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

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Abstract

Using a panel dataset of 70 countries spanning 42 years (1970-2011), we investigate the distinct effects of social globalisation and trade openness on national trends in markers of diet quality (supplies of animal proteins, free fats and sugar, average body mass index – BMI – and diabetes prevalence). Our key methodological contribution is the application of a grouped fixed-effects (GFE) estimator, which extends linear fixed-effects models. The GFE estimator partitions our sample into distinct groups of countries in order to control for time-varying unobserved heterogeneity that follows a group-specific pattern. We find that increasing social globalisation has a significant impact on the supplies of animal protein and sugar available for human consumption, as well as on mean BMI. Specific components of social globalisation such as information flows (via television and the Internet) drive these results. Trade openness has no effect on dietary outcomes or health. These findings suggest that the social and cultural aspects of globalisation should receive greater attention in research on the nutrition transition.

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

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1 Introduction

High- and middle-income countries have experienced a profound shift in their population diet over recent decades. Food supply, as measured by the calories available for human consumption,[1] has increased significantly, which has improved food security (Thompson et al., 2012). However, 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 carbohydrates other than sugar has risen a little while, on the contrary, the supplies of animal protein, free fat, and sugar have exhibited significant growth.[2] Popkin (1993) introduced the concept of nutrition transition to describe these dietary changes. Middle-income countries are currently experiencing their nutrition transition, with considerable growth rates in the supply of animal protein and fat.[3] The convergence to high-income countries over the past 40 years remains, however, only moderate.[4] High-income countries are indeed at an advanced state of their nutrition transition but their growth rates in animal protein and fat supplies have not yet reached a plateau.

The nutrition transition poses important policy challenges for health. Epidemiological studies show that diets rich in sugar, certain types of fat (saturated or trans fats), salt, and fatty meat constitute important risk-factors for non-communicable diseases such as cardiovascular diseases (CVD), diabetes, a number of cancers as well as for intermediary outcomes (e.g. obesity) (Ezzati and Riboli, 2013; WHO, 2015*b*). In 2012, 17.5 million people died from CVD, making them the number one cause of death globally. More than three quarters of CVD deaths take place in low- and middle-income countries, causing substantial economic and welfare losses (WHO, 2015*a*). As a consequence, the World Health Organisation (WHO) regards food-related chronic

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

[2] Carbohydrates are the sugar and starches found in fruit, grains, and vegetables. Products rich in carbohydrates are cereals, pasta, rice, bread, corn, peas, and lentils. We put 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.

[3] This paper focuses on high- and middle-income countries. It does not consider low-income countries as these are at very early stages of the nutrition transition. Among middle-income countries, a distinction is made between upper- and lower-middle-income countries (see the World Bank classification).

[4] Convergence is defined as a reduction over time in the variance of the nutrition components measured in kcal/capita/day.

diseases as a growing threat all over the world, replacing traditional public-health concerns such as undernutrition and infectious diseases (WHO, 2000).[5]

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

This paper looks at trends in nutrition and food-related diseases in a panel of 70 high- and middle-income countries observed between 1970 and 2011. Our empirical analysis relies on the theoretical model on cultural transmission developed by Olivier et al. (2008). This predicts that social globalisation, defined as social interactions between individuals of different countries through migration, tourism, and communication technologies, produces convergence in food cultures. Trade openness, which describes the integration of a country into the world economy, is predicted to preserve food cultures by lowering the costs of local cultural food products.

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 investigated using the KOF globalisation indices, which measure the economic, social, and political dimensions of globalisation for a large number of countries starting in 1970. 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

[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 food inequality within countries.

[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; the sample in Miljkovic et al. (2015) 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 effects) to examine the link between globalisation and obesity. They find a positive effect of globalisation on obesity.

on female overweight. Miljkovic et al. (2015) also find a positive impact of social globalisation on obesity. However, unlike Goryakin et al. (2015), they find that a sub-dimension of economic globalisation, trade openness, has a positive impact on country obesity, while FDI has no effect. One explanation for these contradictory results is that Miljkovic et al. (2015) do not control for rising incomes, which are likely to increase consumption (via the income effect).

We add to this literature by studying the effects of both social globalisation and trade openness – measured using the sub-components of the KOF indices – on three key indicators of nutrition transition: the supplies of animal protein, free fat and sugar available for human consumption. These nutrients exhibit the highest growth rates over the past 40 years. We also test how globalisation affects two main health outcomes associated with the nutrition transition: mean Body Mass Index (BMI) and the prevalence of diabetes.[7]

All of our regressions control for the income effects of economic globalisation. In addition, we use the Grouped Fixed-Effects (GFE) estimator of Bonhomme and Manresa (2015). First, we partition our sample of 70 countries into a number of distinct groups using an algorithm. Then, we group the time-varying component of unobserved heterogeneity by fully interacting group dummies with year dummies. Thereby, we can control for time-varying unobserved heterogeneity under the assumption that it follows a group pattern. In other words, we can account for trends in the potentially unobserved confounders of globalisation. This feature differentiates the GFE estimator from country fixed-effects models that only control for time-constant unobserved heterogeneity. This method thus greatly reduces any omitted-variable bias in the identification of the effect of social globalisation and trade openness. The GFE estimator hence allows for long-run analyses when additional control variables are not available over the longer time period.

Our results suggest that social globalisation has a positive and significant effect on the supply of animal protein and sugar. This effect is small in size, as a one-unit increase in the index of

[7] A high intake of sugar increases the risk of overweight and type-2 diabetes (Te Morenga et al., 2013; Imamura et al., 2016). Free fats are associated with an increased risk of coronary heart disease mortality (Leren, 1968; de Souza et al., 2015) and animal proteins elevate the risk of type-2 diabetes (Malik et al., 2016). However, diet is not the only channel through which globalisation affects health outcomes. For example, athletes and supermodels can motivate individuals to exercise more and thereby affect health outcomes. Due to the weaknesses of the diabetes data we report the diabetes results in the Appendix in section 10.

social globalisation is associated with a 1.2% (0.9%) increase in the energy (kcal/capita/day) derived from animal proteins (sugar). On the contrary, social globalisation has no significant impact on the supply of free fats. Additional GFE regression results show that the effect of social globalisation comes from information flows (e.g. Internet, television and newspapers). Social globalisation also has a positive effect on mean BMI. Trade openness has no impact on dietary outcomes or health.

The remainder of the paper proceeds as follows. Section 2 explains the theoretical background and Section 3 describes the data used in the empirical analysis. Section 4 presents the estimation strategy, and the results appear in Section 5. Finally, Section 6 concludes.

2 Theoretical background

In the theoretical model developed by Olivier et al. (2008), social globalisation and trade openness can have opposing effects on the inter-country heterogeneity in (food) cultures. In their model, consumers choose between a domestic cultural good X_i (e.g. national cuisine) and a foreign cultural good $X_{j \neq i}$. Consumption defines membership of a cultural group. Consumers derive utility not only from the consumption of the good but also from social interactions with other individuals consuming the same cultural good. This additional utility can be interpreted as the cultural externality $I_i(q_{i,t})$ at date t from the consumption of good X_i. $I_i(q_{i,t})$ increases in $q_{i,t}$, the fraction of individuals affiliated with culture i at date t, and is bounded below by 1. A larger group reinforces the sense of belonging and facilitates social exchange. The expected utility of a consumer in culture i who consumes the cultural good X_i at date t is thus:

$$U_i(x_{i,t}) = (I_i(q_{i,t}))x_{i,t} \tag{1}$$

An individual in culture i consuming a cultural good $X_{j\neq i}$ different from her own cultural good does not benefit from social interactions, so that her expected utility at date t is given by:

$$U_i(x_{j\neq i,t}) = x_{j,t} \tag{2}$$

An overlapping-generations model then describes the dynamic transmission of cultural preferences across generations. Parents value their children's consumption through the filter of their own consumption. It is thus costly for altruistic parents of type i to see their children make consumption choices of type j. Parents hence have an incentive to transmit their own culture. This incentive rises with the cultural externalities $I_i(q_{i,t})$ and falls with the market price of the domestic good X_i.

As country i becomes socially integrated, the share of the population $q_{i,t}$ consuming the good X_i, now measured at the world level, is smaller than the pre-integration level. The cultural externalities $I_i(q_{i,t})$ consequently also fall, reducing the incentive of parents to transmit their own culture to their children. This triggers a reduction in domestic demand, which eventually weakens the dominance of the domestic culture. As the same process takes place simultaneously in all of the countries that globalise, the cultural homogeneity within countries is reduced. In Olivier et al. (2008), social globalisation therefore causes a *convergence of (food) cultures* across countries, and consequently the convergence of nutrition patterns.

On the contrary, the model predicts that trade openness *preserves (food) cultures* across countries, and even leads to cultural homogeneity within a country and cultural divergence across countries. If world integration produces a fall in the market price of the domestic good X_i, its consumption increases. This rise in consumption implies a rise in $q_{i,t}$, which strengthens the cultural externalities $I_i(q_{i,t})$. A higher level of $I_i(q_{i,t})$ increases parents' incentives to transmit their own culture to their children, and thus amplifies the initial effect of trade integration. Prices then affect cultural externalities through their effects on both consumption and $q_{i,t}$. In the long run, all individuals will consume the domestic good X_i. This prediction however relies on the model's assumption of perfect competition. Maystre et al. (2014) develop an alternative model based on monopolistic competition, which is empirically compared to that of perfect competition.

The support for the model with imperfect competition is much stronger. As such, the predictions for trade openness have to be taken with caution.

3 Data

Our empirical analysis focuses on four key outcomes that, according to the literature, characterize the nutrition transition: the shares of animal protein, free fat and sugar in the total food supply available for human consumption, and the country-average BMI, whose trend may reflect changes in nutrition intake.

3.1 Nutrition outcomes

The nutrition outcomes are calculated at the country-year level from the raw food-supply data from the Food and Agriculture Organization (FAO).[8] The FAO in addition provides the amounts of fats and proteins for each food item in its nomenclature, so that the raw data expressed in grams/capita/day can be converted into kcal/capita/day. We then determine the dominant type of fat, carbohydrate and protein for each food item, using the distinctions below: [9]

- Free fats (e.g. fats available from oil, butter, and cream), animal and vegetable fats;
- Sugar and other carbohydrates;
- Animal and vegetable proteins.

Figures 1-3 respectively show the trends in the composition of the supplies of protein, fat and carbohydrates between 1970 and 2011 by income group. The amount of energy (kcal/capita/day) derived from animal proteins rose by 70% in upper-middle income countries, and 33% in lower-middle-income countries, as compared to 25% in high-income countries (Figure 1). Similarly,

[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. The FAO balance-sheet data can be found at `http://faostat3.fao.org/download/FB/FBS/E`.

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

the supply of free fat doubled in upper-middle-income countries and rose by 78% in lower-middle-income countries, but only 30% in high-income countries (Figure 2). Last, the supply of sugar grew by about 25% in middle-income countries but rose only little in high-income countries (Figure 3).

Insert Figures 1, 2, and 3 here

3.2 Health outcomes

BMI is calculated as weight in kilograms divided by the square of height in meters (kg/m^2). This individual index is commonly used to classify underweight, normal weight, overweight and obesity in adults, despite its well-known limitations (Burkhauser and Cawley, 2008). Country-average BMI data are obtained from NCD Risk Factor Collaboration (NCD-RisC), a global network of health scientists.[10] The dataset covers the 1975-2011 period and is constructed from population-based studies. The final data are age-standardised (NCD Risk Factor Collaboration, 2016) and we construct the mean BMI variable by averaging the female and male BMI values.

3.3 Social globalisation and trade openness

To test the predictions of the model in Olivier et al. (2008), we account separately for social globalisation and trade openness. We construct both variables using data from the sub-components of the KOF globalisation index developed by Dreher (2006). These data are available for a large sample of countries on a yearly basis since 1970.[11]

Social globalisation is defined as a composite index with two sub-components: (i) Personal contacts (measured by telephone traffic, transfers, international tourism, the share of the population that is foreign, and international letters), and (ii) Information flows (Internet users, television

[10] We thank the research group for sharing their data. The data can be accessed at: `http://www.ncdrisc.org/index.html`. We acknowledge that country averages do not reveal which parts of the distribution are responsible for the observed trends.

[11] See Section 2 in the Appendix for a detailed presentation of the KOF globalisation index. We thank the KOF team for sharing their data. The data can be found at: `http://globalisation.kof.ethz.ch/`.

users and the size of the newspaper sector as a percentage of gross domestic product – GDP). The trade-openness index combines trade flows and indicators for trade openness (e.g. hidden import barriers, tariffs and taxes on international trade, all reverse-coded). Both social and trade indices take values on a scale from 0 to 100, with higher values indicating higher levels of globalisation. The KOF data further provide two covariates for robustness checks: financial globalisation and stocks of FDI.

As shown in Figure 4, globalisation has intensified in recent decades. High- and middle-income countries experienced a sharp upward trend in both social globalisation and trade openness between the beginning of the 1990s and the 2008 crisis. In our sample, information flows are the main drivers of social globalisation. Social globalisation and trade openness are strongly correlated (0.81), as are the two sub-components 'personal contacts' and 'information flows' of social globalisation (0.61).[12] In order to control for the income effect induced by globalisation, we include GDP per capita and its square in all the regressions.[13]

Insert Figure 4 here

We use a balanced estimation sample of 2,940 observations from 70 high- and middle-income countries over a 42-year (1970-2011) period, covering 76% of the world population.[14] Dropping all countries with missing values for any of the outcome variables or covariates produces an estimation sample that is very similar to the original sample (see Section 3 in the Appendix). Our estimation results are thus not likely to be affected by selection bias. About 40% of the countries are high-income countries and 60% middle-income countries. Table I reports some summary statistics. On average, 143 kcal/capita/day come from animal protein, 360 kcal/capita/day from free fat, and about 600 kcal/capita/day from sugar. The mean scores of social globalisation and trade openness are both about 50 points on the 0-100 scale. Mean GDP per capita is about

[12] However in simple OLS regressions, the variance inflation factor of all of the variables is substantially lower than the rule of thumb value of 10. Multicollinearity is thus not likely to bias the estimates.
[13] GDP per capita at constant 2005 prices in thousands of USD (at purchasing power parity). The data come from the World Development Indicators (World Bank).
[14] We could have used an unbalanced panel, but our aim is to identify group patterns of heterogeneity that are comparable across countries, i.e. identified over the same time period. The data are not weighted by population, as we are interested in predictions at the country level. Moreover, population size changes over time and is likely to be endogenous with respect to nutrition indicators.

10,500 US dollars (USD). Due to data availability, the sample used for estimating the effects of globalisation on health outcomes is restricted to the 1975-2011 period and includes $N = 2,590$ observations. The mean BMI is 24.2, i.e. slightly below the cut-off point of 25 for overweight defined by the WHO (WHO, 2015*c*).

Insert Table I here

4 Estimation strategy

4.1 The 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 on a country's openness and its nutrition patterns. This will bias the estimated effect of globalisation on nutrition and health. A standard solution is to use fixed-effects estimators. However, including country fixed-effects will yield unbiased estimates only if the unobserved country characteristics are constant over time.

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 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. We then fully interact group dummies with year dummies. Thereby, we allow each group to have a different time trend and the group-membership variables may be seen as an index of 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. A key issue here is therefore the choice of the optimal number of groups (see below).[15]

In our setting, the assumption that countries cluster with respect to the unobserved determinants of nutrition profiles is very plausible. For example, urbanisation is often associated with the nutrition transition. Countries typically follow a S-shaped urbanisation process with moderate rates at the beginning and the end of the process and higher rates in the middle (Clark, 2000). Thus, countries which are at the same stage of the cycle probably encounter parallel urbanisation growth rates over time. Likewise, female labour-force participation has also been found to follow an S-shape over time (Fernández, 2013).

Our estimated equation is as follows:

$$y_{it} = \beta_1 \text{Social glob}_{it} + \beta_2 \text{Trade open}_{it} + \beta_3 GDPpc_{it} + \beta_4 (GDPpc_{it})^2 + \alpha_{g_i t} + v_{it}, \qquad (3)$$

where y_{it} denotes the outcome variable for country i and year t, β_1 and β_2 measure the effect of social globalisation and trade openness respectively, GDP_{pc} is GDP per capita, g_i is country i's group membership, $\alpha_{g_i t}$ denotes the set of year dummies that are individually-estimated within each group, and v_{it} is an i.i.d. error term. In some robustness checks, we additionally control for urbanisation, female labour supply and prices, although this forces us to restrict the time window. Note that we differentiate between two types of technological progress: the first is that produced by interactions with other countries and the country's endowments and resources (e.g. innovation capabilities and political reforms); the second is captured by the GFE estimator, which controls for country-specific factors. The social-globalisation variables thus pick up only the first type of technological progress.

[15] The GFE approach is related to finite mixture models (See Section 4 in the Appendix).

4.2 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:

$$F\left(\boldsymbol{\theta},\boldsymbol{\alpha},\boldsymbol{\gamma}\right)_G = \sum_{i=1}^{N}\sum_{t=1}^{T}\left(y_{it} - x_{it}'\boldsymbol{\theta} - \alpha_{g_it}\right)^2 \tag{4}$$

where $\boldsymbol{\theta}$ is the coefficient vector of the observed covariates x_{it}, α_{g_it} are the group-specific time effects for all g_i taking on values in $\{1,...G\}$ and all $t \in \{1,...T\}$. We denote as $\boldsymbol{\alpha}$ the set of all the α_{gt}'s. Since the sum of squared residuals is minimised over the entire time period T, the algorithm takes into account any unobserved shocks that countries experience during T and groups together countries whose residuals exhibit a similar time profile. Consequently, group membership for each country is fixed over T and is denoted by the g_i. We define as $\boldsymbol{\gamma}$ the set of all g_i's. The estimation algorithm then alternates between an assignment step and an update step. Note that country grouping can vary with the outcome variables y_{it} and the vectors of observed covariates $\boldsymbol{\theta}$.

Step 1 - Assignment Step

Given the 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:

$$g_i = \underset{g\in\{1,...,G\}}{\text{argmin}} \sum_{t=1}^{T}\left(y_{it} - x_{it}'\boldsymbol{\theta^s} - \alpha_{gt}^s\right)^2 \tag{5}$$

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

Step 2 - Update Step

The grouping $\boldsymbol{\gamma^s}$ is used to estimate by OLS 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 (see Section 5 in the Appendix) and show that the modified algorithm reaches the global minimum. This is the algorithm that we use. Last, group membership having been estimated, the variance-covariance matrix is calculated by bootstrapping the entire estimation procedure (100 replications).[16]

4.3 Optimal number of groups

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

To determine the optimal number of groups (separately for each outcome variable) we run GFE estimations with a number of groups G varying between 1 and 12. We first calculate the Bayesian Information Criterion (BIC) to assess the statistical benefit of having more groups.[17] According to Bonhomme and Manresa (2015), the BIC provides an upper bound on the true number of groups if T (years) exceeds N (countries), which is the case in our sample. Second, we test for coefficient stability with increasing G.

[16] The code is available upon request from the authors.
[17] 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 being 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 and $\hat{\sigma}^2$ is an estimate of the variance of the error term v_{it}, which is calculated with $G_{max} = 12$. $\hat{\sigma}^2 = \frac{1}{NT - G_{max}T - N - K} \hat{F}_G$.

To illustrate the procedure, Table II shows the objective function, the BIC value and the GFE coefficient estimates for animal proteins (in logarithms).[18] 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-middle) and these group dummies are interacted with the year fixed-effects. The GFE regressions yield the lowest BIC value for $G = 8$, which is therefore an upper bound on the true number of groups. As depicted in Figure 5, the estimated coefficients on social globalisation and trade openness are fairly stable as we move from $G = 6$ to $G = 8$, indicating that the true G lies between 6 and 8 groups. The value of the GFE objective function with $G = 6$ groups is 85% lower than that with $G = 1$, i.e. a simple OLS specification with year fixed-effects. A further increase in the number of groups does not produce a significant improvement in the objective function. From the above, we select $G = 6$ as the optimal number of groups for animal proteins.

Insert Figure 5 here

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

Insert Table II here

Figure 6 illustrates the usefulness of the GFE approach in controlling for the unobserved time-varying determinants of animal-protein supply. It presents the time trends in the supply of animal proteins (left) and the estimated grouped time effects α_{gt} (right) for the six groups of countries. In the left panel, some groups have rather flat trends in animal proteins while others experience significant growth rates over the period. Group 2, with a sharp upward trend, includes several countries in the Middle East and Central America but also China and Korea. Groups 4 and

[18] Sections 6 and 9 in the Appendix present the optimal number of groups for the two other nutrition outcomes (free fats and sugar), as well as for the health outcome (BMI).

6 exhibit a parallel increase in animal proteins (with a much lower initial level for Group 4). Group 4 includes countries in Sub-Saharan Africa but also India and Indonesia, while Group 6 consists mostly of Latin-American countries. Groups 1, 3, and 5 remain at a constant high level of animal-protein supply over the period. These groups include countries in Europe and North and Latin America, but also Japan, Australia, and some countries in Sub-Saharan Africa.[19] The right panel of the figure clearly shows the importance of accounting for time-varying unobserved heterogeneity: the group-specific time effects are not flat and parallel over time, and are thus not consistent with a fixed-effects model.

Insert Figure 6 here

5 Results

This section presents and compares the estimation results from OLS, standard fixed-effect and GFE models.

5.1 Nutrition and health outcomes

Table III shows the OLS, fixed-effect and GFE estimation results for the supplies of animal protein, free fat and sugar, which are all expressed in *logarithms* (kcal/capita/day). Columns 1, 4, and 7 report the OLS estimates with year fixed-effects capturing yearly shocks that are common to all countries. Social globalisation is here significantly and positively associated with animal protein, free fat and sugar supply (with $p < 0.01$ for animal proteins and sugar, and $p < 0.1$ for free fats). The estimated coefficients on trade openness are insignificant. Columns 2, 5, and 8 show the results with country fixed-effects. Once we control for time-invariant unobservable characteristics, the coefficient on social globalisation becomes insignificant for free fats, suggesting that the previous OLS results were driven by some omitted fixed country characteristics. Columns 3, 6, and 9 present the GFE estimator results. Here, we control for

[19] See Table S7 in the Appendix for the detailed country grouping.

the time-varying unobservable determinants of diet through the inclusion of group-specific time fixed-effects. The effect of social globalisation on the supply of animal proteins (resp. sugar) remains significant at the 1% (resp. 5%) level. Social globalisation again has no impact on free fats. One additional point in the social-globalisation index is associated with a 1.2% rise in the supply of animal proteins (kcal/capita/day) and a 0.9% rise in the supply of sugar. This rise of 1.2% is equivalent to an additional 1.7 kcal/capita/day derived from animal proteins on average (with a minimum of 0.38 and a maximum of 4.3 additional kcal/capita/day). Last, the positive estimated coefficient on GDP per capita and the negative coefficient on its square suggest a hump-shaped relationship between GDP per capita and the outcome variables. The turning point for animal proteins is at 26,500 USD. This value is slightly over the mean GDP per capita of high-income countries in our sample over the 1970-2011 period (22,295 USD).

Insert Table III here

Table IV presents the estimation results for mean BMI. The OLS estimates (columns 1) show that there is a positive and significant correlation between social globalisation and mean BMI ($p < 0.01$). Including country fixed effects renders the coefficient on social globalisation insignificant. After controlling for group time-varying heterogeneity, the coefficient on social globalisation becomes positive and significant at the 10% level. A one-unit rise in the index of social globalisation is associated with an increase in the country-average mean BMI of 0.026 points. A one standard-deviation (18.42) rise in the social globalisation index thus corresponds to an increase of about 2% in mean BMI. The coefficient on trade openness is insignificant.

Insert Table IV here

5.2 Understanding the impact of social globalisation on the nutrition transition

Since the nutrition transition constitutes one important cause of subsequent health outcomes we here further analyse the drivers of the nutrition transition. Our results suggest that globalisation is far from being the main *direct* driver of the moderate convergence of national nutrition patterns. Figure 7 shows the coefficient of variation for the nutrition outcomes (the ratio of the standard deviation to the mean) within and between country groups over time. The convergence between income groups is stronger for animal proteins and free fats than for sugar. Figure 8 plots the changes in the difference in the estimated time effects between groups over time.[20] After controlling for globalisation and GDP, the residual differences between groups attenuate over time for animal proteins (except in Group 6) and sugar, but there is no clear downward trend is free fats. Overall, this suggests that other unobserved factors are likely to be at play.

Insert Figures 7-8 here

Part of the time-varying unobserved heterogeneity in nutrition outcomes may indeed be related to other factors that are commonly associated with the nutrition transition, namely FDI, financial globalisation, urbanisation, female labour-force participation and the Consumer Price Index (CPI) (Popkin, 1999; Datar et al., 2014; Dubois et al., 2014). We consider this possibility by running GFE regressions that include these factors (see Section 8 in the Appendix for the detailed results). Due to data availability, the sample is reduced to the 1990-2011 period and eight countries are dropped. Table V reports the results. Social globalisation continues to have a positive and significant effect on animal proteins and sugar. Column 1 shows our main specification using the restricted sample, and column 2 the estimates with the additional control variables. The coefficient estimates remain almost unchanged. We find again no significant effect of social globalisation or trade openness on free fats (columns 3 and 4).

This result contradicts the theoretical prediction of Olivier et al. (2008) that trade openness preserves food cultures, as otherwise we would have found a negative effect of trade openness on the supply of animal proteins, free fats, and sugar. However as previously mentioned, this prediction relies on the strong assumption of perfect competition.[21] Moreover, countries may preserve their food culture with respect to spices and main ingredients even though the production process may change. Individuals may still eat traditional dishes but increase the size of the meat portions and rely more on processed food items, which contain more sugar and salt (Monteiro,

[20] 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).

[21] The analysis in Hawkes (2005) suggests that (foreign) food companies dominate the industrial sector in many countries.

2009). Food culture may then be preserved, but with the nutrition of ingredients becoming more similar to that in what is commonly understood as the ‘Western diet’.

Insert Table V here

To better understand the drivers of the globalisation-nutrition link, we decompose the social-globalisation variable into its two main sub-components (personal contacts and information flows). The OLS, country fixed-effects and GFE estimation results appear in Table VI. The positive effect of social globalisation on animal proteins and sugar (in columns 3 and 9) is driven by information flows (e.g. Internet, television and trade in newspapers). The sub-components of social globalisation have no impact on free fats, which is consistent with our main results (see Table III, column 6). One explanation of our results could be the role of food advertising in the media. A global review concluded that the most common food products promoted to children are items containing a lot of sugar, such as cereals, soft drinks, savoury snacks and confectionery, as well as fast foods (Cairns et al., 2013). Existing research documents a positive association between the food advertising of energy-dense nutrition-poor foods (including meat) and a greater desire for consumption among adults as well as a higher actual intake among children (Folkvord et al., 2016). A positive effect of advertising on meat consumption has also been reported in work using demand models for the US (Brester and Schroeder, 1995; Capps and Park, 2002).

Insert Table VI here

6 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 economic aspects of globalisation, and mostly consists of case studies of foreign investment 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 globalisation and trade openness on the supply of animal protein, free fat and sugar, as well as on BMI. We apply the standard fixed-effect estimator and the GFE estimator developed by Bonhomme and Manresa (2015). While the former controls for country-specific time-invariant heterogeneity, the latter can be used with group patterns of unobserved time-varying heterogeneity.

Our results suggest that the social dimension of globalisation has a positive and significant effect on the supply of animal proteins and sugar, as well as on mean BMI. Controlling for income, trade openness has no direct impact on nutrition and health outcomes. These findings are relevant for economies and policy-makers, as meat-intensive diets have negative health and environmental consequences (e.g. healthcare costs and externalities). We further show that the effect of social globalisation on animal proteins and sugar is driven by 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.

Last, from a methodological perspective, we show that the GFE estimator has the advantage of controlling for group patterns in unobserved time-varying heterogeneity. The GFE estimator should therefore be seen as an efficient alternative when modelling outcomes that are characterised by time-invariant and time-varying unobserved heterogeneity.

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Table I: Summary statistics

	Mean	Standard deviation	Minimum	Maximum
Nutrition outcomes				
Animal proteins (kcal/capita/day)	143.03	85.26	22.00	422.72
Free fats (kcal/capita/day)	358.81	194.75	16.92	975.33
Sugar (kcal/capita/day)	598.14	211.65	71.49	1077.74
Health outcomes				
Mean BMI	24.21	1.84	18.68	28.72
Covariates				
Social globalisation (0-100)	50.05	18.42	8.67	92.92
Personal contacts (0-100)	48.61	19.43	8.81	90.61
Information flows (0-100)	51.65	21.11	4.40	97.83
Trade openness (0-100)	49.57	19.83	5.48	96.58
GDP per capita (in 000's of 2005 PPP USD)	10.50	13.22	0.14	69.09
FDI (0-100)	55.93	23.83	1.00	100.00
Financial globalisation (0-100)	53.82	19.27	3.15	99.12
Urban population (% of population)	60.89	19.97	8.53	94.83
Female labour force participation (LFP) (%)	52.91	16.50	10.50	83.30
Consumer Price Index (CPI)	67.79	26.73	0.00	114.02

Note: The sample used for health outcomes is slightly smaller ($N = 2,590$) than the sample used for nutrition outcomes ($N = 2,940$) due to missing data for the years 1970-1974. Reported values for the covariates are based on the nutrition sample (the values are very similar for the health sample). The sample for the urban population, female LFP, and CPI covers only 1990-2011 and 62 countries.

Table II: GFE estimates (outcome variable: animal proteins)

Number of groups	Objective function	BIC	Social globalisation	Trade openness	GDP per capita	Squared GDP per capita
1	315.30	0.1115	0.017^{a}	0.001	0.045^{a}	-0.001^{a}
			(0.004)	(0.003)	(0.009)	(0.000)
2	162.95	0.0612	0.017^{a}	-0.001	0.035^{a}	-0.001^{b}
			(0.005)	(0.004)	(0.013)	(0.000)
3	112.87	0.0457	0.019^{a}	-0.001	0.045^{b}	-0.001^{a}
			(0.005)	(0.004)	(0.018)	(0.000)
4	88.12	0.0388	0.016^{a}	-0.000	0.061^{a}	-0.001^{a}
			(0.004)	(0.004)	(0.015)	(0.000)
5	71.10	0.0346	0.015^{a}	0.000	0.051^{a}	-0.001^{b}
			(0.004)	(0.003)	(0.016)	(0.000)
6	58.50	0.0318	0.012^{a}	0.001	0.053^{a}	-0.001^{a}
			(0.004)	(0.003)	(0.015)	(0.000)
7	51.80	0.0311	0.015^{a}	0.001	0.058^{a}	-0.001^{a}
			(0.004)	(0.003)	(0.014)	(0.000)
8♮	46.99	0.0309	0.013^{a}	0.001	0.051^{a}	-0.001^{b}
			(0.003)	(0.003)	(0.016)	(0.000)
9	43.01	0.0311	0.017^{a}	-0.000	0.061^{a}	-0.001^{a}
			(0.003)	(0.003)	(0.014)	(0.000)
10	39.17	0.0314	0.013^{a}	0.002	0.047^{a}	-0.001^{b}
			(0.004)	(0.003)	(0.016)	(0.000)
11	35.33	0.0316	0.012^{a}	0.007^{b}	0.038^{b}	-0.001^{c}
			(0.004)	(0.003)	(0.017)	(0.000)
12	31.74	0.0319	0.010^{a}	0.007^{b}	0.040^{b}	-0.001^{c}
			(0.004)	(0.003)	(0.016)	(0.000)
Alternative specifications:						
Country & year	62.11		0.016^{a}	0.002	0.005	-0.000
fixed-effects			(0.004)	(0.002)	(0.012)	(0.000)
Income groups	248.60		0.014^{a}	0.001	0.020^{b}	-0.000^{b}
x year fixed-effects			(0.004)	(0.003)	(0.010)	(0.000)

Note: This table reports the value of the objective function and the GFE estimated coefficients for $G = 1, ..., 12$. GFE standard errors are calculated with 100 bootstrap replications. The last two estimations provide the results from two alternative specifications: (i) with country and year fixed-effects; and (ii) with countries classified according to their income group (high-, upper-middle-, and lower-middle-income). The 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% levels.

Table III: Globalisation and nutrition outcomes

Outcome	Animal proteins (log)			Free fats (log)			Sugar (log)		
Estimator	OLS	Fixed effects	GFE	OLS	Fixed effects	GFE	OLS	Fixed effects	GFE
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Social globalisation	0.017[a]	0.016[a]	0.012[a]	0.009[c]	0.006	0.001	0.017[a]	0.008[b]	0.009[b]
	(0.004)	(0.004)	[0.004]	(0.005)	(0.004)	[0.007]	(0.004)	(0.004)	[0.004]
Trade openness	0.001	0.002	0.001	-0.003	0.001	0.004	-0.003	0.002	-0.001
	(0.003)	(0.002)	[0.003]	(0.004)	(0.002)	[0.004]	(0.002)	(0.002)	[0.002]
GDP per capita	0.045[a]	0.005	0.053[a]	0.060[a]	-0.004	0.039[c]	0.019[b]	-0.001	0.012
	(0.009)	(0.012)	[0.015]	(0.015)	(0.021)	[0.021]	(0.007)	(0.009)	[0.011]
Squared GDP per capita	-0.001[a]	-0.000	-0.001[a]	-0.001[a]	-0.000	-0.001[c]	-0.000[a]	-0.000	-0.000
	(0.000)	(0.000)	[0.000]	(0.000)	(0.000)	[0.000]	(0.000)	(0.000)	[0.000]
Fixed-effects									
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	315.30	62.11	58.50	503.65	108.74	106.55	229.08	207.70	41.66

Note: This table shows the OLS, fixed-effects and GFE results for the three nutrition outcomes: animal proteins, free fats and sugar supply (in logarithms). Robust standard errors appear in parentheses. The bootstrapped standard errors are in square brackets (100 replications). The GFE results are obtained with $G = 6$ groups. [a], [b], and [c] denote significance at the 1, 5 and 10% levels.

Table IV: Globalisation and mean BMI

Outcome	Mean BMI		
Estimator	OLS	Fixed effects	GFE
	(1)	(2)	(3)
Social globalisation	0.067[a]	-0.004	0.026[c]
	(0.015)	(0.007)	(0.015)
Trade openness	0.007	0.009[b]	0.005
	(0.012)	(0.003)	(0.008)
GDP per capita	0.001	-0.043	0.067
	(0.037)	(0.027)	(0.055)
Squared GDP per capita	-0.001	0.000	-0.001
	(0.001)	(0.000)	(0.001)
Fixed-effects			
Year	Yes	Yes	Yes
Country		Yes	
Group			Yes
Group-year			Yes
Observations	2,590	2,590	2,590
Objective function	3,922.94	169.42	156.68

Note: This table reports the OLS, fixed-effects and GFE results for country-average BMI. Robust standard errors appear in parentheses. Bootstrapped standard errors are in square brackets (100 replications). The GFE results are obtained with $G = 11$ groups. [a] and [c] denote significance at the 1 and 10% levels.

Table V: Robustness check: nutrition outcomes with additional covariates

Outcome	Animal proteins (log)		Free fats (log)		Sugar (log)	
Estimator			GFE			
	(1)	(2)	(3)	(4)	(5)	(6)
Social globalisation	0.011[a]	0.010[a]	-0.004	0.006	0.009[b]	0.007[b]
	(0.004)	(0.003)	(0.006)	(0.004)	(0.004)	(0.003)
Trade openness	0.004	0.003	0.002	-0.000	-0.002	0.002
	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)	(0.002)
FDI		0.000		-0.001		0.001
		(0.001)		(0.001)		(0.001)
Financial globalisation		0.001		0.001		0.001
		(0.002)		(0.002)		(0.001)
GDP per capita	0.025[c]	0.018[c]	0.026[c]	0.020	0.011	0.011
	(0.014)	(0.010)	(0.014)	(0.014)	(0.011)	(0.010)
Squared GDP per capita	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Urbanisation		0.011[a]		0.005		0.007[a]
		(0.003)		(0.004)		(0.003)
Female LFP		0.001		-0.004		-0.009[a]
		(0.003)		(0.004)		(0.003)
CPI		0.002[c]		0.001		-0.000
		(0.001)		(0.001)		(0.001)
Fixed-effects						
Year	Yes	Yes	Yes	Yes	Yes	Yes
Group	Yes	Yes	Yes	Yes	Yes	Yes
Group-year	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,364	1,364	1,364	1,364	1,364	1,364
Objective function	10.17	9.21	14.53	11.95	7.04	6.89

Note: This table shows the GFE estimation results for the supplies of animal proteins, free fats and sugar (in logarithms). Due to the additional covariates, the sample covers only the 1990-2011 period and 62 countries. Columns 1, 3, and 5 show the main specification using this reduced sample. Bootstrapped standard errors (100 replications). The GFE results are obtained with $G = 8$ (except $G = 7$ for columns 2 and 6, and $G = 9$ for column 4). [a], [b], and [c] denote significance at the 1, 5 and 10% levels.

Table VI: The sub-components of social and economic globalisation and nutrition outcomes

Outcome	Animal proteins (log)			Free fats (log)			Sugar (log)		
Estimator	OLS	Fixed effects	GFE	OLS	Fixed effects	GFE	OLS	Fixed effects	GFE
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Personal contacts	0.005^b	0.005^c	0.004	0.003	0.000	0.002	0.004	0.000	-0.000
	(0.002)	(0.003)	[0.003]	(0.003)	(0.004)	[0.005]	(0.003)	(0.002)	[0.003]
Information flows	0.012^a	0.010^a	0.012^a	0.005^c	0.004^c	0.004	0.013^a	0.006^a	0.007^a
	(0.003)	(0.002)	[0.003]	(0.003)	(0.003)	[0.004]	(0.002)	(0.002)	[0.002]
Trade openness	0.002	0.002	0.003	-0.002	0.001	0.005	-0.002	0.002	-0.001
	(0.003)	(0.002)	[0.003]	(0.004)	(0.002)	[0.004]	(0.003)	(0.002)	[0.003]
GDP per capita	0.044^a	0.006	0.059^a	0.061^a	-0.002	0.047^b	0.017^b	0.001	0.006
	(0.009)	(0.012)	[0.014]	(0.015)	(0.021)	[0.018]	(0.008)	(0.009)	[0.010]
Squared GDP per capita	-0.001^a	-0.000	-0.001^a	-0.001^a	-0.000	-0.001^b	-0.000^a	-0.000	-0.000
	(0.000)	(0.000)	[0.000]	(0.000)	(0.000)	[0.000]	(0.000)	(0.000)	[0.000]
Fixed-effects									
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	313.10	61.12	47.06	505.96	108.42	83.12	221.86	45.26	24.05

Note: This table reports the OLS, fixed-effects and GFE results for the sub-components of social and economic globalisation and the nutrition outcomes. Robust standard errors are in parentheses. Bootstrapped standard errors appear in square brackets (100 replications). The GFE results are obtained with $G = 8$ groups for animal proteins and free fats and $G = 10$ for sugar. ^{a}, ^{b}, and ^{c} denote significance at the 1, 5 and 10% levels.

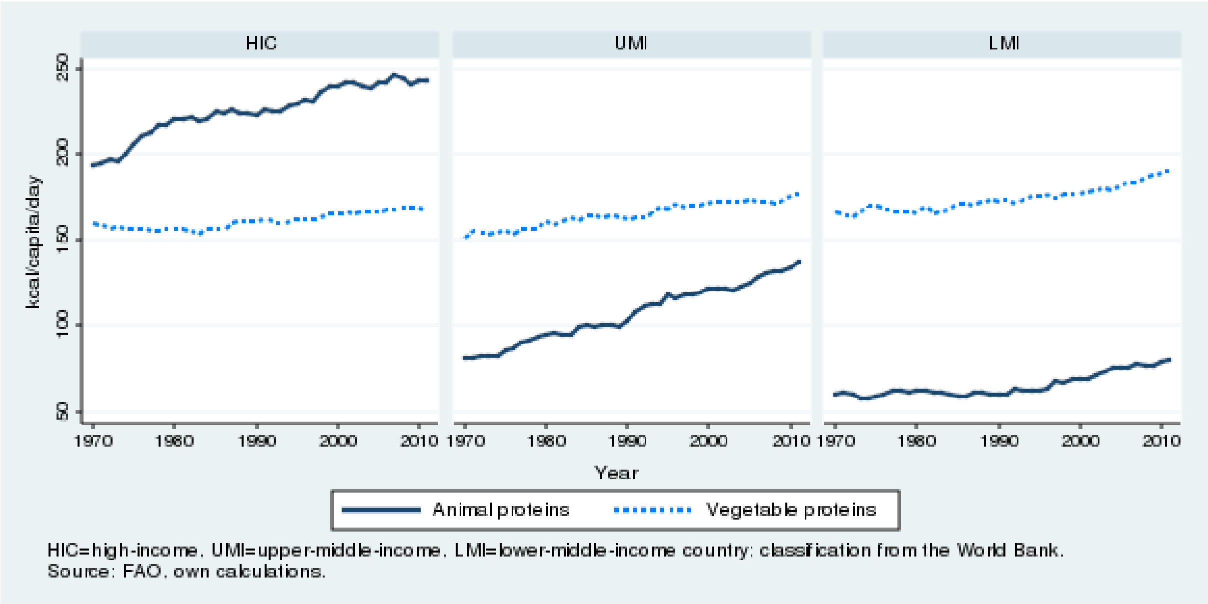

Figure 1: The composition of protein supply, 1970-2011

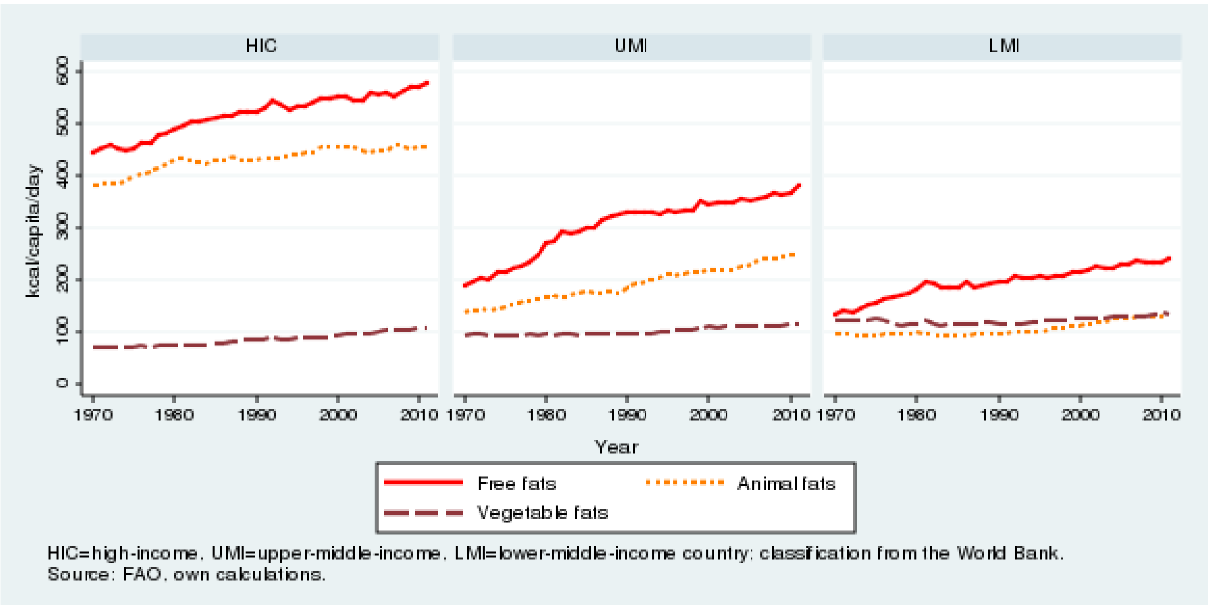

Figure 2: The composition of fat supply, 1970-2011

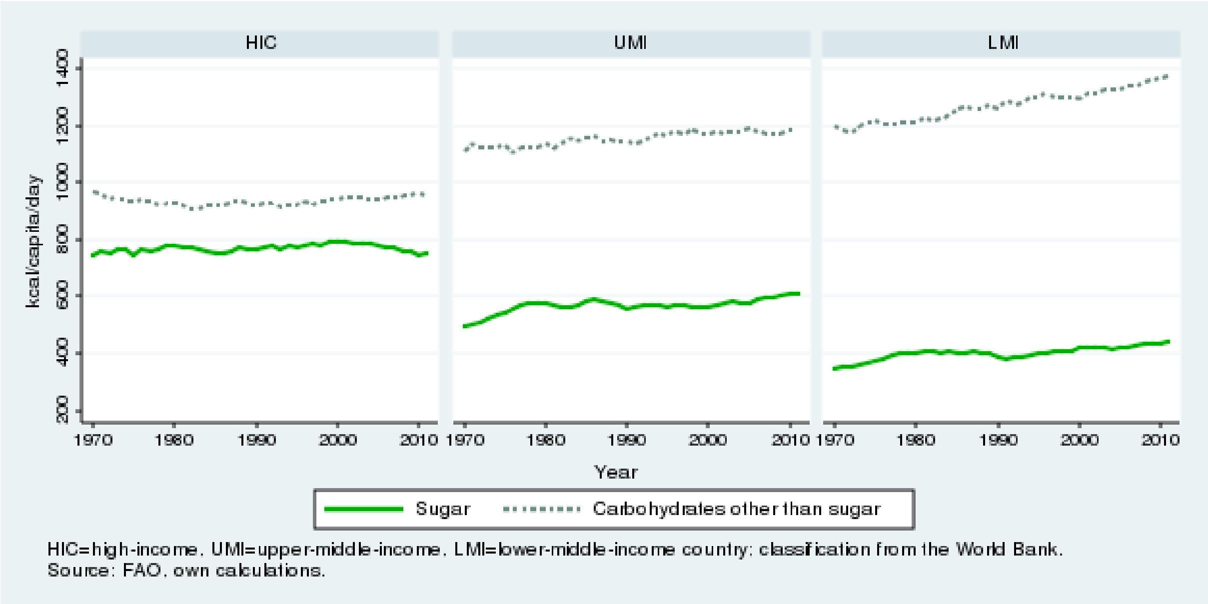

Figure 3: The composition of carbohydrate supply, 1970-2011

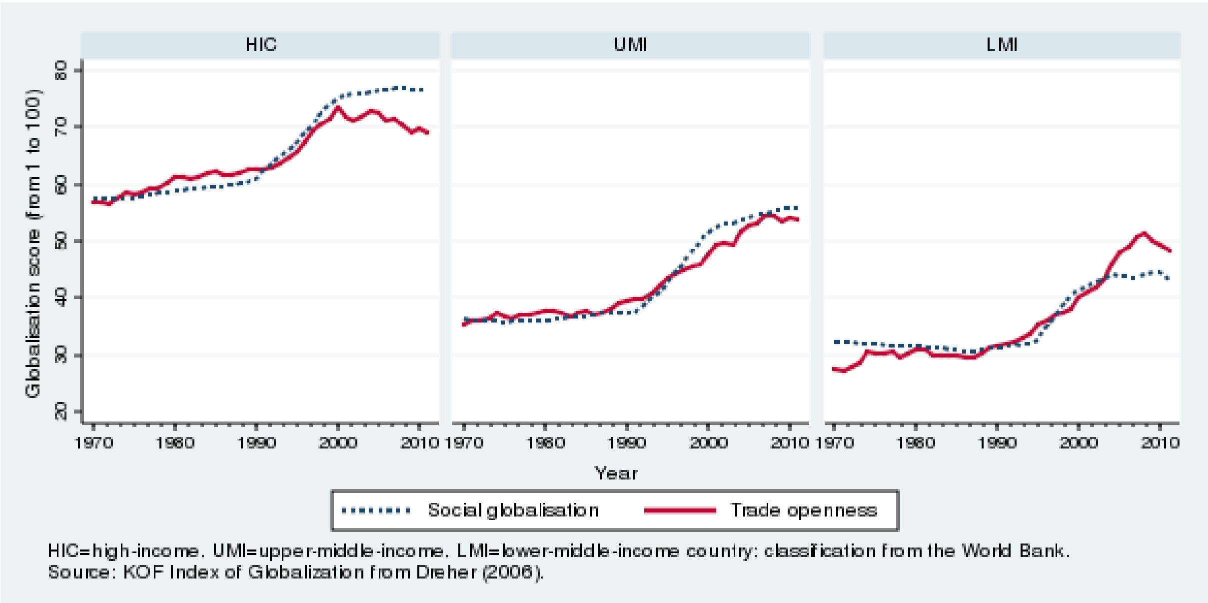

Figure 4: Social globalisation and trade openness, 1970-2011

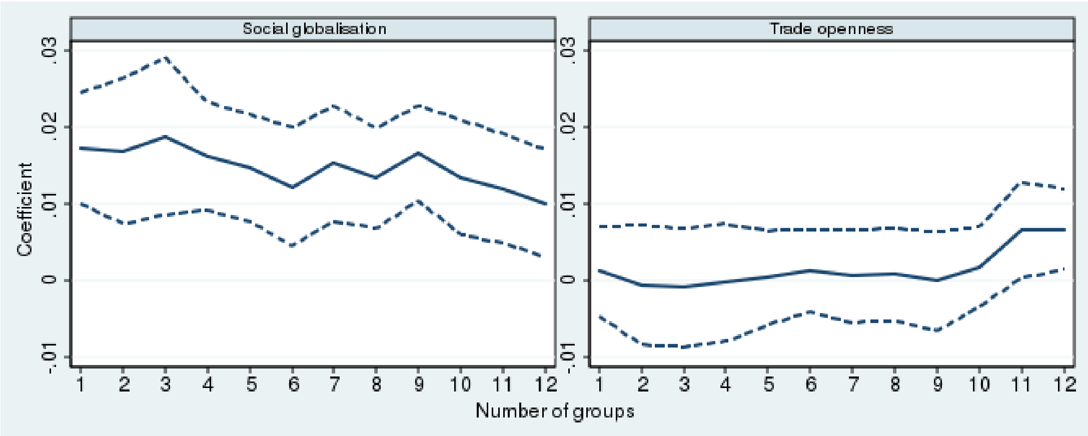

Figure 5: Supply of animal proteins (log): globalisation coefficients

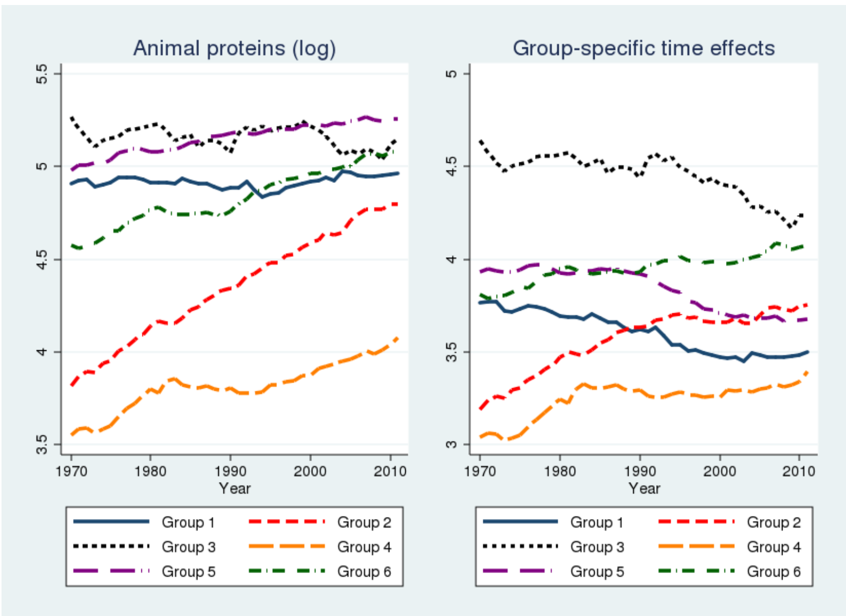

Figure 6: Supply of animal proteins (log) and group time effects, by group

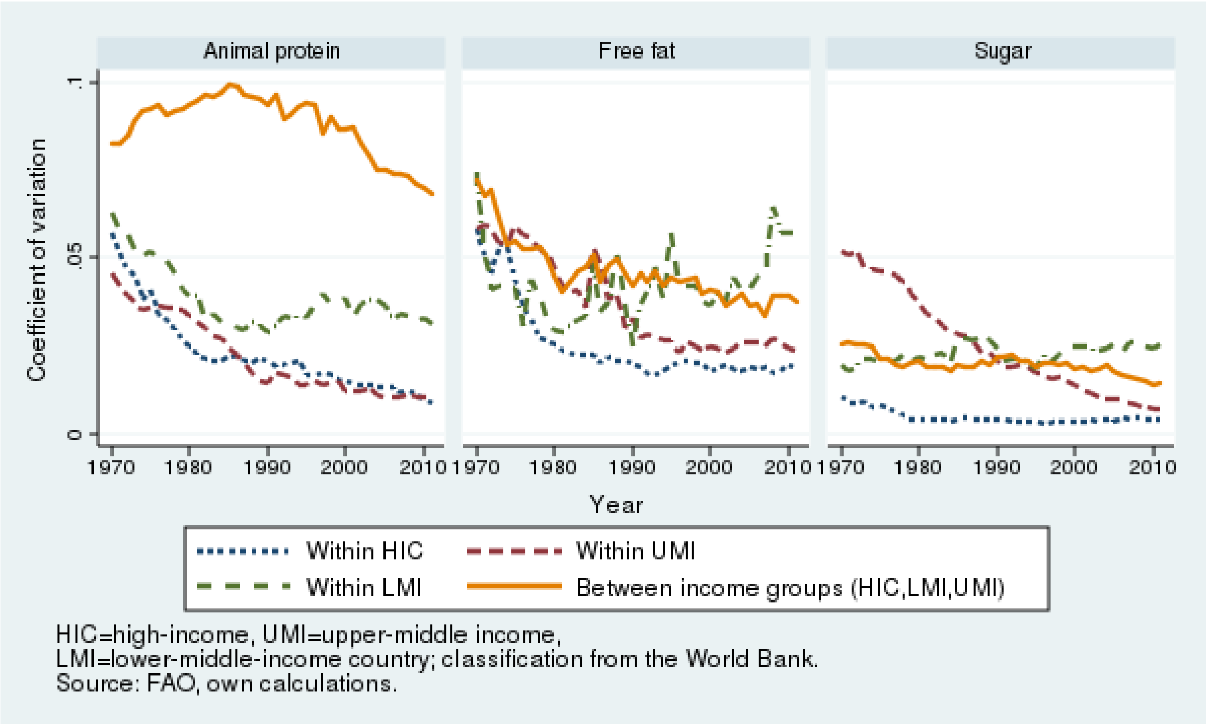

Figure 7: The coefficient of variation for nutrition outcomes, 1970-2011

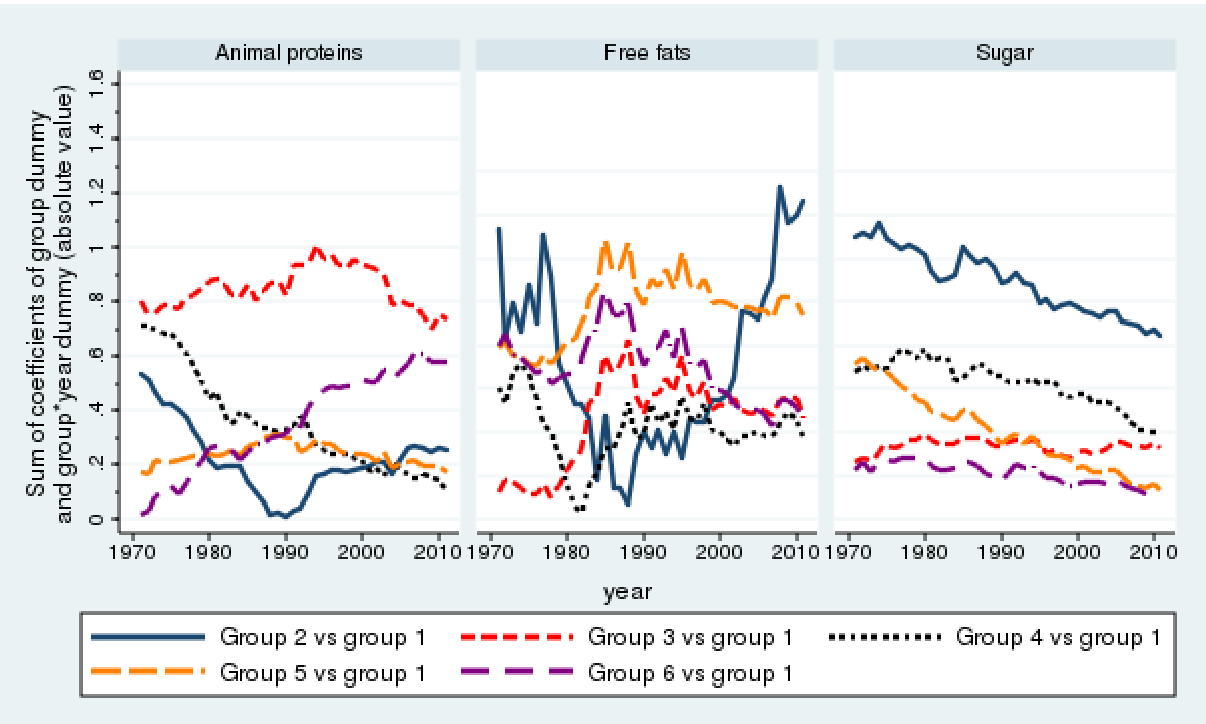

Figure 8: Convergence between groups for nutrition outcomes after controlling for social globalisation, trade openness, and GDP per capita, 1970-2011

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

A Appendix

A.1 The classification of nutrients

Table A1: The 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

Table A1: The classification of food items

Nutrient	Fats			Carbohydrates		Proteins	
	Free	Vegetable	Animal	Other	Sugar	Animal	Vegetable
Coconut Oil	x			x			x
Sesame seed Oil	x			x			x
Olive Oil	x			x			x
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		x	
Bovine Meat			x	x		x	
Mutton & Goat Meat			x	x		x	
Pig Meat			x	x		x	
Poultry Meat			x	x		x	
Meat, Other			x	x		x	
Giblets + (Total)			x	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	

Table A1: The classification of food items

Nutrient	Fats			Carbohydrates		Proteins	
	Free	Vegetable	Animal	Other	Sugar	Animal	Vegetable
Demersal Fish			x	x		x	
Pelagic Fish			x	x		x	
Marine Fish, Other			x	x		x	
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.

A.2 Social globalisation and trade openness indices

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*).

We construct indices for social globalisation and trade openness using data from Dreher (2006). Social globalisation intends to capture direct interactions among people living in different countries, the potential flows of ideas and images, and the extent to which beliefs and values move across national borders. Trade openness is one component of the index for economic globalisation, along with financial globalisation and foreign direct investment (FDI). In our analysis, we focus on trade openness, as it closely mirrors the definition of trade integration used by Olivier et al. (2008). To check for potential biases, we also run estimations controlling for financial globalisation and FDI. Financial globalisation includes portfolio investments, income payments to foreign nationals and capital-account restrictions.

Tables A2 and A3 present the definitions of the variables used to construct the indices for social globalisation and trade openness. Each variable is transformed into an index on a scale of zero to one hundred, with higher values denoting greater globalisation. We exclude the sub-component "Cultural proximity" from the calculation of the social-globalisation index. Similarly, for economic globalisation we rearrange the different sub-components into three groups (trade openness, financial globalisation and FDI). The data are transformed according to the percentiles of the original distribution. The weights for calculating the sub-indices are determined via a principal-components analysis using the entire sample of countries and years (KOF Index of Globalisation, 2016*b*).

Table A2: Definition of social globalisation

Social globalisation	
Indices and Variables	Definitions
Personal contacts (49%)	
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 (51%)	
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 of newspapers and periodicals (percent of GDP).

Source: KOF Index of Globalisation (2016*a*). The link to the KOF website is `http://globalization.kof.ethz.ch/`.

Table A3: Definition of economic globalisation

Economic globalisation	
Indices and Variables	Definitions
Trade openness (45%)	
Trade (percent of GDP)	Sum of exports and imports of goods and services (percent of GDP).
Hidden import barriers	The index is based on the 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	This includes import duties, export duties, profits of export or import monopolies, exchange profits, and exchange taxes (in percent of all current revenues).
Financial globalisation (45%)	
Portfolio investment	Sum of stocks of portfolio investment assets and portfolio investment liabilities (as a percent of GDP).
Income payments to foreign nationals	Employee compensation paid to nonresident workers and investment income (payments on direct investment, portfolio investment, other investment). Income from the use of intangible assets excluded (percent of GDP).
Capital account restrictions	This index is based on two components: (i) a survey question in the 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) the IMF's Annual Report on Exchange Arrangements and Exchange Restrictions.
Foreign Direct Investment (FDI) (10%)	
FDI, stocks	Sum of the inward and outward FDI stocks (as a percent of GDP).

Source: KOF Index of Globalisation (2016*a*). The link to the KOF website is `http://globalization.kof.ethz.ch/`.

A.3 The sample of countries

The original sample consists of 149 high- and middle-income countries (the countries included in the FAO, WDI and KOF data). These countries are depicted in Figure I. However, our aim is to identify group patterns of heterogeneity that are comparable across countries, i.e. identified over the same time period. We therefore restrict our sample to those 70 countries that do not have any missing values in the outcome variable or the covariates (Figure II). We thereby lose a number of countries in Eastern Europe and Central Asia. Comparing the means of the outcome variables and the covariates shows that the final sample is very similar to the raw sample (Table A4).

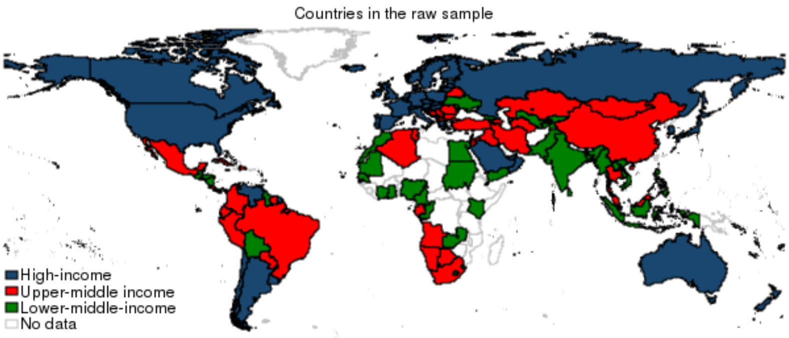

Figure I: Countries in the raw sample

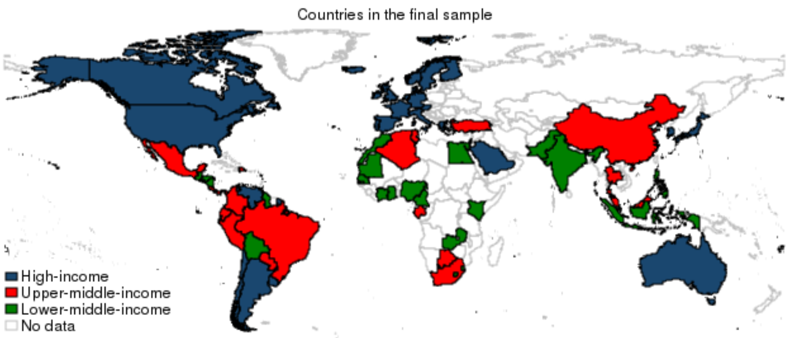

Figure II: Countries in the final sample

Table A4: Comparing the raw and final samples

	Raw sample			Final sample		
	Mean	Standard deviation	Number of countries	Mean	Standard deviation	Number of countries
Animal proteins (kcal/capita/day)	163.56	74.73	148	163.22	81.47	70
Free fats (kcal/capita/day)	379.76	192.25	148	419.07	207.49	70
Sugar (kcal/capita/day)	606.63	195.60	148	613.92	185.77	70
Social globalisation (0-100)	62.61	17.55	146	60.36	17.30	70
Trade openness (0-100)	60.26	17.27	136	58.48	16.29	70
GDP per capita ('000s of 2005 US Dollars, PPP)	12.65	16.62	145	14.53	17.18	70

A.4 The relationship with finite mixture models

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

First, finite mixture models require assumptions that restrict the relationship between the unobserved heterogeneity and the covariates. The covariates are assumed to be independent from unobserved time-varying factors. By contrast, the GFE estimator is more robust, as it leaves this 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 the latent classes (no heteroscedasticity).

A.5 Estimation procedure

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

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

Step 1 - Parameter starting values
First, the starting values of the parameters $(\boldsymbol{\theta}^{\mathbf{0}}, \boldsymbol{\alpha}^{\mathbf{0}})$ are chosen and the algorithm is used to obtain an initial grouping of the countries $\boldsymbol{\gamma_{init}}$.

Step 2 - Neighbourhood jumps
The key feature is the inclusion of a neighbourhood jump, where n countries are randomly reallocated into n randomly-selected groups in order to produce a new grouping $\boldsymbol{\gamma}'$. 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 $\boldsymbol{\gamma}'$ is then used to carry out an updating step producing new parameter values $(\boldsymbol{\theta}', \boldsymbol{\alpha}')$.

Step 3 - Local search
The algorithm is applied using these new parameter values $(\boldsymbol{\theta}', \boldsymbol{\alpha}')$. A local search is then carried out in order to ensure that the algorithm identified 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 in the objective function, the resulting new grouping is labelled $\boldsymbol{\gamma}''$ and the initial grouping is set to $\boldsymbol{\gamma_{init}} = \boldsymbol{\gamma}''$. Step 2 is then repeated 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 has identified a local minimum. In a next step, the neighbourhood jump is repeated 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 algorithms without neighbourhood search, the algorithm with the search requires fewer starting values (N_s) to reach a reliable solution and is therefore more efficient. Moreover, Bonhomme and Manresa (2015) show that it is also more reliable. We therefore use the algorithm with neighbourhood search 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 calculated by bootstrapping with 100 replications.[22]

A.6 The optimal number of groups for free fat and sugar supplies

This section investigates the optimal number of groups for the outcome variables of the supply of free fats and sugar. Tables A5 and A6 show the objective function, the BIC value and coefficient estimates for regressions with different numbers of groups G. For both outcome variables the upper bound of the optimal number of groups is $G = 9$, which produces the lowest BIC value.

Figure III plots the coefficient estimates for social globalisation and trade openness over the different numbers of groups. Visual inspection reveals that the coefficients for sugar, and to a lesser extent free fats, do not vary much between $G = 9$ and $G = 6$. We therefore choose $G = 6$ as the optimal number of groups.

[22] Bootstrapped standard errors are obtained following the approach in Bonhomme and Manresa (2015), i.e. by setting $neigh_{max} = 10$, $N_s = 5$, and $iter_{max} = 5$.

Table A5: GFE estimates (outcome variable: free fat supply (log))

Number of groups	Objective function	BIC	Social globalisation	Trade openness	GDP per capita	Squared GDP per capita
1	503.65	0.1787	0.009[c]	-0.003	0.060[a]	-0.001[a]
			(0.005)	(0.004)	(0.015)	(0.000)
2	237.57	0.0908	-0.003	0.000	0.057[a]	-0.001[a]
			(0.006)	(0.003)	(0.011)	(0.000)
3	178.68	0.0734	0.005	0.001	0.038[c]	-0.001[c]
			(0.006)	(0.003)	(0.020)	(0.000)
4	145.75	0.0649	0.005	0.002	0.039[b]	-0.001[b]
			(0.007)	(0.004)	(0.018)	(0.000)
5	125.07	0.0605	0.005	0.002	0.044[b]	-0.001[b]
			(0.006)	(0.003)	(0.018)	(0.000)
6	106.55	0.0569	0.001	0.004	0.039[c]	-0.001[c]
			(0.007)	(0.004)	(0.021)	(0.000)
7	93.48	0.0551	0.002	0.005	0.040[b]	-0.001[b]
			(0.006)	(0.003)	(0.020)	(0.000)
8	83.30	0.0543	0.006	0.005	0.045[b]	-0.001[b]
			(0.006)	(0.004)	(0.019)	(0.000)
9♮	74.75	0.0540	0.003	0.004	0.025	-0.000
			(0.006)	(0.003)	(0.019)	(0.000)
10	68.92	0.0547	0.003	0.005	0.026	-0.000
			(0.006)	(0.003)	(0.019)	(0.000)
11	61.46	0.0548	-0.002	-0.000	0.035[c]	-0.000
			(0.006)	(0.003)	(0.020)	(0.000)
12	55.05	0.0553	-0.002	-0.001	0.036[c]	-0.000
			(0.006)	(0.003)	(0.019)	(0.000)
Alternative specifications						
Country & year	108.74		0.006	0.001	-0.004	-0.000
fixed-effects			(0.004)	(0.002)	(0.021)	(0.000)
Income groups	462.07		0.006	-0.003	0.045[a]	-0.001[a]
x year fixed-effects			(0.005)	(0.004)	(0.014)	(0.000)

Note: This table shows the value of the objective function, the BIC value and the GFE estimated coefficients for different numbers of country groups. Standard errors are calculated with 100 bootstrap iterations (except in the last two estimations). The last two estimations provide the results of two alternative specifications: (i) with fixed-effects and (ii) with countries classified 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% levels.

Table A6: GFE estimates (outcome variable: sugar supply (log))

Number of groups	Objective function	BIC	Social globalisation	Trade openness	GDP per capita	Squared GDP per capita
1	229.08	0.0807	0.017[a]	-0.003	0.019[b]	-0.000[a]
			(0.004)	(0.002)	(0.007)	(0.000)
2	113.34	0.0424	0.014[a]	-0.002	0.011	-0.000
			(0.005)	(0.002)	(0.016)	(0.000)
3	75.79	0.0306	0.010[a]	-0.002	0.005	-0.000
			(0.004)	(0.003)	(0.012)	(0.000)
4	55.79	0.0248	0.010[a]	0.001	0.009	-0.000
			(0.003)	(0.002)	(0.010)	(0.000)
5	47.77	0.0231	0.009[a]	-0.000	0.010	-0.000
			(0.004)	(0.002)	(0.010)	(0.000)
6	41.66	0.0220	0.009[b]	-0.001	0.012	-0.000
			(0.004)	(0.002)	(0.011)	(0.000)
7	33.71	0.0203	0.007[c]	0.000	0.011	-0.000
			(0.004)	(0.003)	(0.010)	(0.000)
8	30.16	0.0202	0.008[b]	-0.001	0.012	-0.000
			(0.003)	(0.003)	(0.009)	(0.000)
9♮	27.13	0.0201	0.007[b]	0.001	0.010	-0.000
			(0.003)	(0.003)	(0.009)	(0.000)
10	25.16	0.0205	0.009[a]	0.001	0.009	-0.000
			(0.003)	(0.003)	(0.008)	(0.000)
11	22.38	0.0205	0.010[a]	-0.004	0.015[c]	-0.000[c]
			(0.003)	(0.003)	(0.009)	(0.000)
12	20.98	0.0211	0.010[a]	-0.004	0.015[c]	-0.000[c]
			(0.003)	(0.003)	(0.008)	(0.000)
Alternative specifications						
Country & year fixed-effects	45.97		0.008[b]	0.002	-0.001	-0.000
			(0.004)	(0.002)	(0.009)	(0.000)
Income groups x year fixed-effects	207.70		0.016[a]	-0.003	0.010	-0.000[b]
			(0.004)	(0.002)	(0.006)	(0.000)

Note: This table reports the value of the objective function, the BIC value and the GFE estimated coefficients for different numbers of groups. Standard errors are calculated with 100 bootstrap iterations (except in the last two estimations). The last two estimations provide the results of two alternative specifications: (i) with fixed-effects and (ii) with countries classified 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% levels.

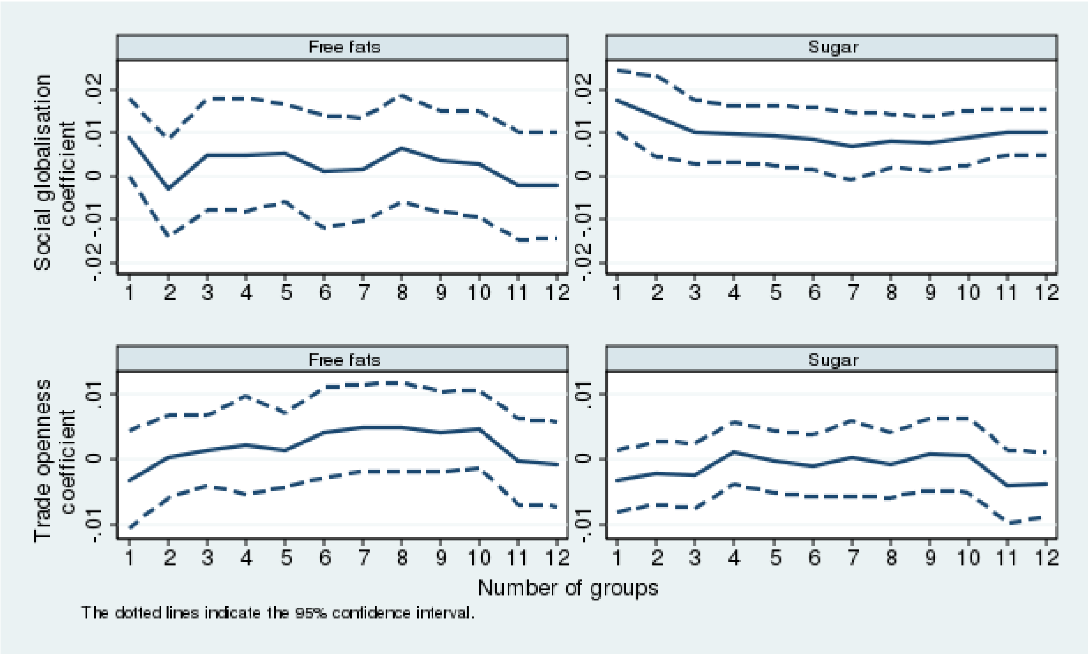

Figure III: The coefficients on social globalisation and trade openness for free fats and sugar

A.7 Country groupings for animal proteins

Table A7: The grouping of countries for animal proteins

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

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

A.8 A robustness check with additional controls

To test the robustness of our results, we add further covariates to our regressions: FDI, financial globalisation, urbanisation, female labour-force participation, and the Consumer Price Index (CPI). Due to data constraints, our sample is reduced to the years 1990-2011 and eight countries (Argentina, Chile, China, Germany, Guyana, Lesotho, Nicaragua and Venezuela) are dropped from the sample.

The KOF dataset provides information on *FDI* and *financial globalisation* (see Section A.2 for details). The data for urbanisation, female labour-force participation, and CPI come from the World Development Indicators database.[23] The variable *urbanisation* is the percentage of a country's population living in metropolitan areas with more than one million people in 2000. All countries with missing values in 2000 were manually checked, and found not to have metropolitan areas of over one million: they are therefore coded as zero. The variable *female labour-force participation* is the proportion of the female population aged 15-64 that is economically active. The *CPI* reflects changes in the cost to the average consumer of acquiring a basket of goods and services that may be fixed or changed at specified intervals, such as annually. The Laspeyres formula is generally used and the data are period averages. Tables A8, A9, and A10 present the estimation results for the different numbers of groups.

Table A8: A robustness check: animal proteins (log) with additional covariates

No. of groups	Obj.	BIC	Social global.	Trade openness	FDI	Financial global.	GDP per capita	Squared GDP per capita	Urban.	Female LFP	CPI
1	84.69	0.0647	0.015[a]	0.003	-0.002	0.001	0.021[b]	-0.000[b]	0.008[a]	0.000	0.000
			(0.004)	(0.003)	(0.002)	(0.002)	(0.009)	(0.000)	(0.002)	(0.003)	(0.002)
2	35.11	0.0289	0.014[a]	0.004	-0.002	0.001	0.014	-0.000	0.007[b]	-0.001	0.001
			(0.004)	(0.003)	(0.002)	(0.003)	(0.013)	(0.000)	(0.003)	(0.004)	(0.002)
3	21.09	0.0192	0.016[a]	0.005[b]	-0.000	0.000	0.014	-0.000	0.004	0.000	0.005[a]
			(0.004)	(0.003)	(0.002)	(0.003)	(0.013)	(0.000)	(0.003)	(0.004)	(0.002)
4	15.94	0.0161	0.012[a]	0.006[b]	-0.000	-0.001	0.014	-0.000	0.005	-0.001	0.002
			(0.004)	(0.003)	(0.001)	(0.002)	(0.012)	(0.000)	(0.004)	(0.003)	(0.002)
5	13.30	0.0147	0.013[a]	0.004	0.000	-0.001	0.030[b]	-0.000	0.005	0.001	0.004[b]
			(0.003)	(0.003)	(0.002)	(0.002)	(0.012)	(0.000)	(0.004)	(0.003)	(0.002)
6	11.03	0.0137	0.013[a]	0.005[b]	0.000	-0.001	0.034[a]	-0.000[b]	0.005	-0.000	0.002
			(0.004)	(0.002)	(0.002)	(0.002)	(0.013)	(0.000)	(0.004)	(0.003)	(0.002)
7	9.21	0.0130	0.010[a]	0.003	0.000	0.001	0.018[c]	-0.000	0.011[a]	0.001	0.002[c]
			(0.003)	(0.003)	(0.001)	(0.002)	(0.010)	(0.000)	(0.003)	(0.003)	(0.001)
8	8.25	0.0129	0.008[a]	0.005[c]	-0.001	0.001	0.020	-0.000	0.010[a]	-0.000	0.000
			(0.003)	(0.003)	(0.002)	(0.002)	(0.013)	(0.000)	(0.003)	(0.003)	(0.001)
9♮	7.33	0.0128	0.009[a]	0.005[c]	-0.001	0.001	0.020	-0.000	0.010[b]	-0.000	0.000
			(0.003)	(0.003)	(0.001)	(0.002)	(0.013)	(0.000)	(0.004)	(0.003)	(0.001)
10	6.68	0.0129	0.009[a]	0.005[c]	-0.001	0.001	0.019[c]	-0.000	0.010[a]	-0.000	0.000

Note: This table shows the value of the objective function, the BIC value and the GFE estimated coefficients for different numbers of groups when including additional controls. The standard errors are calculated with 100 bootstrap iterations. ♮ marks the regression with the minimum BIC value. [a], [b], and [c] denote significance at the 1, 5 and 10% levels.

[23] `http://data.worldbank.org/data-catalog/world-development-indicators`.

Table A9: A robustness check: free fats (log) with additional covariates

No. of groups	Obj.	BIC	Social global.	Trade openness	FDI	Financial global.	GDP per capita	Squared GDP per capita	Urban.	Female LFP	CPI
1	143.57	0.1095	0.008[c]	-0.004	-0.001	0.002	0.047[a]	-0.001[a]	0.001	-0.011[a]	0.000
			(0.005)	(0.005)	(0.003)	(0.003)	(0.012)	(0.000)	(0.003)	(0.003)	(0.002)
2	50.77	0.0424	0.001	-0.000	-0.004[c]	0.000	0.042[a]	-0.000[b]	0.003	-0.008[c]	0.001
			(0.005)	(0.004)	(0.002)	(0.003)	(0.011)	(0.000)	(0.003)	(0.005)	(0.002)
3	28.98	0.0275	-0.002	0.004	-0.001	0.003	0.026	-0.000	0.006[c]	-0.008[c]	0.003[c]
			(0.005)	(0.003)	(0.001)	(0.002)	(0.016)	(0.000)	(0.003)	(0.004)	(0.002)
4	22.65	0.0238	0.002	0.002	0.001	0.002	0.016	-0.000	0.006[c]	-0.013[a]	0.005[a]
			(0.004)	(0.003)	(0.001)	(0.002)	(0.016)	(0.000)	(0.004)	(0.004)	(0.002)
5	19.50	0.0225	0.001	0.001	0.001	0.002	0.018	-0.000	0.006[c]	-0.013[a]	0.005[a]
			(0.005)	(0.003)	(0.001)	(0.002)	(0.015)	(0.000)	(0.003)	(0.004)	(0.002)
6	16.89	0.0216	0.000	0.000	-0.000	0.003	0.031[b]	-0.000	0.004	-0.013[a]	0.003[b]
			(0.005)	(0.003)	(0.001)	(0.002)	(0.016)	(0.000)	(0.004)	(0.004)	(0.001)
7	14.55	0.0209	-0.002	-0.002	0.000	0.004[b]	0.028[c]	-0.000	0.001	-0.012[a]	0.004[a]
			(0.005)	(0.003)	(0.002)	(0.002)	(0.016)	(0.000)	(0.004)	(0.004)	(0.001)
8	13.34	0.0210	-0.001	-0.001	0.001	0.002	0.033[b]	-0.000	0.002	-0.010[b]	0.004[b]
			(0.004)	(0.002)	(0.002)	(0.002)	(0.016)	(0.000)	(0.003)	(0.004)	(0.002)
9♮	11.95	0.0209	0.006	-0.000	-0.001	0.001	0.020	-0.000	0.005	-0.004	0.001
			(0.004)	(0.003)	(0.001)	(0.002)	(0.014)	(0.000)	(0.004)	(0.004)	(0.001)
10	10.91	0.0212	-0.003	-0.002	0.001	0.000	0.036[b]	-0.000[c]	0.002	-0.009[b]	0.004[b]
			(0.004)	(0.002)	(0.002)	(0.002)	(0.015)	(0.000)	(0.003)	(0.004)	(0.002)

Note: This table lists the value of the objective function, the BIC value and the GFE estimated coefficients for different numbers of groups when including additional controls. The standard errors are calculated with 100 bootstrap iterations. ♮ marks the regression with the minimum BIC value. [a], [b], and [c] denote significance at the 1, 5 and 10% levels.

Table A10: A robustness check: sugar (log) with additional covariates

No. of groups	Obj.	BIC	Social global.	Trade openness	FDI	Financial global.	GDP per capita	Squared GDP per capita	Urban.	Female LFP	CPI
1	69.07	0.0526	0.016[a]	-0.002	-0.001	0.001	0.006	-0.000	0.003	-0.004[c]	-0.002
			(0.004)	(0.002)	(0.002)	(0.002)	(0.008)	(0.000)	(0.002)	(0.002)	(0.002)
2	28.78	0.0235	0.013[a]	0.000	-0.000	0.004[b]	0.013	-0.000	0.005	-0.005	0.000
			(0.004)	(0.003)	(0.002)	(0.002)	(0.012)	(0.000)	(0.003)	(0.004)	(0.002)
3	17.74	0.0158	0.012[a]	0.006[b]	0.001	-0.001	0.013	-0.000	0.006[c]	-0.004	-0.000
			(0.004)	(0.003)	(0.002)	(0.002)	(0.015)	(0.000)	(0.003)	(0.003)	(0.002)
4	11.98	0.0121	0.013[a]	0.001	-0.001	0.002[c]	0.025[b]	-0.000	0.006	-0.005	-0.001
			(0.003)	(0.002)	(0.001)	(0.001)	(0.011)	(0.000)	(0.004)	(0.003)	(0.001)
5	10.09	0.0111	0.012[a]	0.003	-0.001	0.001	0.022[b]	-0.000	0.006[b]	-0.005	-0.001
			(0.004)	(0.002)	(0.001)	(0.001)	(0.010)	(0.000)	(0.003)	(0.004)	(0.001)
6	7.84	0.0100	0.010[a]	0.004[c]	0.000	0.000	0.000	0.000	0.006[c]	-0.009[b]	-0.001
			(0.004)	(0.002)	(0.001)	(0.001)	(0.010)	(0.000)	(0.003)	(0.003)	(0.001)
7	6.89	0.0097	0.007[b]	0.002	0.001	0.001	0.011	-0.000	0.007[a]	-0.009[a]	-0.000
			(0.003)	(0.002)	(0.001)	(0.001)	(0.010)	(0.000)	(0.003)	(0.003)	(0.001)
8♮	5.68	0.0093	0.005[c]	0.005[b]	0.000	-0.000	0.003	0.000	0.005[c]	-0.004	-0.000
			(0.003)	(0.002)	(0.001)	(0.001)	(0.010)	(0.000)	(0.003)	(0.003)	(0.001)
9	5.23	0.0094	0.005	0.005[b]	0.000	-0.000	-0.000	0.000	0.005[c]	-0.004	0.000
			(0.003)	(0.002)	(0.001)	(0.001)	(0.011)	(0.000)	(0.003)	(0.003)	(0.001)
10	4.73	0.0095	0.005[c]	0.005[b]	0.001	-0.000	0.000	0.000	0.005[c]	-0.004	0.000
			(0.003)	(0.002)	(0.001)	(0.001)	(0.011)	(0.000)	(0.003)	(0.003)	(0.001)

Note: This table shows the value of the objective function, the BIC value and the GFE estimated coefficients for different numbers of groups when including additional controls. The standard errors are calculated with 100 bootstrap iterations. ♮ marks the regression with the minimum BIC value. [a], [b], and [c] denote significance at the 1, 5 and 10% levels.

A.9 The optimal number of groups for BMI

We now consider the optimal number of groups for the BMI. Table A11 reports the objective function, the BIC value and the coefficient estimates for regressions with different numbers of groups. The optimal number of groups is $G = 12$ according to the BIC value. Since the coefficient does not greatly vary between $G = 11$ and $G = 12$ we choose $G = 11$ as the optimal number of groups. This is a conservative approach, as the size of the estimated coefficient on social globalisation is smaller here.

Table A11: GFE estimates (outcome variable: mean BMI)

Number of Groups	Objective function	BIC	Social globalisation	Trade openness	GDP per capita	Squared GDP per capita
1	3,922.94	1.53454	0.067[a]	0.007	0.001	-0.001
			(0.015)	(0.012)	(0.037)	(0.001)
2	1,406.80	0.56969	0.039[a]	0.010	0.052	-0.001
			(0.013)	(0.012)	(0.068)	(0.001)
3	794.80	0.34003	0.023	-0.001	0.032	-0.001
			(0.018)	(0.011)	(0.051)	(0.001)
4	581.05	0.26413	0.031[b]	0.001	0.008	-0.000
			(0.015)	(0.011)	(0.051)	(0.001)
5	480.43	0.23191	0.036[b]	0.009	0.005	-0.000
			(0.015)	(0.010)	(0.054)	(0.001)
6	396.93	0.20631	0.019	0.002	0.046	-0.001
			(0.016)	(0.010)	(0.058)	(0.001)
7	283.89	0.16929	0.047[a]	0.023[b]	-0.030	0.000
			(0.015)	(0.009)	(0.060)	(0.001)
8	243.33	0.16026	0.046[a]	0.021[a]	-0.020	-0.000
			(0.015)	(0.008)	(0.057)	(0.001)
9	209.32	0.15376	0.038[a]	0.005	0.064	-0.001
			(0.015)	(0.008)	(0.059)	(0.001)
10	182.09	0.14988	0.038[a]	0.006	-0.036	0.000
			(0.015)	(0.007)	(0.059)	(0.001)
11	156.68	0.14670	0.026[c]	0.005	0.067	-0.001
			(0.015)	(0.008)	(0.055)	(0.001)
12♮	135.74	0.14525	0.026[c]	0.005	0.076	-0.001
			(0.014)	(0.008)	(0.053)	(0.001)
13	120.19	0.14587	0.021	0.013[c]	0.058	-0.001
			(0.013)	(0.007)	(0.054)	(0.001)
Alternative specifications						
Country & year fixed-effects	169.42		-0.004	0.009[b]	-0.043	0.000
			(0.007)	(0.003)	(0.027)	(0.000)
Income groups x year fixed-effects	3,455.99		0.054[a]	0.007	-0.077[b]	0.000
			(0.015)	(0.011)	(0.033)	(0.000)

Note: This table reports the value of the objective function, the BIC value and the GFE estimated coefficients for different numbers of groups. The standard errors are calculated with 100 bootstrap iterations (except in the last two estimations). The last two estimations provide the results of two alternative specifications: (i) with fixed-effects and (ii) with countries classified according to their income group (high-, upper-middle-, and lower-middle-income). The 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% levels.

A.10 The results for diabetes

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). Research in high-income countries[24] 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). The estimated effects on trends in diabetes will therefore likely represent a lower bound of the effect of globalisation on the prevalence of type-2 diabetes.
The data on country-average[25] diabetes prevalence come from the NCD Risk Factor Collaboration (NCD-RisC), which is a global network of health scientists.[26] The dataset covers the 1980-2011 period and is constructed from population-based studies. The final data are age-standardised (NCD Risk Factor Collaboration, 2016). The mean diabetes prevalence in our dataset is 0.064.

Table A12 shows that in the GFE results (column 3) social globalisation has a positive effect on diabetes prevalence. The effect size is however close to zero, and the estimated coefficient is only significant at the 10% level. Since this result is not very robust, and only of small economic significance, we conclude that social globalisation has no impact on diabetes prevalence. This finding is not very surprising given the weaknesses of the diabetes data discussed above. We also do not find any effect of trade openness. The GFE regression was estimated using $G = 10$ as the optimal number of groups, since this specification produced the lowest BIC value (see Table A13).

[24] The relative proportions have been much-less analysed in middle- and low-income countries (International Diabetes Federation, 2015).

[25] We acknowledge that country averages do not reveal which parts of the distribution are responsible for the observed trends.

[26] We thank the research group for sharing their data. The data can be accessed at `http://www.ncdrisc.org/index.html`.

Table A12: Diabetes prevalence (%)

Outcome	Diabetes prevalence		
Estimator	OLS	Fixed effects	GFE
	(1)	(2)	(3)
Social globalisation	0.000	0.000	0.000[c]
	(0.000)	(0.000)	[0.000]
Trade openness	0.000	-0.000	0.000
	(0.000)	(0.000)	[0.000]
GDP per capita	-0.000	-0.001[b]	-0.000
	(0.000)	(0.001)	[0.001]
Squared GDP per capita	-0.000	-0.000	-0.000
	(0.000)	(0.000)	[0.000]
Fixed-effects			
Year	Yes	Yes	Yes
Country		Yes	
Group			Yes
Group-year			Yes
Observations	2,240	2,240	2,240
Objective function	0.59	0.06	0.02

Note: This table shows the OLS, fixed-effects and GFE results for country-average BMI. Robust standard errors appear in parentheses. Bootstrapped standard errors are in square brackets (100 replications). The GFE results are obtained with $G = 10$ groups. [b] and [c] denote significance at the 5 and 10% levels.

Table A13: GFE estimates (outcome variable: Diabetes prevalence)

Number of Groups	Objective function	BIC	Social globalisation	Trade openness	GDP per capita	Squared GDP per capita
1	0.59	0.0002660	0.0002	0.0001	-0.0004	-0.0000
			(0.0002)	(0.0002)	(0.0004)	(0.0000)
2	0.24	0.0001105	-0.0000	0.0001	0.0005	-0.0000[c]
			(0.0002)	(0.0001)	(0.0007)	(0.0000)
3	0.12	0.0000606	0.0003	0.0001	-0.0002	-0.0000
			(0.0002)	(0.0002)	(0.0008)	(0.0000)
4	0.07	0.0000404	0.0001	0.0000	0.0006	-0.0000[c]
			(0.0001)	(0.0001)	(0.0007)	(0.0000)
5	0.06	0.0000348	0.0000	-0.0000	0.0009	-0.0000[b]
			(0.0001)	(0.0001)	(0.0006)	(0.0000)
6	0.04	0.0000290	-0.0001	-0.0000	0.0010	-0.0000[b]
			(0.0002)	(0.0001)	(0.0006)	(0.0000)
7	0.04	0.0000263	0.0002	0.0002[c]	-0.0007	-0.0000
			(0.0002)	(0.0001)	(0.0007)	(0.0000)
8	0.03	0.0000249	-0.0000	-0.0000	0.0005	-0.0000
			(0.0001)	(0.0001)	(0.0006)	(0.0000)
9	0.02	0.0000236	-0.0000	-0.0000	0.0006	-0.0000[c]
			(0.0002)	(0.0001)	(0.0006)	(0.0000)
10♮	0.02	0.0000235	0.0003[c]	0.0001	-0.0005	-0.0000
			(0.0002)	(0.0001)	(0.0006)	(0.0000)
11	0.02	0.0000236	0.0001	0.0001	0.0001	-0.0000
			(0.0001)	(0.0001)	(0.0005)	(0.0000)
12	0.02	0.0000239	0.0001	0.0001	0.0001	-0.0000
			(0.0002)	(0.0001)	(0.0005)	(0.0000)
Alternative specifications						
Country & year fixed-effects	0.06		0.0002	-0.0001	-0.0013[b]	-0.0000
			(0.0002)	(0.0001)	(0.0006)	(0.0000)
Income groups x year fixed-effects	0.53		0.0001	0.0001	-0.0013[a]	0.0000
			(0.0002)	(0.0001)	(0.0004)	(0.0000)

Note: This table lists the value of the objective function, the BIC value and the GFE estimated coefficients for different numbers of groups. The standard errors are calculated with 100 bootstrap iterations (except in the last two estimations). The last two estimations provide the results of two alternative specifications: (i) with fixed-effects and (ii) with countries classified according to their income group (high-, upper-middle-, and lower-middle-income). The 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% levels.