is commonly used to classify overweight and obesity in adults.

⁸ The FAO data cover the 1961-2013 period. Since globalisation data are only available from 1970, and the FAO series contain many missing values for 2012 and 2013, we focus on the 1970-2011 period. Access to FAO balance sheet data: <http://faostat3.fao.org/download/FB/FBS/E>.

⁹ The full classification is provided in Section 1 of the Supplementary Appendix.

Diabetes is defined as having a mean fasting plasma glucose value above 7.0 millimoles per litre, or using a glucose-lowering drug. This definition does not distinguish between type 1 and type 2 diabetes, whilst unhealthy diets are well-established risk factors and policy concerns for the latter only (Hu, 2011). However, studies from high-income countries¹⁰ suggest that 87% to 91% of diabetes patients suffer from type 2 diabetes (Boyle et al., 1999; Evans et al., 2000; Bruno et al., 2005; Holman et al., 2015). Therefore, the estimated effects on trends in diabetes will likely represent a lower bound estimate of the effect of globalisation on the prevalence of type 2 diabetes.

Data on country-average BMI and national diabetes prevalence were obtained from the Global Burden of Metabolic Risk Factors of Chronic Diseases Collaborating Group, a worldwide network of clinical and public health researchers.¹¹ The dataset covers the 1980-2008 period and is built by collecting data from health examination surveys and epidemiologic studies. Final data are age-standardised corresponding to the 2000-2025 world population (Finucane et al., 2011).

2.3 Economic and social globalisation

Globalisation can be defined as a global process including “economic integration, transfer of policies across borders, transmission of knowledge, [and] cultural stability” (Al-Rodhan and Stoudmann, 2006). In our analysis, we account separately for the economic and the social dimensions of globalisation. This divide allows us to test the predictions of Olivier et al. (2008)’s model. We use the KOF globalisation measures developed by Dreher (2006), who provides an overall measure of globalisation, as well as quantitative information on both its economic and social aspects.¹² Data are available for a large sample of countries on a yearly basis since 1970.

¹⁰ Relative proportions have not been much studied in middle- and low-income countries (International Diabetes Federation, 2015).

¹¹ We thank the research group for sharing their data. Access to data: <https://www1.imperial.ac.uk/publichealth/departments/ebs/projects/eresh/majidezzati/healthmetrics/metabolicriskfactors/>.

¹² See Section 2 in the Supplementary Appendix for a detailed presentation of the KOF index of globalisation. We thank the KOF team for sharing their data. Access to data: <http://globalisation.kof.ethz.ch/>.

The KOF measure of economic globalisation has two subcomponents: (i) Actual flows (e.g. trade, FDI, portfolio investment, and income payments to foreign nationals), and (ii) Trade openness (e.g. hidden import barriers, tariffs, taxes on international trade, and capital account restrictions, all reverse-coded). Social globalisation is also a composite index, with three subcomponents: (i) Personal contacts (measured by telephone traffic, transfers, international tourism, share of foreign population, and international letters), (ii) Information flows (Internet users, television and trade in newspapers), and (iii) Cultural proximity (e.g. number of McDonald's restaurants and Ikea stores per capita as well as trade in books). Both economic and social indexes take values on a scale from 1 to 100, with higher values indicating higher levels of globalisation.

As shown in Figure 4, globalisation has intensified over the last decades. High- and middle-income countries experienced a sharp upward trend in both economic globalisation and social globalisation between the beginning of the 90s and the 2008 crisis. Trade flows (for economic globalisation) and information flows (for social globalisation) are the two main drivers of countries' world integration. In our sample, the economic and social dimensions of globalisation exhibit a high correlation (0.84), as well as the two subcomponents 'cultural proximity' and 'information flows' of social globalisation (0.74).¹³ In addition to its direct impact on nutrition and health, economic globalisation may also have some indirect effects through economic growth. To disentangle both types of effects and test more precisely for Olivier et al. (2008)'s predictions regarding economic globalisation, we include the GDP per capita and its square term in all the regressions.¹⁴

Insert Figure 4 here

We use a balanced estimation sample of 2,940 observations from 70 countries followed over 42 years (1970-2011) and covering 76% of the world population.¹⁵ Dropping all countries with missing values in any of the outcome variables or covariates yields an estimation sample that is

¹³ However in simple OLS regressions, all variables exhibit a variance inflation factor (VIF) substantially lower than the rule of thumb of 10. Thus, multicollinearity is not likely to bias the estimates.

¹⁴ GDP per capita at constant 2005 prices in thousand USD (purchasing power parity). Data come from the World Development Indicators (World Bank). Access to data: <http://data.worldbank.org/data-catalog/world-development-indicators>.

¹⁵ We could have used an unbalanced panel, but we wanted to identify grouped patterns of heterogeneity comparable across countries, i.e. identified over the same time period.

very similar to the original sample, although the mean index of globalisation and the mean GDP per capita are slightly higher (see Section 3 in the Supplementary Appendix for details). Our estimation results are thus not likely to be affected by some selection bias. About 40% of the countries are high-income countries and 60% are middle-income countries. Table I reports some summary statistics. On average, 143 kcal/capita/day are provided by animal protein sources, 359 kcal/capita/day by free fat, and 598 kcal/capita/day by sugar. The mean score of economic globalisation is 52 points and higher than social globalisation (44 points) on a scale from 0 to 100. Mean GDP per capita is about 10,500 US dollars (USD). Due to data availability, the sample used for estimating the effect of globalisation on health outcomes is restricted to the period 1980-2008 and includes $N = 2,436$ observations. The mean of country-average BMIs is 24.6, i.e. slightly below the cut-off point of 25 for overweight defined by the WHO (WHO, 2015c). 8.4% of the population suffers from diabetes.

Insert Table I here

3 Estimation strategy

3.1 Grouped Fixed-Effects (GFE) estimator

A number of unobservable country characteristics may simultaneously affect a country's level of globalisation and its food supply. For example, cultural norms and unobserved trends in food innovation may both impact a country's openness and its nutrition patterns. This will bias the estimated effect of globalisation on nutrition and health. A standard solution consists in the use of the fixed-effects estimator. Including country fixed-effects will yield unbiased estimates only if all of the unobserved country characteristics are constant over time.

Here we relax this condition by using the GFE model developed by Bonhomme and Manresa (2015). The GFE model relies on the assumption that the number of distinct country-specific time patterns of unobserved heterogeneity is relatively small, so that the sample of countries can be partitioned into distinct groups having the same patterns of time-invariant *and* time-varying

unobserved heterogeneity. In practice, countries are endogenously grouped by using an iterative algorithm, which alternates between a clustering procedure and regressions. Countries whose time profiles of the outcome variable – net of the effect of covariates – are the most similar are grouped together in order to minimize a least-squares criterion. Group dummies and years dummies are fully interacted in the regression equation, and the group membership variables may be seen as indexing the time-varying paths of unobserved heterogeneity. As the allocation process uses the time profile of the residuals and not the time profile of the outcome variable, the identification of the effects of the covariates relies on within-group variations over time and across countries. The GFE estimator assumes that there are at most as many time-varying paths of unobserved heterogeneity as there are groups. Therefore, a key issue is the choice of the optimal number of groups (see below).¹⁶

In our setting, the assumption that countries cluster with respect to unobserved determinants of nutrition profiles is highly plausible. For example, urbanisation is often associated with the nutrition transition. Countries typically follow a S-shaped cyclical urbanisation process with moderate rates at the beginning and at the end of the process and higher rates in the middle of the cycle (Clark, 2000). Thus, countries which are at the same stage of the cycle probably encounter parallel urbanisation growth rates over time. The same phenomenon may be observed with female labour force participation across the process of economic development, or with the expansion of supermarkets in the developing world. The latter started in rich countries of Latin America in the 1990s, and occurred in East and South-East Asia and poor Latin American countries 10 years later (Reardon et al., 2003).

Our estimated equation is as follows:

$$y_{it} = \beta_1 \text{Social glob}_{it} + \beta_2 \text{Economic glob}_{it} + \beta_3 \text{GDPpc}_{it} + \beta_4 (\text{GDPpc}_{it})^2 + \alpha_{g_{it}} + v_{it},$$

where y_{it} denotes the outcome variable for country i and year t , β_1 and β_2 measure the effect of social and economic globalisation, GDPpc is GDP per capita, g_i is country i 's group membership, $\alpha_{g_{it}}$ denotes the group-specific time fixed-effect and v_{it} is an i.i.d. error term. Fortunately, GDP

¹⁶ The GFE approach has a link with finite mixture models (See Section 4 in the Supplementary Appendix for a discussion on it).

data are available for the entire period 1970-2011. In some robustness checks, we additionally control for urbanisation and female labour supply, but this forces use to restrict the time window.

3.2 Detailed estimation procedure

We now present the main features of the estimation procedure (for a detailed description, see Bonhomme and Manresa (2015)). Group membership is estimated together with the model coefficients in order to minimize the following least-squares objective function:

$$F(\boldsymbol{\theta}, \boldsymbol{\alpha}, \boldsymbol{\gamma})_G = \sum_{i=1}^N \sum_{t=1}^T (y_{it} - x'_{it} \boldsymbol{\theta} - \alpha_{g_{it}})^2$$

where $\boldsymbol{\theta}$ is the coefficient vector of the observed covariates x_{it} , $\alpha_{g_{it}}$ is the group-specific time effects for all g_i taking values in $\{1, \dots, G\}$ and all $t \in \{1, \dots, T\}$. We denote as $\boldsymbol{\alpha}$ the set of all $\alpha_{g_{it}}$'s. Group membership for each country is denoted by g_i and we denote as $\boldsymbol{\gamma}$ the set of all g_i 's. The estimation algorithm then alternates between an assignment step and an update step.

Step 1 - Assignment Step

Given parameter values at iteration s (e.g. $\boldsymbol{\theta}^s, \boldsymbol{\alpha}^s$), the countries are sorted into groups by minimizing the sum of the squared residuals over all years and for each country i :

$$g_i = \operatorname{argmin}_{g \in \{1, \dots, G\}} \sum_{t=1}^T (y_{it} - x'_{it} \boldsymbol{\theta}^s - \alpha_{gt}^s)^2$$

The assignment step results in a grouping $\boldsymbol{\gamma}^s = \{g_i^s; i = 1, \dots, N\}$.

Step 2 - Update Step

The grouping $\boldsymbol{\gamma}^s$ is used to estimate by OLS regressions a new set of coefficients $(\boldsymbol{\theta}^{s+1}, \boldsymbol{\alpha}^{s+1})$. The alternation between the assignment and update steps stops when the difference in coefficients between two iterations is smaller than some threshold (10^{-64} in our regressions).

One drawback of the procedure is that the algorithm may converge to a local minimum and not to the global minimum, depending on the choice of the initial starting values. To address this issue, Bonhomme and Manresa (2015) incorporate a variable neighbourhood search method in the algorithm (for more details, see Section 5 in the Supplementary Appendix). They provide

evidence that the modified algorithm reaches the global minimum. We thus apply this algorithm. Last, group membership being estimated, the variance-covariance matrix is computed by bootstrapping the entire estimation procedure (100 replications).¹⁷

3.3 Optimal number of groups

The choice of the optimal number of groups is a balancing task. On one hand, if the chosen number is higher than the true number of groups, then the GFE estimator remains consistent. In that case, the time profile of unobserved heterogeneity is simply very similar across some groups. Increasing the number of groups will decrease statistical efficiency but will not change too much the estimates. On the other hand, if the chosen number is smaller than the true number of groups and if the unobserved effects are correlated with the covariates, then the GFE estimator becomes inconsistent (omitted variable bias). Increasing the number of groups will then increase the efficiency and impact on the estimates.

To determine the optimal number of groups – separately for each outcome variable used in our empirical analysis –, we run GFE estimations with a number of groups G varying between 1 and 12. First, we calculate the Bayesian Information Criterion (BIC) to assess the statistical benefit of having more groups.¹⁸ According to Bonhomme and Manresa (2015), the BIC provides an upper bound on the true number of groups if T (years) grows at a slower rate than N (countries), which is the case in our sample. Second, we test for coefficients' stability with increasing G .

To illustrate the procedure, Table II reports the objective function, the BIC value, and the GFE coefficient estimates obtained for animal protein (in logarithm).¹⁹ It also shows the results for a benchmark specification that includes country and year fixed-effects, and a second specification where countries are grouped *a priori* according to their GDP (high, upper-middle, and lower-

¹⁷ The code is available upon request from the authors.

¹⁸ The BIC is a penalized measure of statistical fit, with the penalty depending on the number of parameters. $BIC(G) = \frac{1}{NT} * \hat{F}_G + \hat{\sigma}^2 \frac{GT+N+K}{NT} \ln(NT)$, with G the number of groups, N the number of countries in the sample, T the number of years, and K the number of covariates. \hat{F}_G is the sum of squared residuals of the regression with G groups. $\hat{\sigma}^2$ is an estimate of the variance of the error term v_{it} and is computed with $G_{max} = 12$. $\hat{\sigma}^2 = \frac{1}{NT - G_{max}T - N - K} \hat{F}_{G_{max}}$.

¹⁹ Sections 6 and 7 in the Supplementary Appendix present the optimal number of groups for the two other nutrition outcomes (free fat and sugar), as well as for the health outcome variables (BMI and diabetes prevalence).

middle) and these group dummies are interacted with year fixed-effects. The GFE regressions yield the lowest BIC value for $G = 9$, which is therefore an upper bound on the true number of groups. As depicted in Figure 5, the estimated coefficients on social and economic globalisation are quite stable when moving from $G = 6$ to $G = 9$ groups, indicating that the true G lies between 6 and 9. The value of the GFE objective function with $G = 6$ groups is 80% lower than the value obtained with $G = 1$, i.e. a simple OLS specification. A further increase in the number of groups does not induce a significant improvement in the objective function. Using all these information, we select $G = 6$ as the optimal number of groups for animal protein.

Insert Figure 5 here

Table II shows two additional results. First, the GFE estimator with $G \geq 6$ groups provides a smaller objective function than the GFE estimator, showing the advantage of accounting for time-varying cross-country heterogeneity. Second, the value of the objective function is substantially larger when countries are simply classified according to their income group. This last result suggests that grouping based on income does not capture much of the unobserved time-varying heterogeneity.

Insert Table II here

Figure 6 illustrates the ability of the GFE approach to control for the unobserved time-varying determinants of animal protein supply. It presents the time trends in the supply of animal protein (left) and the estimated group time effects α_{gt} (right) for the 6 groups of countries. On the left panel, some groups exhibit rather flat trends in animal protein, while others experience significant growth rates over the period. Group 3, which encounters a sharp upward trend, includes several countries from the Middle East and North Africa. Groups 1 and 4 face a parallel increase in animal protein (with a much lower initial level for group 4). Group 4 includes countries in Sub-Saharan Africa but also India, while group 1 is dominated by Latin American countries. Groups 5 and 6, which remain at a constant high level of animal protein supply over the period, contain many European countries as well as Japan, Australia, and the United States. Finally, the supply of animal protein in group 2 is also remarkably stable since 1970, albeit at a lower level

than for groups 5 and 6. Group 2 combines a mix of countries in Europe, Latin America, as well as in Sub-Saharan Africa.²⁰ In the right panel of the figure, the group-specific time effects show more convergence and less dispersion than the group-specific trends in animal protein. Yet, the group time effects are very heterogeneous across groups and years. The GFE approach can thus cope with a large amount of time-invariant and time-varying heterogeneity in the data.

Insert Figure 6 here

4 Results

This section presents and compares estimation results from OLS, standard fixed-effects, and GFE models. The estimates show that social globalisation has a positive and significant impact on animal protein supply, and a milder impact on sugar supply. The effect of social globalisation is essentially driven by the increase in personal contacts and information flows (e.g. Internet). Economic globalisation is unrelated to the supplies of protein, free fat and sugar at given income level. We find no effect of social globalisation but a negative effect of economic globalisation on BMI and diabetes. We also find that the GFE estimator performs better than simple fixed-effect models for nutrition outcomes, but not for health outcomes.

4.1 Nutrition outcomes

Table III displays OLS, fixed-effect, and GFE estimation results for the supplies of animal protein, free fat and sugar, which are all expressed in *logarithm* (of kcal/capita/day). Columns 1, 4, and 7 report OLS estimates with year fixed-effects that capture yearly shocks common to all countries. Social globalisation is significantly and positively associated with animal protein, free fat and sugar supply (with $p < 0.01$ for animal protein and sugar, and $p < 0.05$ for free fat). Insignificant effects are obtained for economic globalisation (except for animal protein, but at the 10% level only). Columns 2, 5, and 8 show the results when we add country fixed-effects. Once

²⁰ See Table S9 in the Supplementary Appendix for the detailed grouping of countries.

we control for time-invariant unobservable characteristics, the coefficient on social globalisation becomes insignificant for free fat and sugar, suggesting that previous OLS results were driven by some omitted country fixed characteristics. Columns 3, 6, and 9 present the GFE estimator results. Here, we control for time-varying unobservable determinants of the diet through the inclusion of group-specific time fixed-effects. The effect of social globalisation on the supply of animal protein remains significant at the 1% level, and similar to the country fixed-effect estimates. Social globalisation has again no impact on free fat and sugar.²¹ An additional point on the social globalisation index is associated with a significant 0.9% increase in the supply of animal protein (kcal/capita/day). Or, said differently, a one standard deviation increase (20.65) in the index of social globalisation raises on average animal protein supply by about 20.4%.²² Last, the positive coefficient estimate on GDP per capita and the negative one on its squared value suggest an inverted U-shape relationship between GDP per capita and the outcome variables. The turning point for animal protein is at 22,500 USD. This value is very similar to the mean GDP per capita of high income countries included in our sample over the 1970-2011 period (22,295 USD).

Insert Table III here

4.2 Understanding the impact of social globalisation on the nutrition transition

A widespread belief is that globalisation would be the key driver of the nutrition transition. In fact, our results suggest that it is far from being the main *direct* driver of the convergence of national nutrition patterns. Figure 7 shows the coefficient of variation (defined as the ratio of the standard deviation to the mean) over time for the nutrition outcomes. Middle-income countries are clearly catching up to high-income countries regarding supply of animal protein, and to a smaller extent with respect to free fat and sugar. However, our estimates reveal that the observed convergence across countries is not explained by globalisation, and only moderately related

²¹ Table S6 in the Supplementary Appendix however shows that the estimated coefficient on social globalisation for sugar is positive and significant for groups $G = 1$ to $G = 5$, as well as for $G = 7$ and $G = 8$. The discussion section provides evidence that some subcomponents of social globalisation have indeed had some impact on sugar supply.

²² A one standard deviation increase in the score of social globalisation approximately corresponds to a jump in social globalisation's level from Croatia to Singapore or from Turkey to France (based on 2011 values).

to rising GDP per capita. Figure 8 plots the changes in the difference in the estimated time effects between groups over time.²³ After controlling for globalisation and GDP, the residual differences between groups attenuate over time for all of the three outcomes (except for free fat supply, group 2), suggesting that some unobserved factors also explain the observed nutrition convergence of countries.

Insert Figures 7-8 here

Part of the time-varying unobserved heterogeneity in the nutrition outcomes may indeed be related to three key factors commonly associated with the nutrition transition, namely urbanisation, female labour force participation, and the Consumer Price Index (CPI) (Popkin, 1999; Datar et al., 2014; Dubois et al., 2014). We examine this assumption by running GFE regressions and controlling for these factors (see Section 9 in the Supplementary Appendix for detailed results). Due to data availability, the sample is reduced to the 1990-2011 period, and we further have to drop 8 countries when controlling for the CPI. Table IV reports the results. The optimal number of groups is higher than in our main GFE estimates, indicating that the trends in the three additional control variables are not the main sources of the time-varying heterogeneity captured by the group time effects.²⁴ Interestingly, social globalisation has still a positive and significant effect on animal protein. The coefficient estimate remains almost unchanged (columns 1 and 2). We find again no significant effect of globalisation on free fat (columns 3 and 4), but the coefficients on social and economic globalisation are both positive for sugar (columns 5 and 6), albeit at the 10% level only. This result contradicts the theoretical predictions of Olivier et al. (2008). However, as discussed in the introduction, nutrition is not food culture, and it is possible that economic globalisation preserves food culture, but not the way food is produced. If economic globalisation increases the demand for market production of traditional food, then the supply side may answer by technological innovations in the production process implying an increase in the use of sugar-rich inputs. In addition, Olivier et al. (2008)'s prediction

²³ These differences are calculated as the sum of the group dummy and the grouped time effect, e.g. for group 3 and year 1971 it is the sum of $group_3$ and $group_3 * year_{1971}$ relative to the base group (group 1).

²⁴ Note also that we focus on a more recent period characterized by an acceleration of the globalisation process, and therefore more heterogeneity across countries. This might explain why we need more groups to control for time-varying heterogeneity.

is reversed under increasing returns to scale (Maystre et al., 2014). Such increasing returns to scale are likely to characterize industries using large amounts of sugar (e.g. soft-drinks).

Insert Table IV here

In line with the theoretical predictions by Olivier et al. (2008), our results show that social globalisation is associated with a convergence in the supply of animal protein, and to a lesser extent of sugar, across countries. To better understand the drivers of the globalisation-nutrition connection, we decompose the KOF index into its different subcomponents. The social dimension of globalisation includes three subcomponents (personal contacts, information flows, and cultural proximity), while the economic dimension is made of two subcomponents (actuals flows and trade openness).

The OLS, country fixed-effects, and GFE estimation results are presented in Table V. The positive effect of social globalisation on animal protein is driven by personal contacts (e.g. telephone traffic, transfers, international tourism, foreign population, and international letters) and more significantly information flows (e.g. Internet, television and trade in newspapers). Cultural proximity, as measure by number of McDonald's restaurants or Ikea stores per capita and trade in books, is not significant. One explanation could be that it captures proximity to Western standards rather than cultural homogeneity between countries. Moreover, the subcomponents of social globalisation have no impact on free fat, which is consistent with our main results (see Table III, column 6). Finally, information flows have a positive and significant effect on sugar supply. Thus, access to television and Internet plays an important role in explaining the relationship between social globalisation and sugar consumption. This finding seems plausible as food advertising is usually concentrated on items containing a lot of sugar, such as cereals, soft drinks, savoury snacks, and confectionery (Cairns et al., 2013). Existing research also documents a positive association between food advertising expenditure and absolute calorie intake (Pettigrew et al., 2013; Folkvord et al., 2016). Last, the positive effect of economic globalisation on sugar was probably driven by trade openness, rather than by actual flows. A potential explanation is that trade openness eases the possibility for local producers to use sugar as a cheap input food processing (Monteiro et al., 2013).

Insert Table V here

4.3 Health outcomes

Health effects often take time to materialise. Hence, current values of social and economic globalisation are replaced by lagged terms in the estimations of health equations. Lags are defined using the average values of each variable over the past five years. Table VI presents the results. OLS estimates (columns 1 and 4) show that there are positive and significant correlations between social globalisation and health outcomes ($p < 0.01$ for BMI and $p < 0.05$ for diabetes). Including country fixed-effects renders the coefficients on social globalisation insignificant, but economic globalisation has now negative and significant effects on BMI and diabetes (columns 2 and 5). After controlling for group time-varying heterogeneity, neither social globalisation nor economic globalisation are significant.

However, a close examination of the values reached by the objective function reveals that the BIC values of GFE models do not reach a minimum when we increase the number of groups up to the point where the algorithm cannot converge (see Tables S7 and S8 in the Supplementary Appendix. Although the country fixed-effect estimates may be biased by the omission of time-varying unobservable characteristics, these results may have interesting methodological implications. It is well-established that there are strong genetic influences on BMI and diabetes prevalence (often expressed through genes-environment interactions, see Hu, 2011, for diabetes). When the time dimension of the data is low as compared to the cross-sectional dimension, these genetic factors may be better controlled for in a country fixed-effect model than in a GFE model, which groups together countries according to both time-invariant and time-varying heterogeneity. The negative effect of economic globalisation on health, holding income growth constant, should deserve further attention. The difficulty here is that BMI and diabetes are not only determined by food-related behaviours, but also by changes in a number of behavioural and environmental factors (sedentary lifestyle, smoking, chemical exposure etc.). In addition, economic globalisation is likely to have heterogenous effects within countries. While global trade liberalisation has made food products more accessible and cheaper on average, this does

not prevent a large share of the population from facing difficulties in food access, especially when food prices are more volatile as it was the case in the 2000s.

Insert Table VI here

5 Conclusion

Globalisation is often seen as the key driver of the nutrition transition and the ‘global epidemics’ of obesity and diabetes. However, existing evidence concentrates on the sole economic aspects of globalisation and mostly consists in case studies about foreign investments and trade openness.

In this paper, we use a panel of 70 high- and middle-income countries observed between 1970 and 2011, to provide empirical evidence on the distinct effects of social and economic globalisation on the supply of animal protein, free fat, and sugar, as well as on BMI and diabetes prevalence. We apply the standard fixed-effect estimator and the GFE estimator developed by Bonhomme and Manresa (2015). While the former precisely controls for country-specific time-invariant heterogeneity, the latter can be used in the presence of unobserved time-varying heterogeneity following grouped patterns.

Our results suggest that the social dimension of globalisation has a positive and significant effect on the supply of animal protein, and a milder impact on sugar supply. Controlling for income, economic globalisation has no direct impact on nutrition patterns. These findings are relevant for economies and policymakers, as meat-intensive diets have negative health and environmental consequences, with associated healthcare costs and externalities. We further show that the effect of social globalisation on animal protein and sugar is driven by personal contacts with foreigners and more importantly information flows via television and the Internet. This highlights the importance of the cultural dynamics of preferences in consumption and health behaviours. Given that social globalisation seems to be a significant driver of changing diets, further research should focus on factors related to the social dimension of globalisation, such as food advertising on television and the Internet. We also find that, contrary to conventional wisdom, economic

globalisation has a negative effect on average BMI and diabetes prevalence when controlling for country fixed-effects and average income. Further research should investigate the mechanisms underlying this result, and should also precisely investigate the indirect channels (e.g. income, urbanisation, inequalities) through which economic globalisation may affect diets.

Last, from a methodological perspective, we show that the GFE estimator is sometimes but not always superior to the standard fixed-effect estimator. The GFE estimator should therefore not be seen as a generalisation of the fixed-effect estimator, but rather as an efficient alternative for modeling outcomes that are characterised by moderate time-invariant unobserved heterogeneity and potentially important time-varying unobserved heterogeneity.

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Table I: Summary Statistics

	Mean	Standard deviation	Minimum	Maximum
<i>Nutrition outcome variables</i>				
Animal protein (kcal/capita/day)	143.03	85.26	22.00	422.72
Free fat (kcal/capita/day)	358.81	194.75	16.92	975.33
Sugar (kcal/capita/day)	598.14	211.65	71.49	1077.74
<i>Health outcome variables</i>				
Diabetes prevalence	8.36	1.99	3.18	21.82
Mean BMI	24.60	1.77	19.47	28.74
<i>Covariates</i>				
Social globalisation	44.06	20.65	6.83	92.31
Personal contacts	48.61	19.43	8.81	90.61
Information flows	51.65	21.11	4.40	97.83
Cultural proximity	31.53	30.58	1.00	95.95
Economic globalisation	52.14	17.17	17.27	97.09
Actual flows	53.37	18.91	8.14	99.30
Trade openness	51.24	23.35	4.29	98.26
GDP per capita	10.50	13.22	0.14	69.09

Note: The sample used for health outcomes is slightly smaller ($N = 2,436$) than the sample used for nutrition outcomes ($N = 2,940$). Reported values for the covariates are based on the nutrition sample (values are very similar for the health sample).

Table II: GFE estimates (outcome variable: animal protein (log))

Number of groups	Objective function	BIC	Social globalisation	Economic globalisation	GDP per capita	Squared GDP per capita
1	346.31	0.1227	0.011 ^a (0.004)	0.005 ^c (0.003)	0.054 ^a (0.009)	-0.001 ^a (0.000)
2	183.28	0.0691	0.010 ^b (0.004)	-0.001 (0.004)	0.037 ^a (0.013)	-0.001 ^c (0.000)
3	124.53	0.0509	0.013 ^a (0.004)	0.002 (0.003)	0.026 (0.018)	-0.000 (0.000)
4	93.17	0.0420	0.012 ^a (0.003)	0.001 (0.002)	0.045 ^b (0.018)	-0.001 ^b (0.000)
5	76.62	0.0382	0.007 ^b (0.003)	0.003 (0.003)	0.061 ^a (0.017)	-0.001 ^a (0.000)
6	64.50	0.0358	0.009 ^a (0.003)	0.003 (0.002)	0.045 ^b (0.019)	-0.001 ^b (0.000)
7	57.09	0.0351	0.008 ^b (0.003)	0.003 ^c (0.002)	0.074 ^a (0.018)	-0.001 ^a (0.000)
8	50.90	0.0348	0.008 ^b (0.003)	0.003 (0.002)	0.073 ^a (0.020)	-0.001 ^a (0.000)
9 [‡]	45.77	0.0348	0.010 ^a (0.004)	0.004 (0.002)	0.069 ^a (0.023)	-0.001 ^a (0.000)
10	42.80	0.0356	0.008 ^a (0.003)	0.003 (0.003)	0.070 ^a (0.022)	-0.001 ^b (0.000)
11	39.58	0.0363	0.006 ^c (0.003)	0.003 (0.003)	0.016 (0.022)	-0.000 (0.000)
12	37.08	0.0373	0.010 ^a (0.004)	0.003 (0.002)	0.042 ^b (0.020)	-0.000 (0.000)
<i>Alternative specifications:</i>						
Country & year fixed-effects	69.15		0.010 ^a (0.002)	0.003 ^c (0.002)	0.010 (0.013)	-0.000 (0.000)
Income groups x year fixed-effects	266.18		0.009 ^a (0.003)	0.002 (0.003)	0.021 ^b (0.011)	-0.000 ^b (0.000)

Note: The table reports the value of the objective function and the GFE estimated coefficients for $G = 1, \dots, 12$. GFE standard errors computed with 100 bootstrap replications. The last two estimations provides results of two alternative specifications: (i) with country and year fixed effects; and (ii) with countries classify according to their income group (high-, upper-middle-, and lower-middle-income). Income group dummies are interacted with year fixed-effects. [‡] marks the regression with the minimum BIC value. ^a, ^b, and ^c denote significance at the 1, 5 and 10% level.

Table III: Globalisation and nutrition outcomes

Outcome Estimator	Animal protein (log)			Free fat (log)			Sugar (log)		
	OLS	Fixed effects	GFE	OLS	Fixed effects	GFE	OLS	Fixed effects	GFE
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Social globalisation	0.011 ^a (0.004)	0.009 ^a (0.003)	0.009 ^a [0.003]	0.008 ^b (0.004)	0.002 (0.003)	-0.002 [0.004]	0.013 ^a (0.003)	0.003 (0.002)	0.004 [0.003]
Economic globalisation	0.005 ^c (0.003)	0.000 (0.002)	0.003 [0.002]	-0.002 (0.003)	-0.002 (0.003)	0.003 [0.003]	0.000 (0.003)	0.000 (0.002)	0.002 [0.003]
GDP per capita	0.054 ^a (0.009)	0.006 (0.014)	0.045 ^b [0.019]	0.058 ^a (0.014)	0.000 (0.023)	0.053 ^b [0.022]	0.020 ^a (0.007)	0.002 (0.010)	0.015 [0.013]
Squared GDP per capita	-0.001 ^a (0.000)	-0.000 (0.000)	-0.001 ^b [0.000]	-0.001 ^a (0.000)	-0.000 (0.000)	-0.001 ^b [0.000]	-0.000 ^a (0.000)	-0.000 (0.000)	-0.000 [0.000]
<i>Fixed-effects</i>									
Year	yes	yes	yes	yes	yes	yes	yes	yes	yes
Country		yes			yes			yes	
Group			yes			yes			yes
Group-year			yes			yes			yes
Observations	2,940	2,940	2,940	2,940	2,940	2,940	2,940	2,940	2,940
Objective function	346.31	65.43	64.50	507.17	109.82	109.76	253.01	48.08	41.78

Note: The table reports the OLS, fixed-effects, and GFE results for the three nutrition outcomes: animal protein, free fat and sugar supply (in logarithm). Robust standard errors in round brackets. Bootstrapped standard errors in square brackets (100 replications). GFE results are obtained with $G = 6$ groups. ^a, ^b, and ^c denote significance at the 1, 5 and 10% level.

Table IV: Robustness check: nutrition outcomes with additional covariates

Outcome Estimator	Animal protein (log)		Free fat (log)		Sugar (log)	
	(1)	(2)	(3)	(4)	(5)	(6)
Social globalisation	0.006 ^b (0.003)	0.008 ^a (0.002)	0.001 (0.003)	0.001 (0.003)	0.004 (0.003)	0.004 ^c (0.003)
Economic globalisation	-0.003 (0.003)	0.003 (0.003)	-0.002 (0.003)	0.001 (0.003)	0.005 ^c (0.003)	0.005 ^c (0.003)
GDP per capita	0.033 ^b (0.016)	0.033 ^b (0.015)	0.037 ^a (0.013)	0.022 (0.013)	0.015 (0.013)	0.014 (0.011)
Squared GDP per capita	-0.000 (0.000)	-0.000 (0.000)	-0.000 ^c (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)
Urbanisation	0.010 (0.005)	0.004 (0.004)	0.006 (0.003)	0.006 (0.003)	0.002 (0.003)	0.002 (0.003)
Female labour force participation	0.003 (0.015)	-0.012 (0.014)	0.001 (0.012)	-0.008 (0.014)	0.011 (0.012)	0.009 (0.010)
Squared female labour force part.	-0.000 (0.000)	0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)
Consumer price index		0.003 (0.001)		0.005 (0.001)		0.000 (0.001)
<i>Fixed-effects</i>						
Year	yes	yes	yes	yes	yes	yes
Group	yes	yes	yes	yes	yes	yes
Group-year	yes	yes	yes	yes	yes	yes
Observations	1,540	1,364	1,540	1,364	1,540	1,364
Objective function	11.11	9.58	17.76	14.15	9.08	7.68

Note: The table reports GFE estimation results for the supplies of animal protein, free fat, and sugar (in logarithm). Additional covariates are included. Bootstrapped standard errors (100 replications). GFE results obtained with $G = 9$ ($G = 8$ in column 2) for animal protein, $G = 8$ ($G = 7$ in column 4) for free fat, and $G = 7$ groups for sugar. Due to the additional covariates, the sample covers the 1990-2011 period. In addition, 8 countries (Argentina, Chile, China, Germany, Guyana, Lesotho, Nicaragua, and Venezuela) are dropped in columns 2, 4, and 6. ^a, ^b, and ^c denote significance at the 1, 5 and 10% level.

Table V: Subcomponents of social and economic globalisation and nutrition outcomes

Outcome Estimator	Animal protein (log)			Free fat (log)			Sugar (log)		
	OLS	Fixed effects	GFE	OLS	Fixed effects	GFE	OLS	Fixed effects	GFE
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
<i>Social globalisation</i>									
Personal contacts	0.006 ^b (0.003)	0.005 ^c (0.003)	0.007 ^c [0.004]	0.005 (0.004)	0.001 (0.004)	0.004 [0.005]	0.005 ^c (0.003)	0.001 (0.002)	0.001 [0.003]
Information flows	0.012 ^a (0.003)	0.009 ^a (0.002)	0.007 ^b [0.003]	0.006 ^c (0.003)	0.005 ^c (0.003)	0.003 [0.004]	0.013 ^a (0.003)	0.006 ^a (0.002)	0.006 ^b [0.003]
Cultural proximity	-0.001 (0.001)	0.001 (0.001)	0.001 [0.001]	0.001 (0.002)	-0.000 (0.001)	-0.001 [0.001]	-0.000 (0.001)	-0.001 (0.001)	0.000 [0.001]
<i>Economic globalisation</i>									
Actual flows	-0.001 (0.002)	-0.001 (0.001)	-0.001 [0.002]	-0.005 ^b (0.002)	-0.001 (0.002)	-0.003 [0.002]	-0.002 (0.002)	0.000 (0.001)	-0.001 [0.002]
Trade openness	0.004 (0.002)	0.002 ^c (0.001)	0.001 [0.002]	0.002 (0.003)	-0.001 (0.002)	0.004 [0.003]	0.001 (0.002)	0.001 (0.001)	0.004 [0.002]
GDP per capita	0.038 ^a (0.011)	0.004 (0.012)	0.048 ^a [0.017]	0.044 ^a (0.017)	0.000 (0.022)	0.049 ^a [0.019]	0.009 (0.009)	0.002 (0.009)	0.006 [0.012]
Squared GDP per capita	-0.001 (0.000)	-0.000 (0.000)	-0.001 [0.000]	-0.001 (0.000)	-0.000 (0.000)	-0.001 [0.000]	-0.000 (0.000)	-0.000 (0.000)	-0.000 [0.000]
<i>Fixed-effects</i>									
Year	yes	yes	yes	yes	yes	yes	yes	yes	yes
Country		yes			yes			yes	
Group			yes			yes			yes
Group-year			yes			yes			yes
Observations	2,940	2,940	2,940	2,940	2,940	2,940	2,940	2,940	2,940
Objective function	308.26	60.35	57.92	493.76	108.23	90.63	220.59	45.30	33.42

Note: The table reports OLS, fixed-effects and GFE results for the subcomponents of social and economic globalisation and the nutrition outcomes. Robust standard errors in round brackets. Bootstrapped standard errors in square brackets (100 replications). GFE results are obtained with $G = 6$ groups for animal protein and $G = 7$ for free fat and sugar. ^a, ^b, and ^c denote significance at the 1, 5 and 10% level.

Table VI: Globalisation and health outcomes

Outcome Estimator	Mean BMI			Diabetes prevalence		
	OLS	Fixed effects	GFE	OLS	Fixed effects	GFE
	(1)	(2)	(3)	(4)	(5)	(6)
Social globalisation (lagged)	0.064 ^a (0.015)	-0.003 (0.006)	0.006 [0.014]	0.040 ^b (0.019)	0.015 (0.021)	-0.012 [0.023]
Economic globalisation (lagged)	0.014 (0.013)	-0.018 ^a (0.006)	0.013 [0.011]	-0.001 (0.014)	-0.047 ^b (0.021)	-0.010 [0.016]
GDP per capita	-0.034 (0.036)	0.004 (0.019)	-0.004 [0.049]	-0.163 ^a (0.037)	-0.080 (0.070)	-0.096 [0.068]
(GDP per capita) ²	-0.000 (0.001)	-0.000 (0.000)	-0.000 [0.001]	0.001 ^a (0.000)	0.001 (0.001)	0.001 [0.001]
<i>Fixed-effects</i>						
Year	yes	yes	yes	yes	yes	yes
Country		yes			yes	
Group			yes			yes
Group-year			yes			yes
Observations	2,436	2,436	2,436	2,436	2,436	2,436
Objective	4,196.45	194.76	184.06	6,467.19	1,100.01	490.29

Note: The table reports the OLS, fixed-effects, and GFE results for the two health outcomes: country-average BMI and diabetes prevalence. Social and economic globalisation are lagged by their average values over the past five years. Robust standard errors in round brackets. Bootstrapped standard errors in square brackets (100 replications). GFE results are obtained with $G = 10$ groups. ^a, ^b, and ^c denote significance at the 1, 5 and 10% level.

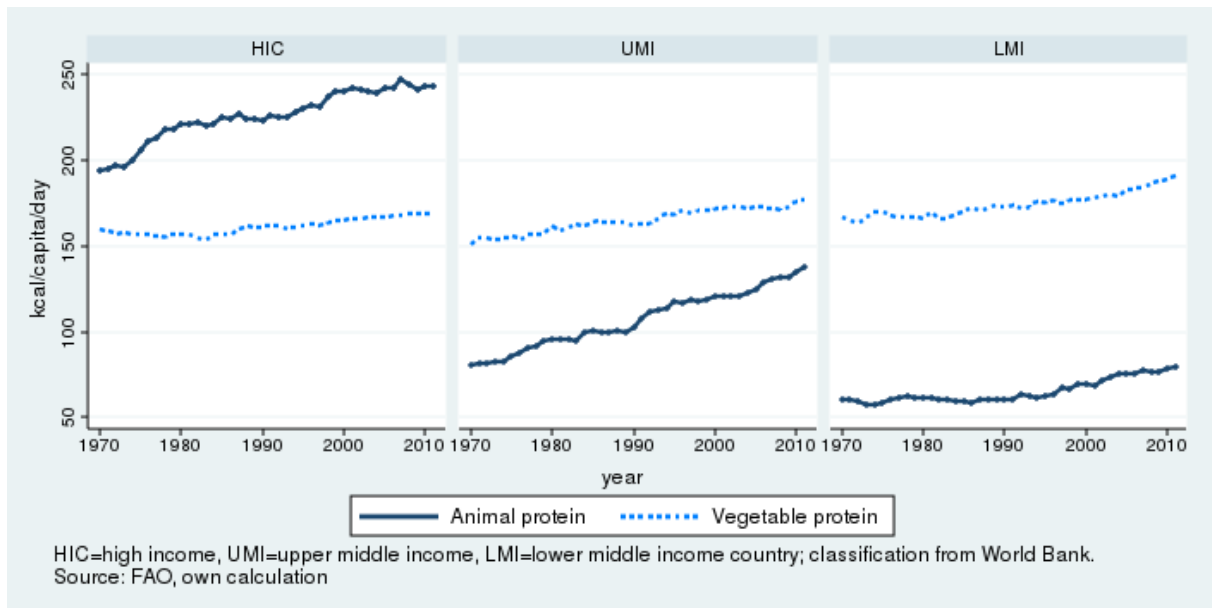


Figure 1: Composition of protein supply, 1970-2011

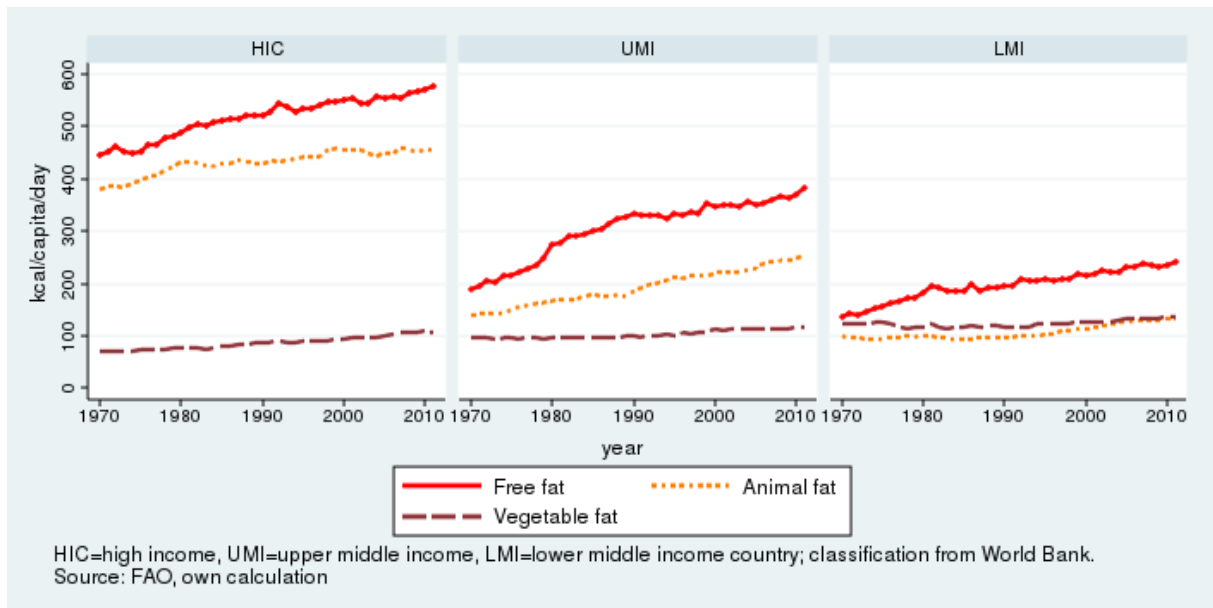


Figure 2: Composition of fat supply, 1970-2011

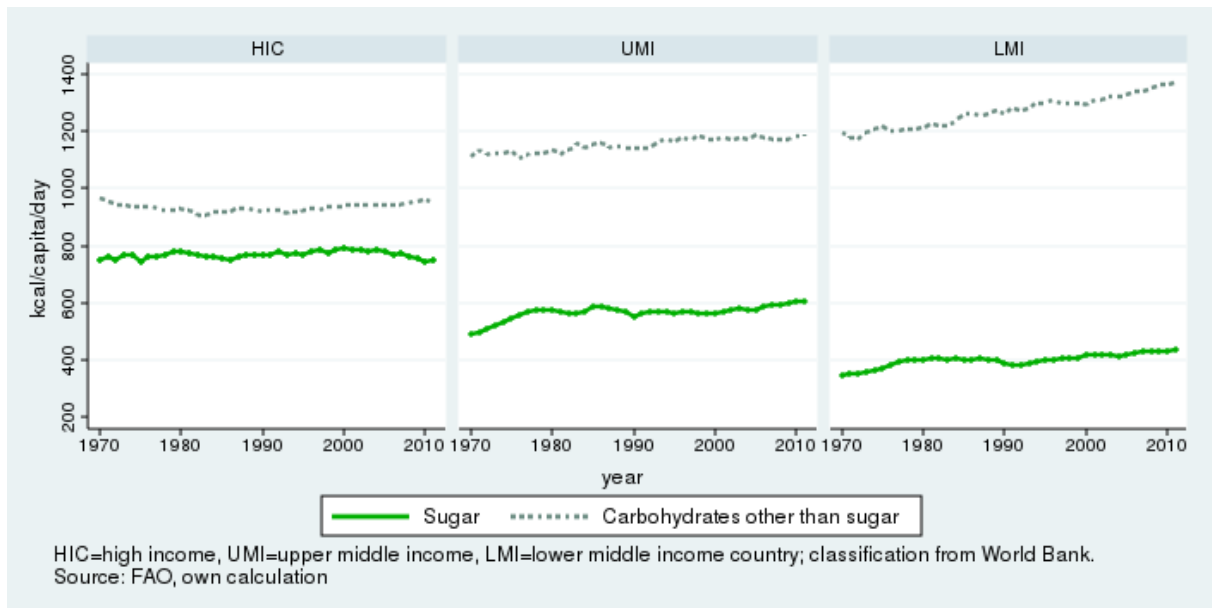


Figure 3: Composition of carbohydrates supply, 1970-2011

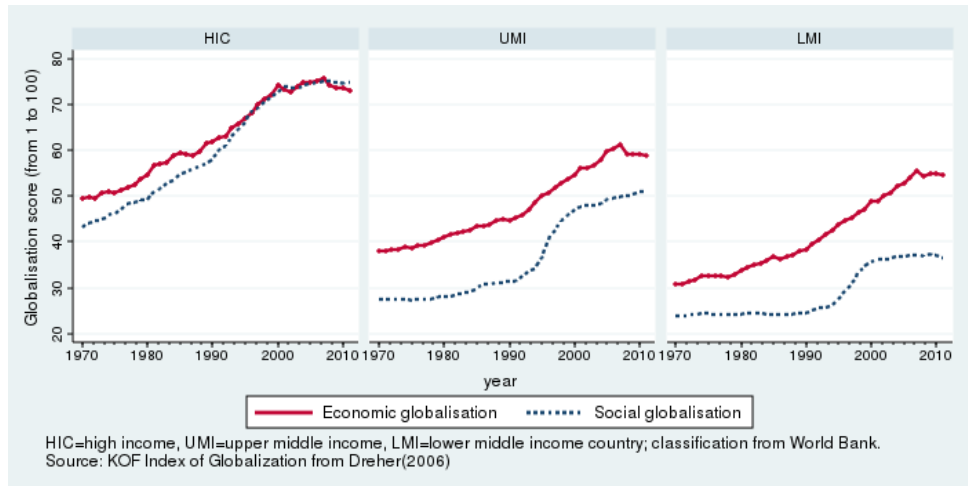


Figure 4: Social and economic globalisation, 1970-2011

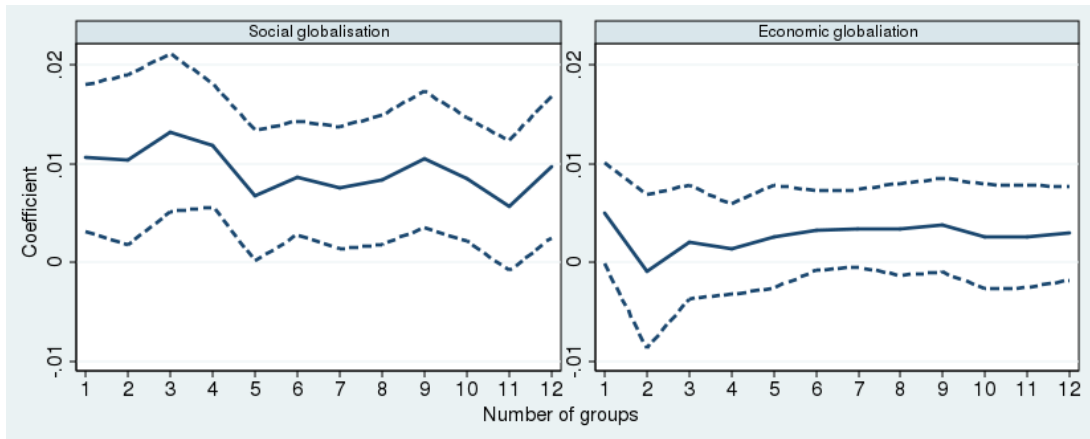


Figure 5: Outcome variable: supply of animal protein (log), globalisation coefficients

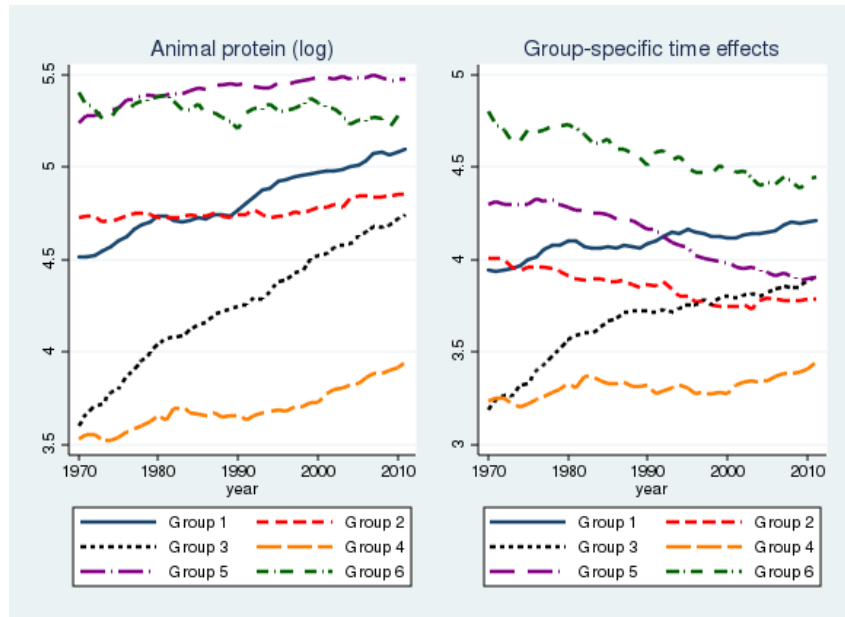


Figure 6: Supply of animal protein (log) and group time effects, by group

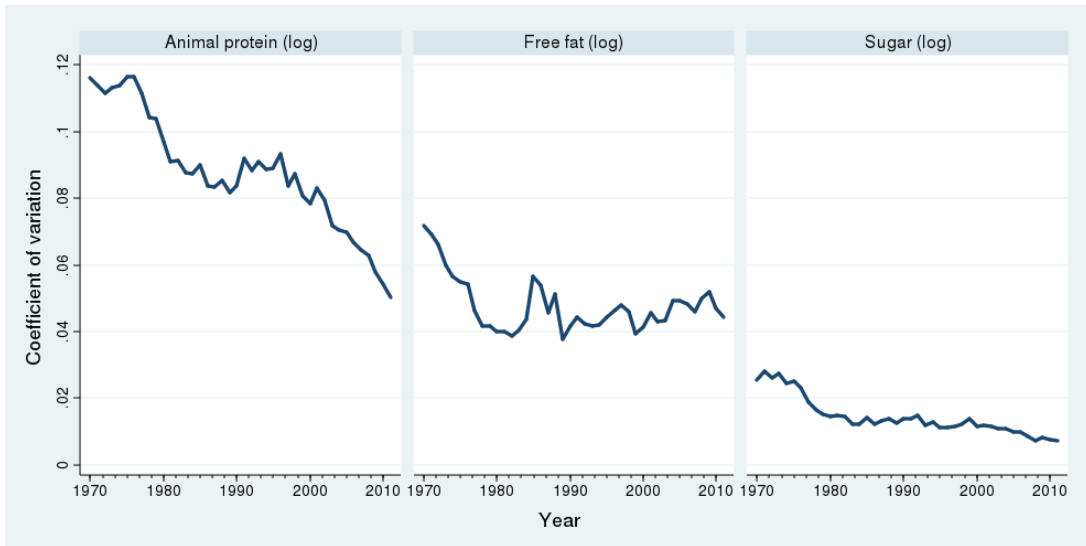


Figure 7: Coefficient of variation for nutrition outcomes, 1970-2011

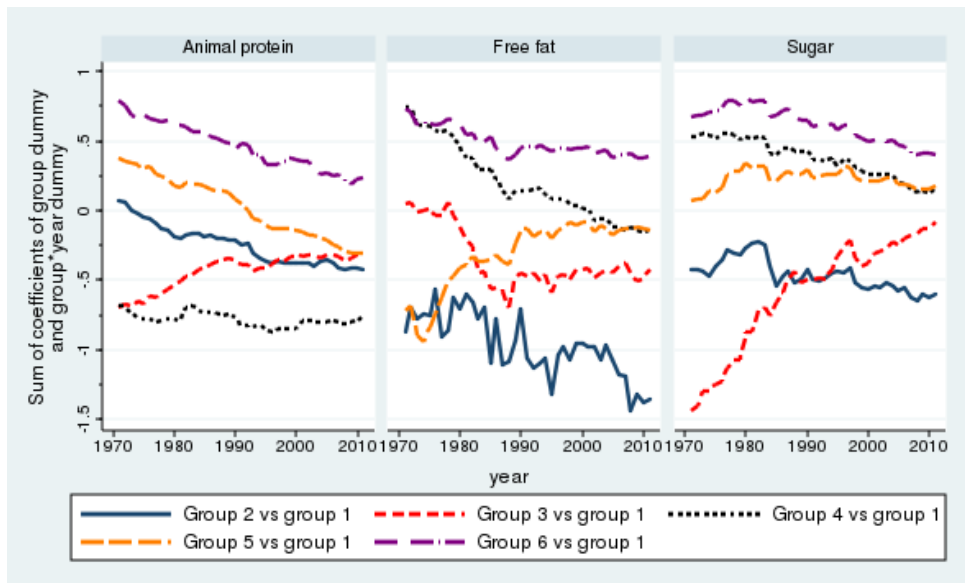


Figure 8: Convergence of groups for nutrition outcomes after controlling for globalisation and GDP per capita, 1970-2011

Note: the groupings may vary from one outcome to another.

Supplementary Appendix for:

“Globalisation and national trends in nutrition and health:

A grouped fixed-effects approach to inter-country heterogeneity”

October 2016

1 Classification of nutrients

Table S1: Classification of food items

Nutrient	Fats		Carbohydrates		Proteins		
	Free	Vegetable	Animal	Other	Sugar	Animal	Vegetable
Cereals - excluding beer		x		x			x
Wheat and products		x		x			x
Rice (Milled Equivalent)		x		x			x
Barley and products		x		x			x
Maize and products		x		x			x
Rye and products		x		x			x
Oats		x		x			x
Millet and products		x		x			x
Sorghum and products		x		x			x
Cereals, Other		x		x			x
Amyl roots + (Total)		x		x			x
Cassava and products		x		x			x
Potatoes and products		x		x			x
Sweet potatoes		x		x			x
Yams		x		x			x
Roots, Other		x		x			x
Sugar cultures + (Total)	x				x		x
Sugar cane	x				x		x
Sugar beet	x				x		x
Sugar & stimulants + (Total)		x			x		x
Sugar non-centrifugal		x			x		x
Sugar (Raw Equivalent)		x			x		x
Sweeteners, Other		x			x		x
Honey		x			x		x
Legumes + (Total)		x		x			x
Beans		x		x			x
Peas		x		x			x
Pulses, Other and products		x		x			x
Hull fruits + (Total)		x		x			x
Oleaginous plant + (Total)		x		x			x
Soybeans		x		x			x
Groundnuts (Shelled Eq.)		x		x			x
Sunflower seed		x		x			x
Rape and Mustard seed		x		x			x
Cottonseed		x		x			x
Coconuts - Incl. Copra		x		x			x
Sesame seed		x		x			x
Palm kernels		x		x			x
Olives (including preserved)		x		x			x
Oil crops, Other		x		x			x
Vegetable oils + (Total)	x			x			x
Soybean Oil	x			x			x
Groundnut Oil	x			x			x
Sunflower seed Oil	x			x			x
Rape and Mustard Oil	x			x			x
Cottonseed Oil	x			x			x
Palm Kernel Oil	x			x			x
Palm Oil	x			x			x
Coconut Oil	x			x			x
Sesame seed Oil	x			x			x
Olive Oil	x			x			x

Table S1: Classification of food items

Nutrient	Fats		Carbohydrates		Proteins	
	Free	Vegetable Animal	Other	Sugar	Animal	Vegetable
Ricebran Oil	x		x			x
Maize Germ Oil	x		x			x
Oilcrops Oil, Other	x		x			x
Vegetables + (Totals)		x		x		x
Tomatoes and products		x		x		x
Onions		x		x		x
Vegetables, Other		x		x		x
Fruits - excluding wine + (Total)		x		x		x
Oranges, tangerines		x		x		x
Lemons, Limes and products		x		x		x
Grapefruit and products		x		x		x
Citrus, Other		x		x		x
Bananas		x		x		x
Plantains		x		x		x
Apples and products		x		x		x
Pineapples and products		x		x		x
Dates		x		x		x
Grapes and products (excl. wine)		x		x		x
Fruits, Other		x		x		x
Stimulants + (Total)						x
Coffee and products						x
Cocoa Beans and products						x
Tea (including mate)						x
Spices + (Total)						x
Pepper						x
Pimento						x
Cloves						x
Spices, Other						x
Alcoholic beverages + (Total)				x		x
Wine				x		x
Beer				x		x
Beverages, Fermented				x		x
Beverages, Alcoholic				x		x
Alcohol, Non-Food				x		x
Meat products + (Total)			x		x	
Bovine Meat			x		x	
Mutton & Goat Meat			x		x	
Pig Meat			x		x	
Poultry Meat			x		x	
Meat, Other			x		x	
Giblets + (Total)			x		x	
Animal fats + (Total)	x		x		x	
Butter, Ghee	x		x		x	
Cream	x		x		x	
Fats, Animals, Raw	x		x		x	
Fish, Body Oil	x		x		x	
Fish, Liver Oil	x		x		x	
Eggs + (Total)		x	x		x	
Milk - excluding butter + (Total)		x		x	x	
Fish and sea food + (Total)		x	x		x	
Freshwater Fish		x	x		x	
Demersal Fish		x	x		x	
Pelagic Fish		x	x		x	
Marine Fish, Other		x	x		x	

Table S1: Classification of food items

Nutrient	Fats		Carbohydrates		Proteins		
	Free	Vegetable	Animal	Other	Sugar	Animal	Vegetable
Crustaceans			x	x		x	
Cephalopods			x	x		x	
Molluscs, Other			x	x		x	
Aquatic products, others + (Total)			x	x		x	
Meat, Aquatic Mammals			x	x		x	
Aquatic Animals, Others			x	x		x	
Aquatic Plants		x		x		x	
Diverse products	x	x		x			x

Note: This classification was kindly provided by Pierre Combris.

2 Social and economic globalisation index

The KOF Index of Globalisation was developed by Dreher (2006). It “defines globalisation to be the process of creating networks of connections among actors at multi-continental distances, mediated through a variety of flows including people, information, and ideas, capital and goods” (KOF Index of Globalisation, 2016*b*).

Social globalisation intends to capture direct interactions among people living in different countries, potential flows of ideas and images, the extent to which beliefs and values move across national borders, as well as the domination of U.S. cultural products. Economic globalisation captures actual flows and trade barriers.

Tables S2 and S3 contain the definition of the variables used to construct the social and economic indices of globalisation. Each variable is transformed to an index on a scale of one to hundred, where hundred is the maximum value for a specific variable. Higher values denote greater globalisation. The data are transformed according to the percentiles of the original distribution. The weights for calculating the sub-indices are determined with the help of principal component analysis for the entire sample of countries and years (KOF Index of Globalisation, 2016*b*).

Table S2: Definition of social globalisation

Social globalisation	
Indices and Variables	Definitions
Personal contacts (33%)	
International telephone traffic	Sum of international incoming and outgoing fixed telephone traffic (in minutes per person).
Government and workers' transfers	Sum of gross inflows and gross outflows of goods, services, income, or financial items without a quid pro quo (in percent of GDP).
International tourism	Sum of arrivals and departures of international tourists (share of population).
Stock of foreign population	Number of foreign or foreign-born residents in a country (in percent of total population).
International letters	Number of international letters sent and received (per capita).
Information flows (35%)	
Internet users (per 100 people)	People with access to the worldwide internet network.
Television users (per 100 people)	Share of households with a television set.
Trade in newspapers	Sum of exports and imports in newspapers and periodicals (percent of GDP).
Cultural proximity (32%)	
Number of McDonald's restaurants	per 100,000 people.
Number of IKEA	per 100,000 people.
Trade in books	Sum of exports and imports in books and pamphlets (percent of GDP).

Source: KOF Index of Globalisation (2016a), link to KOF website: <http://globalization.kof.ethz.ch/>

Table S3: Definition of economic globalisation

Economic globalisation	
Indices and Variables	Definitions
Actual flows (50%)	
Trade (percent of GDP)	Sum of exports and imports of goods and services (percent of GDP).
FDI, stocks	Sum of inward and outward FDI stock (percent of GDP).
Portfolio investment	Sum of portfolio investment assets stocks and portfolio investment liabilities stocks (percent of GDP).
Trade openness (50%)	
Hidden import barriers	Index based on Global Competitiveness Report's survey question: "In your country, tariff and non-tariff barriers significantly reduce the ability of imported goods to compete in the domestic market."
Mean tariff rate	As the mean tariff rate increases, countries are assigned lower ratings.
Taxes on international trade	Includes import duties, export duties, profits of export or import monopolies, exchange profits, and exchange taxes (in percent of all current revenues).
Capital account restrictions	Index based on two components: (i) survey question of Global Competitiveness Report: "Foreign ownership of companies in your country is (1) rare, limited to minority stakes, and often prohibited in key sectors or (2) prevalent and encouraged." (ii) IMF's Annual Report on Exchange Arrangements and Exchange Restrictions.

Source: KOF Index of Globalisation (2016a), link to KOF website: <http://globalization.kof.ethz.ch/>

3 Sample of countries

The original sample consists of 149 countries (e.g. countries included in FAO and KOF data). These countries are represented on Figure S1. However, our aim is to identify grouped patterns of heterogeneity comparable across countries, i.e. identified over the same time period. Therefore, we restrict our sample to those 70 countries without any missing values in the outcome variable or the covariates (Figure S2). Thereby, we lose some countries in Eastern Europe and Central Asia. A comparison of the means of the outcome variables and the covariates shows that the final sample includes countries consuming slightly more nutrients, having a marginally higher index of globalisation and being slightly richer than the raw sample.

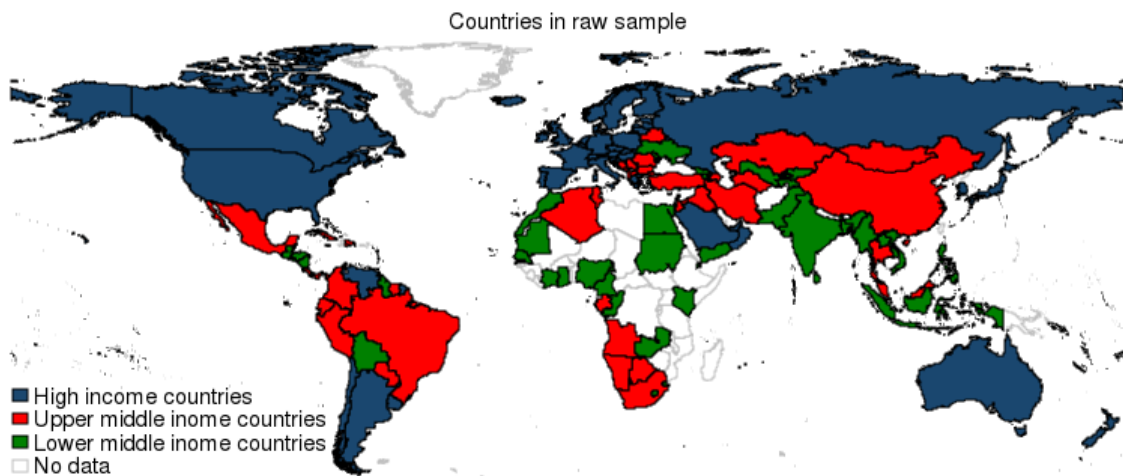


Figure S1: Countries in the raw sample

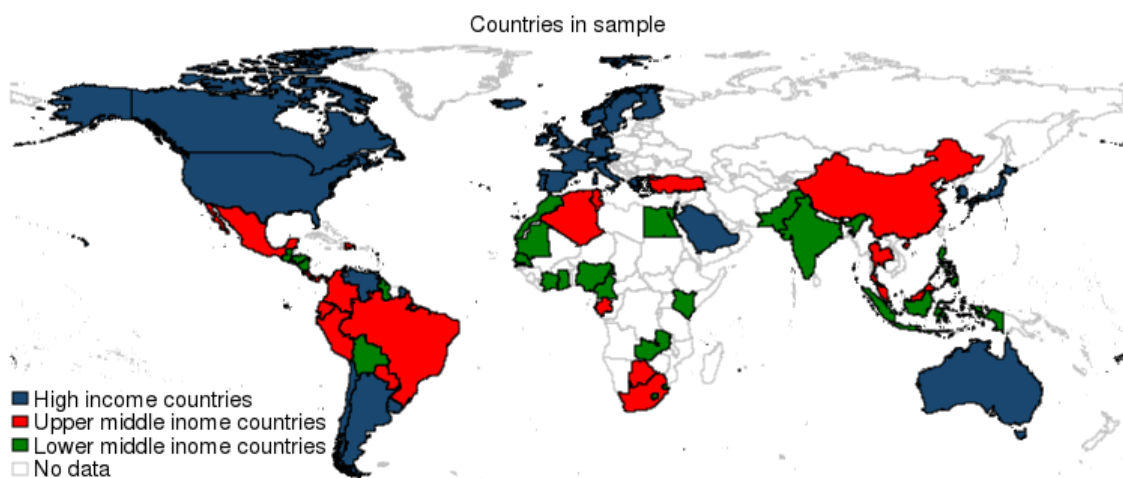


Figure S2: Countries in the final sample

Table S4: Comparison between raw and final samples

	Raw sample			Final sample		
	Mean	Standard deviation	Number of countries	Mean	Standard deviation	Number of countries
Animal protein	146.70	80.75	173	163.22	81.47	70
Free fat	356.45	191.46	173	419.07	207.49	70
Sugar	554.93	224.81	173	613.92	185.77	70
Social globalisation	50.79	21.24	172	56.38	20.30	70
Economic globalisation	61.30	15.98	147	63.36	14.36	70
GDP per capita (constant 2005 in 1000 USD)	10.91	15.97	169	14.53	17.18	70

4 Relationship with finite mixture models

Finite mixture models, also known as latent class models, can be used in the presence of clustering units by latent traits. These models are based on the idea that data arise from two or more underlying groups with common distributional form but different parameters (Aitkin and Rubin, 1985). The GFE estimator is more robust than finite mixture models, and for two reasons:

First, finite mixture models require assumptions restricting the relationship between unobserved heterogeneity and covariates. The covariates are assumed to be independent from unobserved time-varying factors. By contrast, the GFE estimator is more robust, as it leaves the relationship unspecified.

Second, the GFE estimator allows for some (limited) time and spatial correlation in the error term, while the finite mixture models require strict assumptions about the distribution of the error term (Bonhomme and Manresa, 2015). In particular, Bonhomme and Manresa (2015) show that finite mixture models are equivalent to the GFE estimator only in the case of a normal distribution with similar variances across latent classes (no heteroscedasticity).

5 Estimation procedure

This section describes the incorporation of a variable neighbourhood search method to make the algorithm more efficient.

Let θ be the coefficient vector of all covariates common to all countries. α_{gt} denotes the group-specific time effects for all $g \in \{1, \dots, G\}$ and all $t \in \{1, \dots, T\}$. We denote as α the set of all α_{gt} 's. Group membership for each country is denoted by g_i and we denote as γ the set of all g_i 's.

Step 1 - starting value of parameters

First, starting values for the parameters (θ^0, α^0) are chosen and the algorithm is used to obtain an initial grouping of the countries γ_{init} .

Step 2 - neighbourhood jump

The key feature is the inclusion of a neighbourhood jump, where n countries are randomly reallocated into n randomly selected groups, in order to get a new grouping γ' . These random jumps allow for an efficient exploration of the objective function. Initially, $n = 1$ and only one country is reallocated to another group. The new grouping γ' is then used to perform an update step and to obtain new parameter values (θ', α') .

Step 3 - local search

Using these new parameter values (θ', α') , the algorithm is applied. A local search is then performed in order to ensure that the algorithm found the best local solution. To this end, every country i is subsequently re-assigned to all groups except its 'own' group.

If the local search results in any improvement of the objective function, the resulting new grouping is labelled γ'' and the initial grouping is set to $\gamma_{init} = \gamma''$. Step 2 is then repeated by keeping n constant, followed by a new local search.

If the local search does not lead to any re-assignment, this means that the algorithm found a local minimum. In a next step, the neighbourhood jump is repeated by setting $n = n + 1$. Two countries are randomly reallocated to two randomly selected groups.

Steps 2 and 3 are performed $iter_{max}$ times (the maximum number of iterations), by setting n back to $n = 1$ once $neigh_{max}$ (the maximum number of neighbourhoods) has been reached. $iter_{max}$ and $neigh_{max}$ are determined by the researcher.

Compared to an algorithm without a neighbourhood search method, the algorithm incorporating it requires fewer starting values (N_s) to arrive to a reliable solution and is therefore more efficient. Moreover, Bonhomme and Manresa (2015) demonstrate that it is also more reliable. Therefore, we use the algorithm with the neighbourhood search method for our estimations, and following Bonhomme and Manresa (2015), set N_s , $neigh_{max}$, and $iter_{max}$ all equal to 10. To account for the fact that group membership is estimated, the variance-covariance matrix is computed by using bootstrapping with 100 replications.¹

6 Optimal number of groups for free fat and sugar supplies

This section investigates the optimal number of groups for the outcome variables supply of free fat and supply of sugar. Tables S5 and S6 show the objective function, the BIC value, and the coefficient estimates for regressions with different numbers of groups G . For both outcome variables free fat and sugar, the upper bound of the optimal number of groups is $G = 9$. The estimation with 9 groups indeed achieves the lowest BIC value.

Figure S3 plots the coefficient estimates for social and economic globalisation over the different numbers of groups. A graphical inspection reveals that the coefficients for sugar, and to a lesser extent for free fat do not vary much between $G = 5$ and $G = 9$. Furthermore, the GFE estimator is not biased even if the selected number of groups is higher than the true number. We therefore take a conservative approach and choose $G = 6$ as the optimal number of groups.

¹ Bootstrapped standard errors are obtained by following Bonhomme and Manresa (2015)'s approach, i.e. by setting $neigh_{max} = 10$, $N_s = 5$, and $iter_{max} = 5$.

Table S5: GFE estimates (outcome variable: free fat supply (log))

Number of groups	Objective function	BIC	Social globalisation	Economic globalisation	GDP per capita	Squared GDP per capita
1	507.17	0.1798	0.008 ^b (0.004)	-0.002 (0.003)	0.058 ^a (0.014)	-0.001 ^a (0.000)
2	235.15	0.0899	0.001 (0.003)	-0.004 (0.003)	0.054 ^a (0.012)	-0.001 ^a (0.000)
3	181.39	0.0743	0.004 (0.004)	-0.002 (0.003)	0.045 ^b (0.019)	-0.001 ^b (0.000)
4	150.57	0.0665	0.001 (0.003)	0.002 (0.004)	0.047 ^b (0.020)	-0.001 ^b (0.000)
5	127.89	0.0614	0.002 (0.004)	-0.000 (0.004)	0.055 ^a (0.020)	-0.001 ^b (0.000)
6	109.76	0.0579	-0.002 (0.004)	0.003 (0.003)	0.053 ^b (0.022)	-0.001 ^b (0.000)
7	96.53	0.0560	0.002 (0.004)	-0.004 (0.003)	0.044 ^b (0.021)	-0.000 (0.000)
8	86.05	0.0551	-0.001 (0.003)	0.002 (0.004)	0.077 ^a (0.020)	-0.001 ^a (0.000)
9 [‡]	75.42	0.0541	0.000 (0.004)	-0.004 (0.003)	0.039 ^c (0.020)	-0.001 (0.000)
10	69.42	0.0548	0.002 (0.003)	0.003 (0.004)	0.031 (0.021)	-0.000 (0.000)
11	61.19	0.0546	-0.002 (0.004)	-0.001 (0.004)	0.039 ^b (0.017)	-0.000 ^c (0.000)
12	54.81	0.0551	-0.002 (0.003)	-0.002 (0.004)	0.039 ^b (0.018)	-0.000 (0.000)
<i>Alternative specifications</i>						
Country & year fixed-effects	109.82		0.002 (0.003)	-0.002 (0.003)	0.000 (0.023)	-0.000 (0.000)
Income groups x year fixed-effects	484.28		0.010 ^a (0.003)	-0.002 (0.003)	0.033 ^a (0.012)	-0.001 ^b (0.000)

Note: The table reports the value of the objective function, the BIC value and the GFE estimated coefficients for different numbers of countries' groups. Standard errors are computed with 100 bootstrap iterations (except in the last two estimations). The last two estimations provides the results of two alternative specifications: (i) with fixed-effects and (ii) with countries classify according to their income group (high-, upper-middle-, and lower-middle-income). Income group dummies are interacted with year fixed-effects. [‡] marks the regression with the minimum BIC value. ^a, ^b, and ^c denote significance at the 1, 5 and 10% level.

Table S6: GFE estimates (outcome variable: sugar supply (log))

Number of groups	Objective function	BIC	Social globalisation	Economic globalisation	GDP per capita	Squared GDP per capita
1	253.01	0.0889	0.013 ^a (0.003)	0.000 (0.003)	0.020 ^a (0.007)	-0.000 ^a (0.000)
2	127.51	0.0473	0.008 ^b (0.004)	0.000 (0.004)	0.015 (0.019)	-0.000 (0.000)
3	77.13	0.0312	0.007 ^a (0.002)	-0.001 (0.003)	0.007 (0.014)	-0.000 (0.000)
4	59.52	0.0263	0.007 ^a (0.002)	0.003 (0.003)	0.007 (0.011)	-0.000 (0.000)
5	50.46	0.0242	0.006 ^a (0.002)	0.003 (0.003)	0.009 (0.011)	-0.000 (0.000)
6	41.78	0.0223	0.004 (0.003)	0.002 (0.003)	0.015 (0.013)	-0.000 (0.000)
7	36.14	0.0214	0.004 ^c (0.002)	0.002 (0.002)	0.015 (0.012)	-0.000 (0.000)
8	31.83	0.0210	0.004 ^c (0.002)	0.002 (0.002)	0.017 (0.012)	-0.000 (0.000)
9 [‡]	28.18	0.0208	0.002 (0.002)	0.001 (0.002)	0.022 ^a (0.008)	-0.000 ^b (0.000)
10	25.76	0.0210	0.003 (0.002)	0.002 (0.003)	0.019 ^c (0.010)	-0.000 ^c (0.000)
11	23.77	0.0214	0.003 (0.002)	0.001 (0.002)	0.019 ^b (0.008)	-0.000 ^c (0.000)
12	21.60	0.0217	0.004 ^b (0.002)	0.000 (0.002)	0.007 (0.009)	-0.000 (0.000)
<i>Alternative specifications</i>						
Country & year fixed-effects	48.08		0.003 (0.002)	0.000 (0.002)	0.002 (0.010)	-0.000 (0.000)
Income groups x year fixed-effects	230.21		0.010 ^a (0.003)	-0.002 (0.003)	0.008 (0.006)	-0.000 ^b (0.000)

Note: The table reports the value of the objective function, the BIC value, and the GFE estimated coefficients for different numbers of countries' groups. Standard errors are computed with 100 bootstrap iterations (except in the last two estimations). The last two estimations provides the results of two alternative specifications: (i) with fixed-effects and (ii) with countries classify according to their income group (high-, upper-middle-, and lower-middle-income). Income group dummies are interacted with year fixed-effects. ‡ marks the regression with the minimum BIC value. ^a, ^b, and ^c denote significance at the 1, 5 and 10% level.



Figure S3: Outcome variables free fat and sugar, coefficients of economic and social globalisation

7 Optimal number of groups for health outcomes

We now study the optimal number of groups for our two health outcomes, namely mean BMI and diabetes prevalence. Tables S7 and S8 report the objective function, the BIC value, and the coefficient estimates for regressions with different numbers of groups. The algorithm does not converge for $G > 10$. We therefore use $G = 10$ as our optimal number of groups. For the mean BMI, the coefficient on social globalisation is always positive. By choosing $G = 10$ as the optimal number of groups, we follow a conservative approach (in that case, the size of the corresponding coefficient on social globalisation is the smallest one in term of magnitude). For diabetes prevalence, the coefficients are less stable than for mean BMI.

Table S7: GFE estimates (outcome variable: mean BMI)

Number of groups	Objective function	BIC	Social globalisation (lagged)	Economic globalisation (lagged)	GDP per capita	Squared GDP per capita
1	4,196.45	1.7562	0.064 ^a (0.015)	0.014 (0.013)	-0.034 (0.036)	-0.000 (0.001)
2	1,519.67	0.6656	0.053 ^b (0.021)	0.008 (0.015)	-0.013 (0.063)	-0.000 (0.001)
3	903.44	0.4210	0.036 ^b (0.018)	0.013 (0.016)	0.025 (0.045)	-0.001 (0.001)
4	640.60	0.3214	0.023 ^c (0.014)	0.013 (0.014)	0.020 (0.039)	-0.000 (0.000)
5	485.91	0.2662	0.039 ^b (0.018)	0.024 (0.016)	-0.037 (0.052)	0.000 (0.001)
6	368.55	0.2263	0.026 (0.016)	0.016 (0.014)	-0.012 (0.053)	-0.000 (0.001)
7	293.94	0.2040	0.009 (0.016)	0.015 (0.012)	-0.006 (0.059)	-0.000 (0.001)
8	249.42	0.1940	0.010 (0.014)	0.014 (0.012)	-0.004 (0.050)	-0.000 (0.001)
9	211.10	0.1866	0.008 (0.013)	0.015 (0.011)	-0.033 (0.051)	0.000 (0.001)
10 [‡]	184.06	0.1838	0.006 (0.014)	0.013 (0.011)	-0.004 (0.049)	-0.000 (0.001)
<i>Alternative specifications</i>						
Country & year fixed-effects	194.76		-0.003 (0.006)	-0.018 ^a (0.006)	0.004 (0.019)	-0.000 (0.000)
Income groups x year fixed-effects	3,681.83		0.071 ^a (0.011)	0.010 (0.011)	-0.135 ^a (0.029)	0.001 ^a (0.000)

Note: The table reports the value of the objective function, the BIC value, and the GFE estimated coefficients for different numbers of countries' groups. Standard errors are computed with 100 bootstrap iterations (except in the last two estimations). The last two estimations provides the results of two alternative specifications: (i) with fixed-effects and (ii) with countries classify according to their income group (high-, upper-middle-, and lower-middle-income). Income group dummies are interacted with year fixed-effects. [‡] marks the regression with the minimum BIC value. ^a, ^b, and ^c denote significance at the 1, 5 and 10% level.

Table S8: GFE estimates (outcome variable: diabetes prevalence)

Number of groups	Objective function	BIC	Social globalisation (lagged)	Economic globalisation (lagged)	GDP per capita	Squared GDP per capita
1	6,467.19	2.7441	0.040 ^b (0.019)	-0.001 (0.014)	-0.163 ^a (0.037)	0.001 ^a (0.000)
2	3,276.20	1.4563	0.041 ^b (0.018)	-0.002 (0.017)	-0.165 ^a (0.054)	0.001 (0.001)
3	1,981.52	0.9469	0.012 (0.018)	0.011 (0.014)	-0.136 ^b (0.057)	0.001 (0.001)
4	1,463.37	0.7563	0.011 (0.019)	-0.011 (0.019)	-0.086 (0.064)	0.000 (0.001)
5	1,071.86	0.6177	-0.017 (0.018)	-0.005 (0.017)	-0.052 (0.063)	0.000 (0.001)
6	882.44	0.5621	-0.009 (0.018)	-0.016 (0.020)	-0.038 (0.070)	0.000 (0.001)
7	755.98	0.5323	-0.010 (0.022)	-0.008 (0.017)	-0.051 (0.079)	0.000 (0.001)
8	650.86	0.5112	-0.012 (0.021)	-0.010 (0.017)	-0.035 (0.065)	0.000 (0.001)
9	555.03	0.4940	0.022 (0.024)	0.026 (0.017)	-0.155 ^b (0.077)	0.001 (0.001)
10 [‡]	490.29	0.4895	-0.012 (0.023)	-0.010 (0.016)	-0.096 (0.068)	0.001 (0.001)
<i>Alternative specifications</i>						
Country & year fixed-effects	1,100.01		0.015 (0.021)	-0.047 ^b (0.021)	-0.080 (0.070)	0.001 (0.001)
Income groups x year fixed-effects	6,685.82		0.062 ^a (0.017)	-0.001 (0.014)	-0.276 ^a (0.047)	0.003 ^a (0.001)

Note: The table reports the value of the objective function, the BIC value, and the GFE estimated coefficients for different numbers of countries' groups. Standard errors are computed with 100 bootstrap iterations (except in the last two estimations). The last two estimations provides the results of two alternative specifications: (i) with fixed-effects and (ii) with countries classify according to their income group (high-, upper-middle-, and lower-middle-income). Income group dummies are interacted with year fixed-effects. [‡] marks the regression with the minimum BIC value. ^a, ^b, and ^c denote significance at the 1, 5 and 10% level.

8 Country grouping for animal protein

Table S9: Grouping of countries for animal protein

Group	Countries
1	Fiji, Malaysia, Norway, Portugal, Bolivia, Brazil, Chile, Colombia, Costa Rica, Ecuador, Guyana, Mexico, Panama, Venezuela, Pakistan, Gabon
2	Philippines, Thailand, Austria, Denmark, Germany, Netherlands, Sweden, United Kingdom, Dominican Republic, Nicaragua, Peru, Trinidad and Tobago, Canada, Botswana, Cote d'Ivoire, Ghana, Kenya, Senegal, South Africa, Swaziland
3	China, Republic of Korea, El Salvador, Honduras, Algeria, Egypt, Morocco, Saudi Arabia, Tunisia
4	Indonesia, Guatemala, India, Cameroon, Lesotho, Nigeria, Zambia
5	Australia, Japan, Finland, France, Greece, Ireland, Italy, Spain, Turkey, Barbados, Israel, Malta, United States
6	Iceland, Argentina, Paraguay, Uruguay, Mauritania

Note: This grouping corresponds to the GFE result for the outcome variable supply of animal protein with $G = 6$ groups.

9 Robustness check with additional controls

To test the robustness of our results, we add further covariates in our regressions. We additionally control for urbanisation and female labour force participation. Due to data constraints, our sample is reduced to the years 1990-2011 following the inclusion of both controls.

Data come from the World Development Indicators database². The variable *urbanisation* is defined as the percentage of a country's population living in metropolitan areas that in 2000 had a population of more than one million people. We code all countries with missing values that did not have an urban agglomeration of more than one million people in 2011 as zero. The variable *female labour force participation* is defined as the proportion of the female population aged 15-64 that is economically active. We also include a squared term to account for potential non-linear effects. Tables S10, S11, and S12 present estimation results for varying numbers of groups.

Finally, we also control for *consumer price index (CPI)*. It reflects changes in the cost to the average consumer of acquiring a basket of goods and services that may be fixed or changed

² Website: <http://data.worldbank.org/data-catalog/world-development-indicators>

Table S10: Robustness check: animal protein (log) with additional covariates

Nb. of groups	Objective function	BIC	Social global.	Economic global.	GDP per capita	Squared GDP per capita	Urban.	Female labour force participation	Squared female labour force participation
1	142.53	0.0965	0.015 ^a (0.005)	0.002 (0.003)	0.030 ^a (0.010)	-0.000 ^b (0.000)	0.004 ^c (0.002)	0.002 (0.012)	-0.000 (0.000)
2	59.48	0.0435	0.012 ^a (0.005)	-0.003 (0.006)	0.049 ^a (0.015)	-0.001 ^b (0.000)	0.002 (0.004)	0.014 (0.018)	-0.000 (0.000)
3	33.00	0.0272	0.011 ^b (0.005)	0.000 (0.003)	0.041 ^a (0.014)	-0.001 ^b (0.000)	0.009 ^b (0.004)	0.003 (0.015)	-0.000 (0.000)
4	25.25	0.0230	0.012 ^b (0.005)	-0.001 (0.003)	0.032 ^b (0.015)	-0.000 ^c (0.000)	0.003 (0.004)	0.004 (0.016)	-0.000 (0.000)
5	19.68	0.0203	0.010 ^b (0.004)	-0.001 (0.003)	0.022 (0.019)	-0.000 (0.000)	0.009 ^c (0.005)	0.017 (0.018)	-0.000 (0.000)
6	17.10	0.0195	0.009 ^b (0.004)	-0.001 (0.003)	0.023 (0.016)	-0.000 (0.000)	0.009 ^b (0.004)	0.005 (0.018)	-0.000 (0.000)
7	15.30	0.0192	0.013 ^a (0.003)	-0.003 (0.003)	0.021 (0.018)	-0.000 (0.000)	0.010 ^b (0.005)	-0.002 (0.016)	0.000 (0.000)
8	13.36	0.0189	0.008 ^b (0.004)	-0.001 (0.003)	0.023 (0.015)	-0.000 (0.000)	0.009 (0.006)	-0.001 (0.017)	0.000 (0.000)
9 [‡]	11.11	0.0183	0.006 ^b (0.003)	-0.003 (0.003)	0.033 ^b (0.016)	-0.000 (0.000)	0.010 ^b (0.005)	0.003 (0.015)	-0.000 (0.000)
10	10.49	0.0188	0.005 ^c (0.003)	-0.000 (0.003)	0.057 ^a (0.015)	-0.001 ^b (0.000)	0.005 (0.005)	0.013 (0.017)	-0.000 (0.000)

Note: The table reports the value of the objective function, the BIC value, and the GFE estimated coefficients for different numbers of countries' groups when including additional controls. Standard errors are computed with 100 bootstrap iterations. [‡] marks the regression with the minimum BIC value. ^a, ^b, and ^c denote significance at the 1, 5 and 10% level.

at specified intervals, such as yearly. The Laspeyres formula is generally used and data are period averages. Eight countries for which CPI is not available are dropped from our sample. Estimation results with the CPI variable are available from the authors upon request.

Table S11: Robustness check: free fat (log) with additional covariates

Nb. of groups	Objective function	BIC	Social global.	Economic global.	GDP per capita	Squared GDP per capita	Urban.	Female labour force participation	Squared female labour force participation
1	182.37	0.1244	0.011 ^b (0.005)	-0.007 (0.004)	0.042 ^a (0.013)	-0.000 ^b (0.000)	0.004 (0.003)	-0.002 (0.013)	-0.000 (0.000)
2	71.83	0.0539	0.004 (0.004)	-0.001 (0.005)	0.040 ^a (0.013)	-0.000 ^c (0.000)	0.008 ^b (0.004)	-0.003 (0.014)	-0.000 (0.000)
3	43.99	0.0371	0.009 ^b (0.004)	-0.004 (0.004)	0.026 ^c (0.014)	-0.000 (0.000)	0.012 ^a (0.005)	-0.001 (0.016)	-0.000 (0.000)
4	34.35	0.0322	0.003 (0.004)	-0.004 (0.003)	0.038 ^a (0.013)	-0.000 ^c (0.000)	0.013 ^a (0.004)	0.004 (0.017)	-0.000 (0.000)
5	26.96	0.0287	-0.004 (0.004)	-0.000 (0.003)	0.050 ^a (0.013)	-0.001 ^b (0.000)	0.004 (0.004)	0.003 (0.016)	-0.000 (0.000)
6	23.04	0.0275	0.000 (0.003)	-0.002 (0.003)	0.036 ^a (0.014)	-0.000 (0.000)	0.006 (0.004)	0.016 (0.014)	-0.000 ^c (0.000)
7	20.80	0.0274	0.000 (0.003)	-0.002 (0.003)	0.037 ^a (0.014)	-0.000 ^c (0.000)	0.006 (0.004)	0.002 (0.016)	-0.000 (0.000)
8 [‡]	17.76	0.0267	0.001 (0.003)	-0.002 (0.003)	0.037 ^a (0.013)	-0.000 ^c (0.000)	0.006 ^c (0.003)	0.001 (0.012)	-0.000 (0.000)
9	15.92	0.0268	-0.000 (0.003)	-0.002 (0.003)	0.037 ^a (0.012)	-0.000 ^c (0.000)	0.007 ^c (0.004)	0.002 (0.016)	-0.000 (0.000)

Note: The table reports the value of the objective function, the BIC value, and the GFE estimated coefficients for different numbers of countries' groups when including additional controls. Standard errors are computed with 100 bootstrap iterations. [‡] marks the regression with the minimum BIC value. ^a, ^b, and ^c denote significance at the 1, 5 and 10% level.

Table S12: Robustness check: sugar (log) with additional covariates

Nb. of groups	Objective function	BIC	Social global.	Economic global.	GDP per capita	Squared GDP per capita	Urban.	Female labour force participation	Squared female labour force participation
1	91.56	0.0623	0.013 ^a (0.004)	-0.000 (0.003)	0.010 (0.008)	-0.000 (0.000)	0.002 (0.002)	0.007 (0.009)	-0.000 (0.000)
2	36.40	0.0271	0.011 ^a (0.003)	0.001 (0.004)	0.024 ^b (0.010)	-0.000 (0.000)	0.002 (0.003)	0.013 (0.015)	-0.000 (0.000)
3	23.16	0.0191	0.010 ^a (0.004)	0.005 (0.003)	0.017 (0.013)	-0.000 (0.000)	0.003 (0.003)	0.002 (0.014)	-0.000 (0.000)
4	15.22	0.0146	0.004 (0.003)	0.004 (0.003)	0.027 ^b (0.012)	-0.000 ^c (0.000)	0.004 (0.004)	0.012 (0.013)	-0.000 (0.000)
5	12.35	0.0134	0.005 (0.003)	0.005 ^b (0.002)	0.017 (0.012)	-0.000 (0.000)	0.003 (0.003)	0.010 (0.013)	-0.000 (0.000)
6	10.70	0.0129	0.002 (0.003)	0.002 (0.002)	0.025 ^b (0.011)	-0.000 ^c (0.000)	0.006 ^c (0.003)	0.009 (0.011)	-0.000 (0.000)
7 [‡]	9.08	0.0125	0.004 (0.003)	0.005 ^c (0.003)	0.015 (0.013)	-0.000 (0.000)	0.002 (0.003)	0.011 (0.012)	-0.000 (0.000)
8	8.21	0.0126	0.004 (0.003)	0.005 ^c (0.002)	0.015 (0.011)	-0.000 (0.000)	0.001 (0.003)	0.010 (0.011)	-0.000 (0.000)

Note: The table reports the value of the objective function, the BIC value, and the GFE estimated coefficients for different numbers of countries' groups when including additional controls. Standard errors are computed with 100 bootstrap iterations. [‡] marks the regression with the minimum BIC value. ^a, ^b, and ^c denote significance at the 1, 5 and 10% level.

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