WAGENINGEN UNIVERSITY – DEPARTMENT OF SOCIAL SCIENCES
RURAL SOCIOLOGY GROUP

FROM HUNGER TO OBESITY

AGRICULTURAL SPECIALIZATION AND OBESITY IN LOW- AND MIDDLE-INCOME COUNTRIES

13 MARCH 2018
MSC ORGANIC AGRICULTURE
SPECIALIZATION SUSTAINABLE FOOD SYSTEMS

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SUMMARY

Many low-income countries deliberately pursue agricultural specialization to increase yields and thereby lift their population out of hunger and poverty. Trade is supposed to offset the implied lower diversity of food production and deliver a food supply that supports the health of their population. This study challenges this assumption. I investigate the link between the prevalence of overweight and agricultural specialization. Using a fixed-effects panel regression on data from 65 low- and middle-income countries over the period 1975-2013, I find that countries in which agricultural production is more specialized have a larger share of overweight women. The positive relationship is higher in countries with lower per capita income. The correlation is not statistically different from zero for the male population, which confirms existing empirical evidence that malnourishment tends to be more frequent for women than for men. My results suggest that there are negative health implications of agricultural specialization in poor countries.

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1. INTRODUCTION

The achievements of modern agriculture since the Green Revolution are impressive: While producing enough food has been on humanity's agenda for most of history, at present the world produces more than enough calories to feed its population (IPES-Food 2016). Moreover, hunger has either been virtually eradicated or substantially reduced in many countries. From this perspective, our current food system can be seen as a great success of human civilization.

In the pursuit of higher agricultural productivity,[1] most countries increased the production of similar energy-dense foods, which resulted in a just few major cereal and oil crops that dominate the global food supply. National food production of total calories increased, but so did the homogeneity of food supplies (Khoury et al. 2014). The map on nutritional diversity in Figure 2 shows that the diversity of food production in most countries is relatively low, and staples dominate production. In particular, Herrero et al. (2017) find that sugar and oil crops provide the largest share of calories produced globally. However, more calories do not automatically translate into more nutrients and a high production of calories can mask a global lack of nutrients.

Malnutrition can be associated with both hunger and obesity, but for the first time in history, there are more overweight people in the world than those who suffer from hunger.[2] According to the World Health Organization (WHO 2017 a), overweight is linked to more deaths worldwide than underweight. Excessive weight gain increases the likelihood of noncommunicable diseases (NCDs) such as diabetes, hypertension, coronary heart disease, stroke, and certain cancers (WHO 2014). These diseases are estimated to be responsible for 70% of deaths worldwide and have thus overtaken communicable diseases as the leading global cause of death (WHO 2017 b). Scientists are warning of "a global pandemic of hyperglycemia and diabetes mellitus" and are calling for public interventions (Danaei 2013, p.1493).

Once considered a problem that only affects rich countries, overweight and the incidence of related NCDs have been rapidly increasing in low- and middle-income countries. Between 1975 and 2016, worldwide obesity has nearly tripled. The maps in Figure 1 show how the distribution of overweight population has changed across countries in these four decades. In 1975, the share of overweight people was higher than 40 % in only a few countries of the global North and Oceania, and did not exceed 60% in any country of the world; by 2016, however, many other countries caught up. In several countries, the share of overweight people even surpassed 60%. The increase in obesity has been particularly stark in regions of North Africa,

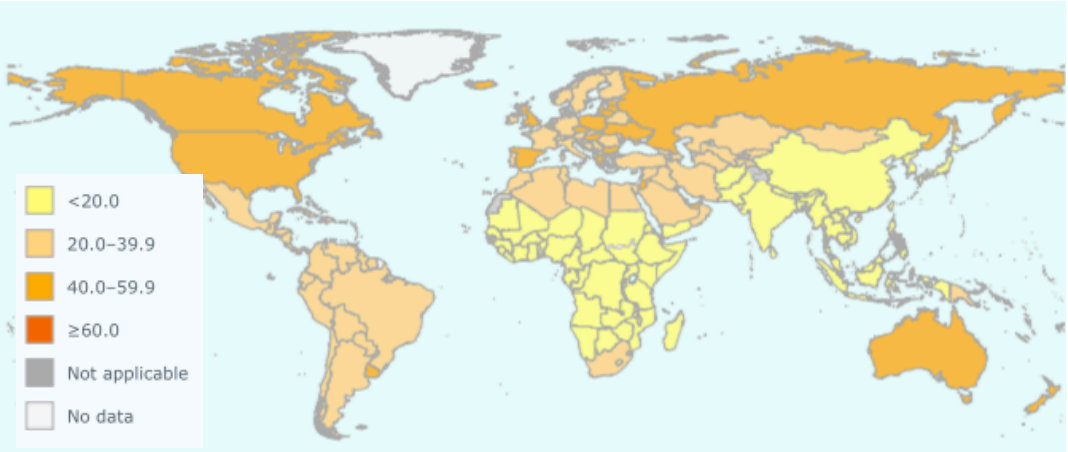
[1] Feeding the population is not the only reason why countries pursue a higher agricultural productivity; many crops are dedicated to the production of fiber and fuel.

[2] At the global level, hunger affected 815 million people in 2016. In the same year, more than two billion people were overweight (1.9 billion adults and 381 million children and adolescents). The figures are based on WHO data for 2016 from http://www.who.int/mediacentre/factsheets/fs311/en/ accessed on December 4th, 2017).

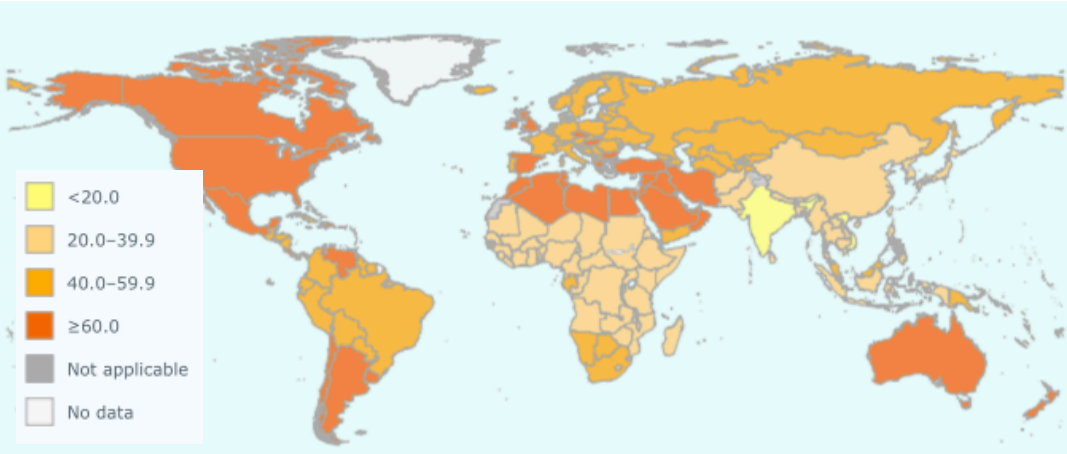
Middle East, and some countries in Latin America. In countries of these regions it rose from below 40% in 1975 to more than 60% in 2016.

Figure 1: Global prevalence of overweight: 1975 vs. 2016

Prevalence of overweight* (%) among adults** in 1975



Prevalence of overweight* (%) among adults** in 2016



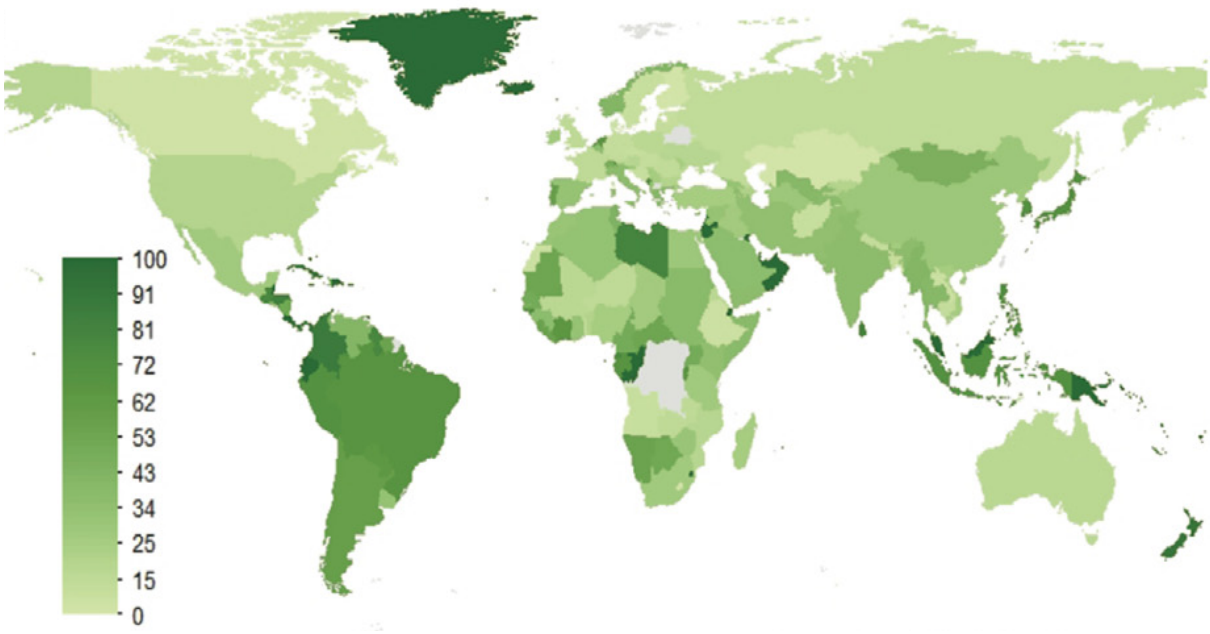
Source: Global Health Observatory, World Health Organization 2017 (http://www.who.int/gho/en/).

*) According to the WHO, a person is considered overweight if her/his Body Mass Index is greater or equal to 25 kg/m^2.
**) All persons of age 18 or higher; the estimates are age standardized.

Despite the attention received by malnutrition and the obesity epidemic in academic literature and among policy-makers, little is known about the causal relationship between agricultural diversity and human health outcomes (Fanzo et al. 2013). Existing research attributes socio-demographic, economic, or political as causes for malnutrition and obesity. There is also a small strand of literature that investigates the relationship between agricultural diversity at the farm level and the diets of the farming households. Moreover, most existing claims are based on anecdotal evidence or case studies that are difficult to generalize. My thesis is an attempt to draw more general conclusions at the level of countries and groups of countries. In particular, using data on 65 low- and middle-income countries over four decades (1975-2013) and a fixed effects panel regression model, this study investigates whether agricultural specialization - the opposite of diversity - plays a role in the rising share of overweight population.

Thus, my main research question is: *Is the increase in the prevalence of overweight in the adult population of low- and middle-income countries associated with agricultural specialization?* I focus on low- and middle-income countries because they have experienced the most recent and rapid transition from hunger to obesity. Moreover, there is evidence that in many poor regions, markets do not function properly or are not accessible to some communities (HLPE 2017), and therefore the diets of this population are dependent on the local diversity of their agriculture.

Figure 2: Global map of nutritional diversity: percent of energy production from non-staples



Source: Remans et al. (2014), p. 176.

Note: The map presents the level of diversity in food production for each country using as a diversity metric the percent of energy coming from non-staples in food production. On a scale from 0 to 100, 0 represents no diversity (only one food item or food items of the same composition) and 100 represents the highest value attained among the countries. The numbers reflect averages between 2000 and 2009.

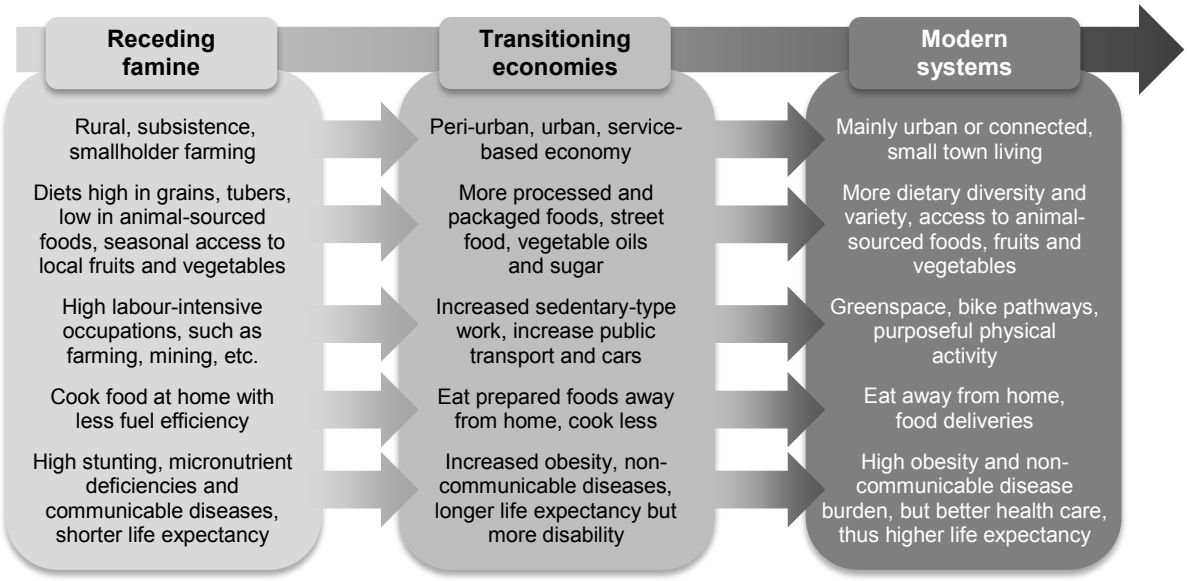
2. THEORETICAL FRAMEWORK

2.1. STATE OF THE ART

A large number of academic and policy papers have been dedicated to determining the underlying causes of an increasingly overweight world population. The issue has been researched along many different dimensions. This section gives an overview of the different strands of literature on this topic.

Popkin (1994) observes a phenomenon that he calls 'nutrition transition' to refer to "changes in lifestyle and dietary patterns driven by urbanization, globalization and economic growth, and their resulting impacts on nutrition and health outcomes."[3] The nutrition transition illustrated in Figure 3 shows how human societies change from predominantly rural systems based on subsistence smallholder farming towards 'modern systems' that are mainly urban. This transition involves simultaneous changes in human activity, diets, and health outcomes. While famine and communicable diseases are receding, obesity increases, along with non-communicable diseases. Some countries in Western Europe and North America could be considered to have reached the phase of 'modern systems'. Most world countries, however, are in the phase of 'transitioning economies' and some are still in the phase of 'receding famine'.

Figure 3: The nutrition transition



Source: HLPE (2017), p. 59.

[3] See HLPE (2017), p. 13, as well as Popkin (1994) and Popkin (2001).

In the nutrition transition framework, one set of explanations for the rise in worldwide obesity refers to economic and demographic changes. As countries experience economic growth and urbanize, their population's diet structure changes and obesity rises (HLPE 2017, Subramanian 2011, Dinsa et al. 2012, Goryakin and Suhrcke 2014). Together with technological change, the rise in wealth and urbanization increase the consumption of calories, oftentimes in the form of processed food, which is better affordable and more widely available than fresh fruit and vegetables. At the same time these changes, and in particular urbanization and the use of technology, lead to a decline in physical activity, which can result in weight gain.

As a second set of explanations, many blame globalization and free market capitalism for the increase in obesity, sometimes referred to as 'globesity'. The opening of markets to global trade and foreign investment may have exposed people to cheaper, processed, and energy-dense foods, thereby accelerating the nutrition transition. Cultural globalization led to more homogeneous tastes and practices around the world – a process called "Mc Donaldization" (Ritzer 2008). Moreover, under the pressure of powerful multinational food companies, many governments tend to withdraw from regulating the food system in a way that would protect consumers. For example, food companies strongly – and sometimes successfully – resist public measures such as taxes on sugared drinks or limits to advertisements of unhealthy food. Existing empirical evidence on the effect of globalization on obesity is mixed. For instance, in a comprehensive empirical analysis that covers 56 countries between 1991 and 2009, Goryakin et al. (2015) find a significant positive effect of globalization on the prevalence of obesity among women. De Soysa and de Soysa (2017), however, find the opposite effect of globalization on children and youth.

A different strand of literature has focused on biophysical and environmental factors as drivers of food system changes that influence nutrition. Frison et al. (2011) highlight the importance of biodiversity, in particular agricultural biodiversity, for sustaining productive ecosystems and supporting human nutrition. In their extensive literature review, Penafiel et al. (2011) conclude that natural and agricultural biodiversity have an impact on dietary diversity and quality. The 2017 report by HLPE states that "Food production is heavily dependent on biodiversity and ecosystems […]. Agricultural systems and food supplies are becoming increasingly homogeneous and dependent on a small number of 'global' crops, including major cereal and oil crops. At the same time, agricultural practices are increasingly moving towards intensified monoculture, which may improve grain yields in the short term but limits the biological diversity necessary for high-quality diets."[4] Herrero et al. (2017) provide evidence that those areas of the world with higher agricultural diversity are the ones that produce more nutrients. In their mapping of global nutrient production, they find that the majority of micronutrients (53–81%) are produced in more diverse agricultural landscapes while the majority of sugar (73%) and oil crops (57%) are produced in less diverse ones.

[4] HLPE (2017), p. 14.

The question whether farm production diversity contributes to dietary diversity has been investigated empirically at the household level in different regions of the world. The mixed evidence helps painting a complex picture of the relationship between on-farm production diversity and dietary quality. On the one hand, Jones (2016) finds that the richness of crop species grown by smallholder farming households in Malawi is associated with diet quality and diversity. Similar observations have been made on smallholder family farms in Ecuador (Oyarzun 2013) and in rural areas of Kenya (M'Kaibi 2017). On the other hand, in a study based on survey data from Indonesia, Kenya, and Uganda, Sibhatu and Qaim (2016) conclude that income generated by market oriented production can contribute more to dietary diversity than a diverse subsistence production conditional on access to well-functioning agricultural markets. Similarly, in a study of three regions in India, Ludwig (2018) finds that only farming households that have high incomes benefit from a positive market effect.

2.2. THEORETICAL FRAMEWORK

The overview of existing research from the previous section reveals the complexity involved in determining the driving factors of obesity. This complexity resides in the multiple dimensions that need to be considered – from environmental and biophysical, to socio-demographic, political and economic – and in their dynamic interaction. The focus of my thesis is on the environmental and biophysical dimensions: specifically, on agricultural production as one of the driving forces behind the increasing share of overweight people.

A theoretical framework of how agricultural outputs affect the health and nutrition of the population is offered by Hawkes and Ruel (2006), who claim that the abundance and the diversity of the food produced, its quality, price, and distribution altogether affect overnutrition, undernutrition, and foodborne illnesses. Ludwig (2018) identifies different pathways through which the quality and quantity of diets of individuals and households can be affected by agricultural production: "[…] agriculture as a producer of food for the farming households, agriculture as an income generator through which food can be purchased, and agriculture as a vehicle for decision-making power on intra-household food allocation through women's participation and empowerment."[5]

A number of case studies (some of which I have enumerated in Section 2.1) show empirically that the linkages between diets and agricultural production are particularly strong in rural areas of developing countries where agricultural production takes place in smallholder settings. While agricultural markets can become more important than production diversity for the nutrition of rural households (Ludwig 2018), there are many regions where markets do not function properly or are not accessible to rural communities (HLPE 2017). This is plausibly the case in low- and middle-income countries, which are the focus of this study.

Taken together, the existing theory and the empirical evidence suggest that farm production diversity can be important for the diversity and quality of diets, especially in lower income

[5] Ludwig (2018), p. 1.

countries. To my knowledge, most empirical papers on this topic use survey data and refer to the *individual household level within specific developing countries.* This study attempts to investigate empirically the link between production diversity and obesity, an indirect outcome of diets, at the *national level across low- and middle-income countries.*

My **main hypothesis** is that the increase in overweight population in low- and middle-income countries is related to agricultural specialization, above and beyond the effects of socio-demographic, economic and political factors.

I expect this to be the case because of the anecdotal evidence presented above that in lower income developing countries the diets of rural, poor, or isolated communities rely greatly upon the local diversity of their agriculture. Fruits and vegetables from own production may be the only affordable nutritious foods for farm households in some areas (Sibhatu 2016), but these households face a trade-off between producing for commercial purposes or for own consumption. If the incentives are such that farmers from a whole village, region, or even country focus on growing a particular crop or just a limited number of crops, this leads to a lack of diversity in that area. As stressed by Sibhatu (2016), "affordable access to diverse foods from the market certainly requires that somebody produces these foods." Moreover, supply chains for calorie-dense staples and processed foods are oftentimes more developed than for fresh and perishable products (Pingali 2015). All of the above suggests that in low income countries that specialize in growing a limited range of crops, the most accessible foods for many people are calorie-dense staples and processed foods. Since diets poor in fruit and vegetables, and rich in calorie-dense processed foods arguably lead to weight gain, it is plausible that low income countries with a higher degree of agricultural specialization are more likely to have a population that is overweight.

This leads to my **second hypothesis** that in low- and middle-income countries with higher agricultural specialization, calorie-dense staples are more common relative to healthy fresh foods like fruit and vegetables.

My **third hypothesis** links the previous two by stating that low- and middle-income countries where calorie-dense staples are more common relative to healthy fresh foods have a larger share of overweight people.

These are three testable assumptions, from which I formulate the following **research questions**:

1. *What is the relationship between agricultural specialization and the prevalence of overweight in low- and middle-income countries beyond the effect of socio-demographic, economic and political factors?*
2. *What is the relationship between agricultural specialization and the share of calorie-dense staples in the domestic food supply of low- and middle-income countries?*
3. *What is the relationship between the share of overweight people and the domestic supply of calorie-dense staples in low- and middle-income countries?*

2.3. BASIC CONCEPTS

Overweight and obesity

The World Health Organization (WHO 2017 a) defines overweight and obesity as "abnormal or excessive fat accumulation that may impair health". To classify overweight and obesity in adults, the most commonly used measure is the Body mass index (BMI). It is a simple index of weight-for-height defined as a person's weight in kilograms divided by the square of her/his height in meters (kg/m^2). Adults are classified according to the WHO as overweight if their BMI is greater than or equal to 25, and obese if their BMI is greater than or equal to 30. While BMI provides a very useful measure of overweight and obesity in the population, it should be considered with caution since it may not correspond to the same degree of fatness in different individuals.

Agricultural specialization

Agricultural specialization is understood here as the opposite of agricultural diversity, or agrobiodiversity. FAO (1999) defines agrobiodiversity as "the variety and variability of animals, plants and micro-organisms that are used directly or indirectly for food and agriculture, including crops, livestock, forestry and fisheries. It comprises the diversity of genetic resources (varieties, breeds) and species used for food, fodder, fibre, fuel and pharmaceuticals. It also includes the diversity of non-harvested species that support production (soil micro-organisms, predators, pollinators), and those in the wider environment that support agro-ecosystems (agricultural, pastoral, forest and aquatic) as well as the diversity of the agro-ecosystems."[6]

There are different diversity metrics that have been proposed to measure agrobiodiversity. Some papers use indicators from the ecology literature (e.g. Shannon Entropy Diversity, Modified Functional Attribute Diversity), others count the number of species produced on a farm (Sibhatu and Qaim 2016), or measure the percent of energy production from non-staples (Remans et al. 2014).

In this study, I propose a simple country and time varying measure of agricultural specialization based on the importance of what I call 'the main crop' in the food production of a country. To identify the main crop, I first calculate the relative abundance of each food item produced by a given country in a given year. The main crop is defined as the crop with the highest share in the total quantity of food produced by that country in that specific year. The resulting country-time varying share of the main crop in domestic food production is interpreted as an approximation of the degree to which a country is specialized in its agricultural production. For instance, in the extreme (hypothetical) case where a country would have a share of the main crop of 100 percent, it would mean that the country is fully specialized in producing one single crop.

[6] Retrieved on March 4th from http://www.fao.org/docrep/007/y5609e/y5609e01.htm#TopOfPage.

Globalization

This study uses the definition of globalization from Dreher (2006) and Gygli et al. (2018) which states that "globalization describes the process of creating networks of connections among actors at intra- or multi-continental distances, mediated through a variety of flows including people, information and ideas, capital, and goods. Globalization is a process that erodes national boundaries, integrates national economies, cultures, technologies and governance, and produces complex relations of mutual interdependence." (Gygli et al., 2018, p. 5).

As in Dreher (2006) and Gygli et al. (2018), I distinguish between the three different dimensions of globalization: economic, social, and political. "Economic globalization characterizes long distance flows of goods, capital and services as well as information and perceptions that accompany market exchanges. Social globalization expresses the spread of ideas, information, images and people. Political globalization characterizes the diffusion of government policies." (Gygli et al. 2018, pp. 5-6)

Free market capitalism

Since its emergence around 1883, the term capitalism has been defined by many scholars. One definition provided by the philosopher Ayn Rand states that "Capitalism is a social system based on the recognition of individual rights, including property rights, in which all property is privately owned." This definition has social, legal, and economic ramifications, the latter being linked to the concept of free markets.

In this study, the notion of free market capitalism that I use is based on the concept of economic freedom from Gwartney et al. (2017): "The cornerstones of economic freedom are personal choice, voluntary exchange, open markets, and clearly defined and enforced property rights. Individuals are economically free when they are permitted to choose for themselves and engage in voluntary transactions as long as they do not harm the person or property of others. […] Put another way, economically free individuals will be permitted to decide for themselves rather than having options imposed on them by the political process or the use of violence, theft, or fraud by others" (Gwartney et al., 2017, p.1). Based on this definition, the authors have developed the Economic Freedom Index to measure the degree to which the institutions and policies of a country are consistent with the idealized definition of economic freedom from economics textbooks in the sense that scarce resources should be allocated and coordinated by free markets rather than centralized planning directed by the government.

3. METHODOLOGY

3.1. EMPIRICAL MODEL

My goal is to investigate whether the share of overweight population in low- and middle-income countries is related to agricultural specialization. Since multiple factors can be associated with obesity, I will identify whether agricultural specialization is correlated with an increase in overweight beyond the effect of other potential drivers of obesity that have been commonly proposed in research. Specifically, I will account for per capita income, urbanization, the dependency of a country on food imports, globalization, and free market capitalism.

I attempt to answer the main research question in a regression analysis that uses country-level data. This means that the results show what happens *on average in a country* relative to another country (macro level), and *not to a specific household or individual* in the population of that country (micro level). To draw inference at the micro level, the analysis would need to be based on data disaggregated at the individual or household level. The current analysis uses time-series-cross-section data, which are characterized by repeated observations (in this case yearly) on the same fixed units (in this case countries). This is a typical situation that suggests itself to using ordinary least squares (OLS) with fixed effects and panel corrected standard errors (Beck, 2001).

I estimate the following regression model:

$$
\begin{aligned}
Share\ of\ overweight\ population_{c,t} = \\
\beta_1\ Share\ of\ main\ crop\ in\ domestic\ food\ production_{c,t} \\
+\ \beta_2\ Share\ of\ imported\ food\ in\ domestic\ food\ supply_{c,t} \\
+\ \beta_3\ Control\ variables_{c,t} \\
+\ \beta_4 \sum_c Country\ dummies_c + \beta_5 \sum_t Year\ dummies_t + \varepsilon_{c,t}
\end{aligned}
\tag{1}
$$

The dependent variable is the share of overweight adult women or men in country *c* in year *t*. I look at men and women separately since the existing empirical evidence suggests that they are affected by overweight to a different extent and for potentially different reasons. According to Case and Menendez (2009), globally, men and women face different risks of obesity and in most countries (with the exception of a few Western European countries), the prevalence of obesity is much higher among women than men.

The independent variable of interest is the share of the main crop in the total domestic food production of country *c* in year *t*. This variable captures the degree of agricultural specialization of a country: a higher share of the dominant crop indicates a more specialized agricultural output of the country. The coefficient of interest is β_1 and it measures the correlation between

the degree of agricultural specialization of a country and the share of its overweight female or male population. For example, a positive coefficient β_1 will imply that ceteris paribus, an increase in the share of the main crop in total agricultural production is associated with a higher share of overweight female or male population.

The second independent variable is the share of imported food in the total domestic supply of country *c* in year *t*. The role of this variable is to control for the dependence of a country's domestic food supply on imported foods. The coefficient β_2 measures how the share of overweight population is affected by the prevalence of imported food in their diet. It is not clear ex ante whether to expect a positive or a negative coefficient. The availability of external food can introduce diversity in the diets of a country that would otherwise rely on a few crops, and hence it may affect obesity in either direction. Alternatively, food imported by low- to middle-income countries often consists of staples and/or processed foods and less of fresh fruit and vegetables, which I would expect to increase the number of overweight people.

In addition, I include a set of variables that control for other time-varying country specific factors that can affect the share of overweight population – economic development, proxied by income per capita; urbanization, measured as the share of the population that lives in urban areas; and total population of a country. There is strong empirical evidence that income per capita and urbanization are important drivers of obesity. Goryakin et al. (2015) find that as countries grow richer, the share of overweight population increases. Similarly, they show that urbanization plays an important role in and is associated with changes in obesity. Finally, I control for population to exclude the possibility that my results are driven by the effect of population growth. It could be, for instance, that countries that have rapid population growth are those with more rapid development in specialized agriculture and obese people.

The cross-sectional and temporal variation in the data makes it possible to include year and country dummies (fixed effects). The role of year dummies is to control for observable and unobservable time trends that are common to all countries in a given year, such as global economic crises or changes in oil prices. Country dummies control for time-invariant country characteristics such as its geographical position or natural resource base, which likely affect the share of overweight population and could be correlated with the independent variables.

To ensure that the effect of agricultural specialization that I estimate is not actually reflecting the effect of increasing globalization or free market capitalism on the prevalence of overweight women and men, I also run regressions where I control explicitly for each of the two factors. This is similar to the approach taken by de Soysa and de Soysa (2017). Regressions with each of these additional control variables provide an estimate of the correlation between agricultural specialization and the share of overweight population beyond concurrent changes in overweight due to globalization or free market capitalism.

3.2. DATA

The research questions formulated above link a human well-being outcome with agricultural diversity, economic and demographic outcomes. To identify trends and estimate causal relationships between all these variables requires "long-term time series of observational data […] at different spatial scales."[7] I integrate different databases to create a dataset that covers all the variables needed for the regressions specified above for 65 countries during the period 1975 to 2013. I focus on countries from the following categories of the FAO classification: 'Low Income Food Deficit Countries', 'Lower-middle-income economies', 'Low income economies', 'Land Locked Developing Countries', and 'Least Developed Countries' (FAO 2017). Table 1 in the Appendix gives an overview of the countries covered in the analysis and the number of years for which data is available for all variables.

For the share of overweight women (men) I use the Health Nutrition and Population Statistics provided by the World Bank (The World Bank 2017). The prevalence of overweight female (male) adults is defined as the percentage of females (males) ages 18 and over whose Body Mass Index (BMI) is more than 25 kg/m^2. BMI is a simple index of weight-for-height, or the weight in kilograms divided by the square of the height in meters. The data is compiled by the World Bank from the Global Health Observatory Data Repository of the World Health Organization.

Data on the share of urban population is taken from the World Bank (The World Bank 2017) which calculates the indicator using World Bank population estimates and urban ratios from the United Nations World Urbanization Prospects. It is defined as the number of persons residing in an area defined by national statistical offices as "urban" per 100 total population.

Data on domestic food production, food imports, and domestic food supply are from the FAOSTAT Food Balance Sheets (FAO 2017). Production data measures the quantity of each crop and animal-based product that a country produces. Domestic supply estimates the food available for human consumption and is computed as production + imports - exports + changes in stocks (decrease or increase), accounting for animal feed and waste. I use the FAOSTAT Macro Indicators for data on GDP and population (FAO 2017).

To measure globalization, I use the KOF Globalization Index[8] (Dreher 2006, Dreher et al. 2008) which is the most widely used measure of globalization in the literature (Potrafke 2015). It is a composite indicator that aggregates the economic, social and political dimensions of globalization. Each of the three components represents a sub-index that can be interpreted on its own and aggregates the information from several indicators. Table 2 in the Appendix lists all the indicators used to compute the Economic, Social and Political Globalization sub-indices that go into the KOF Globalization Index (which I call here Overall Globalization Index) together with their respective weights. These indicators are on a scale from 1 to 100, where

[7] See Fanzo et al. 2013, p. 190.
[8] The KOF Globalization Index (2010) used here measures actual (de facto) globalization. An updated KOF Globalization Index by Gygli et al. (2018) includes both de facto and de jure globalization.

100 is assigned to the maximum value attained by an indicator over the whole sample of countries and the entire period. Economic globalization is subdivided into financial and trade restrictions as well as actual flows. Social globalization is subdivided into personal contact, information flows and cultural proximity.

As a measure of free market capitalism, I proceed as in de Soysa and de Soysa (2017) and use the Economic Freedom Index (Fraser Institute 2017) which captures over time the extent to which the policies and institutions of a country are supportive of economic freedom. The index aggregates information from 42 variables along five dimensions: size of government, legal system and property rights, sound money, freedom to trade internationally, and regulation. Table 3 in the Appendix lists the variables that represent the components of each of the five areas. Each component of the index is rated on a scale from 0 (lowest rating) to 10 (highest rating) that reflects the distribution of the underlying data. The rating of each of the five areas is derived by averaging the ratings of its components, and the five area ratings are then averaged to derive the Economic Freedom Index for each country. Before the year 2000, the index is only available at a 5-year interval; I therefore compute yearly values by linear interpolation for the period 1975-1999.

4. ANALYSIS

4.1. DESCRIPTIVE STATISTICS

This section describes the data set analyzed in this study by presenting summary statistics for all the variables used in the regressions. It also prepares the ground for the in-depth analysis in Section 4.2 by showing the correlations between the outcome variables (share of overweight women and men) and each of the independent variables of interest. Table 1 reports summary statistics of all the variables used in the analysis.

SHARE OF OVERWEIGHT WOMEN AND MEN

The average share of overweight population for the sample of countries considered in this study is 30 percent for women and 21 percent for men, with large differences across countries. The countries in the sample with the lowest share of overweight women are Bangladesh and India, and even there, it increased from 6 percent in 1975 to around 21 percent in 2013. The countries with the highest share of overweight women are Jordan and Egypt, where it reached almost reached 70 percent in 2013 from 43 percent in 1975. The numbers are lower for men but also increasing consistently among the different countries. In Myanmar and India, which report the lowest rates of overweight among men in the sample, the increase is from 5 to 16 percent; in Macedonia and Jordan, the countries with the largest shares of overweight men, the increase is from 33 to 62 percent. Figure 4 shows the change over time in the share of overweight women and men for the countries with the most extreme values, and Figures 1 to 4 in the Appendix show the time series for the rest of the countries. They provide evidence that the share of overweight women and men has increased over time in all the countries covered by this study, which confirms the existence of an obesity epidemic in low- and middle-income countries.

Figure 4: Countries with the lowest and highest shares of overweight women and men

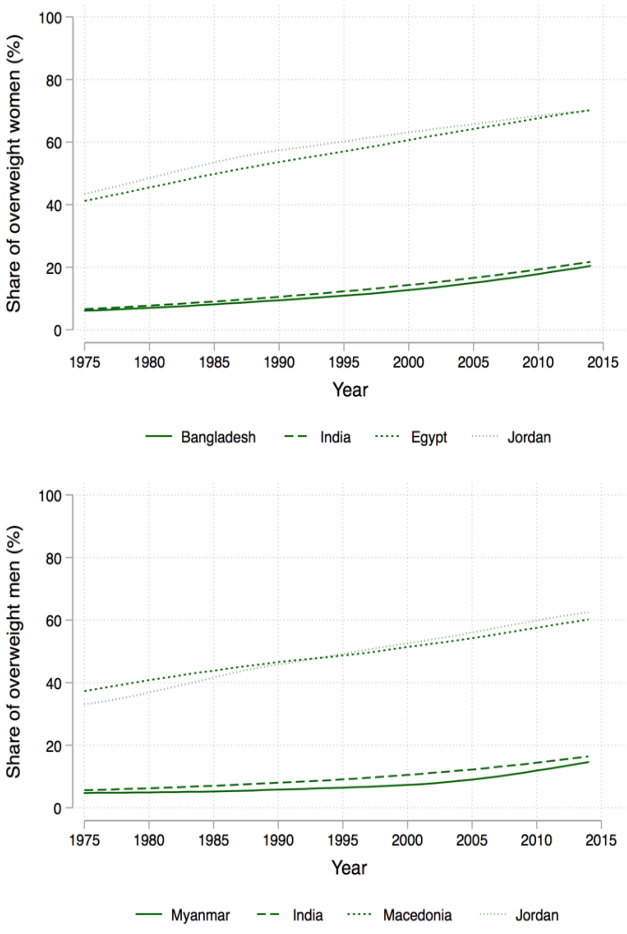


Table 1: Summary statistics

Variable	Observations	Mean	Std. Dev.	Min	Max	Median
Share of overweight women (%)	1663	29.61	14.73	6.1	69.7	25.5
Share of overweight men (%)	1663	20.48	14.12	4.9	61.9	13.9
Share of the main crop in total domestic production (%)	1663	32.19	13.25	10.83	81.21	28.83
Share of food imports in domestic food supply (%)	1663	12.86	15.56	0.12	96.1	7.37
Economic Globalization Index	1663	40.39	14.91	9	82.2	39.73
Social Globalization Index	1663	26.11	12.28	3.04	64.89	24.01
Political Globalization Index	1663	57.95	17.45	20.74	93.68	58.5
Overall Globalization Index	1663	39.96	11.64	12.91	70.88	39.41
Economic Freedom Index	1663	5.49	1.12	1.82	7.83	5.59
Per capita GDP (in 2005 USD per person per year)	1663	1034.1	918.2	75.88	6940.03	716.19
Total population (million persons)	1663	48.92	148.12	0.5	1278.56	10.62
Share of urban population (%)	1663	37.07	15.86	5.42	83.21	36.65

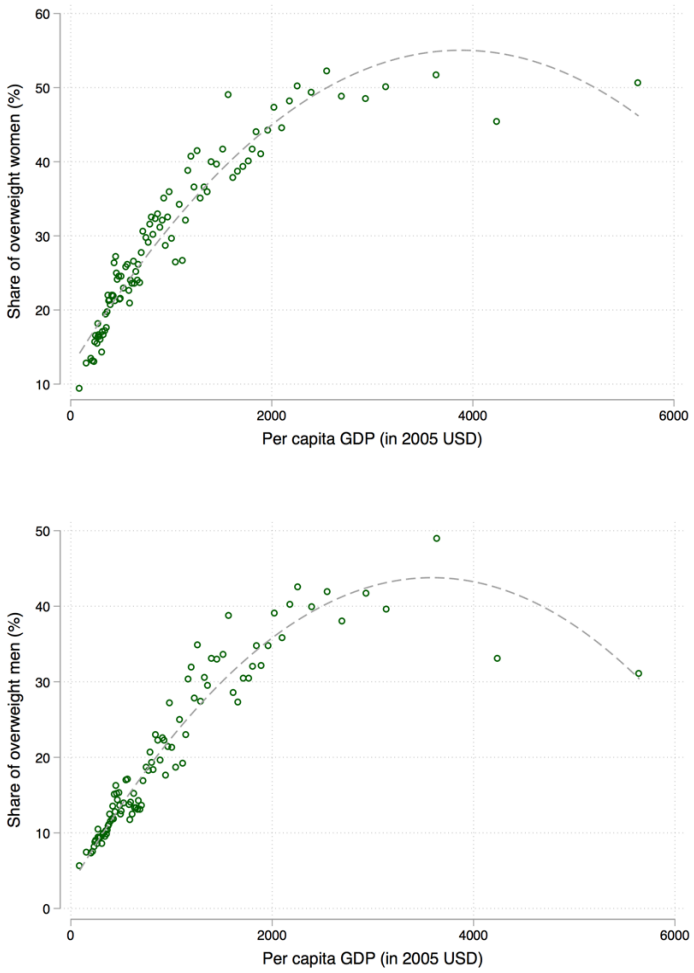
Note: The table presents summary statistics for the main variables used in the empirical tests. 'Share of overweight women (men)' denotes the share of women (men) in the female (male) population who are overweight. 'Share of the main crop in total domestic production' is calculated as the ratio of the domestic production quantity of the main crop of a country to total domestic food production of that country. The main crop of a country is the crop that represents, in terms of tons, the largest share of total domestic food production. 'Share of food imports in domestic food supply' is given by the ratio of food imported to total domestic food supply. The 'Economic Globalization Index', 'Social Globalization Index', and 'Political Globalization Index' measure the degree of integration of a country with the rest of the world along economic, social and political dimensions on a scale from 0 (lowest integration) to 100 (maximum integration). The KOF Globalization Index, called here 'Overall Globalization Index', is the weighted average of the three indices. The 'Economic Freedom Index' captures the extent to which the policies and institutions of a country are supportive of economic freedom. It aggregates information from 42 variables from five areas: size of government, legal system and property rights, sound money, freedom to trade internationally, and regulation. The index is placed on a scale from 0 (lowest rating) to 10 (highest rating). 'Per capita GDP' is the GDP of a country divided by its population, expressed in 2005 US dollars per person per year. 'Total population' is the total population of a country, expressed in million persons. The 'Share of urban population' is computed as the ratio between the number of people living in urban areas and total population. I use yearly country-level data for 65 countries during the period 1975 to 2013. The countries covered in the analysis and the number of years for which data is available for all variables is reported in Table 1 in the Appendix. The share of overweight women and men, and the share of urban population use the Health Nutrition and Population Statistics provided by the World Bank. Data on domestic food production, food imports, and domestic food supply, as well as GDP and population figures are from the FAO Food Balance Sheets and Macro Indicators. For the Overall Globalization Index and its sub-indices, I use the KOF Globalization Index database available at http://globalization.kof.ethz.ch (accessed November 8th, 2017). The Economic Freedom Index is available online at https://www.fraserinstitute.org/economic-freedom (accessed November 9th, 2017).

INCOME PER CAPITA AND POPULATION

In terms of wealth, the average yearly income per person is 1034 dollars (expressed in 2005 USD), and the median is lower than the mean: in half of the country-years observed, the population makes a living from less than 716 dollars per capita and per year. Figures 5 and 6 in the Appendix show the time series of GDP per capita for all the countries in the sample, grouped geographically. The countries at the lowest end of the distribution are in Eastern and Western Africa (except for Cabo Verde where the GDP per capita increased from below 1000 dollars in 1975 to 3000 dollars in 2013), as well as most Asian countries from my sample. In Latin America and in some of the Middle Eastern, European and Central Asian, and South African countries, the incomes are above the sample average. Except for a few countries like Botswana, Kazakhstan, Azerbaijan, Armenia, Tunisia, and Cabo Verde, where incomes raised sharply over time, in many of the countries observed, incomes have not increased significantly, remaining below 1000 dollars per capita.

The two plots in Figure 5 show how, in the sample of countries analyzed in this study, the shares of overweight women and men of a country increase with wealth up to a certain level of GDP per capita. At around 4000 dollars, the share of overweight women levels off and that of men decreases. A

Figure 5: Share of overweight women (men) and per capita income



Note: The two figures show binned scatterplots to visualize the relationship between the share of overweight women/men (y-axis) and per capita income (x-axis). To facilitate visual interpretation, the plots create bins of 'similar' observations (visualized above as small circles) instead of showing every data point in the sample. These bins are created by grouping the observations into 100 equal-sized bins by 'Per capita GDP', computing the mean of the x- and y-variables within each bin, then creating a scatterplot of these data points. The grey dashed line is a quadratic fit line estimated using the underlying data.

concave quadratic function therefore seems to best explain the relationship between the share of overweight population and wealth. This is in line with existing research (Dinsa et al. 2012, Goryakin and Suhrcke 2014). Most circles are concentrated on the left-hand side of the charts, showing that most countries in the sample are at the lower end of the income distribution. It is in that lower range of income where the rate of increase in the share of overweight people is the highest.

The countries in my sample vary greatly in terms of the size of their population. Half of the countries have a relatively small population below 10.6 million people, and the population of most countries is below the sample mean of 49 million. This is visible in Figures 7 and 8 in the Appendix which show the time series for each country's population. The sample mean is higher than the median due to a few very large countries like India, Ukraine, or Nigeria, which are plotted separately in Figure 9 in the Appendix.[9] The figures also illustrate that the population growth during the observed period varies among the countries in the sample. While some register a stark increase in their population size (almost fivefold in Cote d'Ivoire and fourfold in Nigeria, threefold in Guatemala and Angola), in most countries the population size has increased more moderately or stagnated, and even decreased (Ukraine). The growth of the population can be correlated with a more rapid development in specialized agriculture and with more overweight people. It therefore seems reasonable to include in the regression a control variable for time-varying population size to account for the different population growth rates which cannot be captured by country fixed effects.

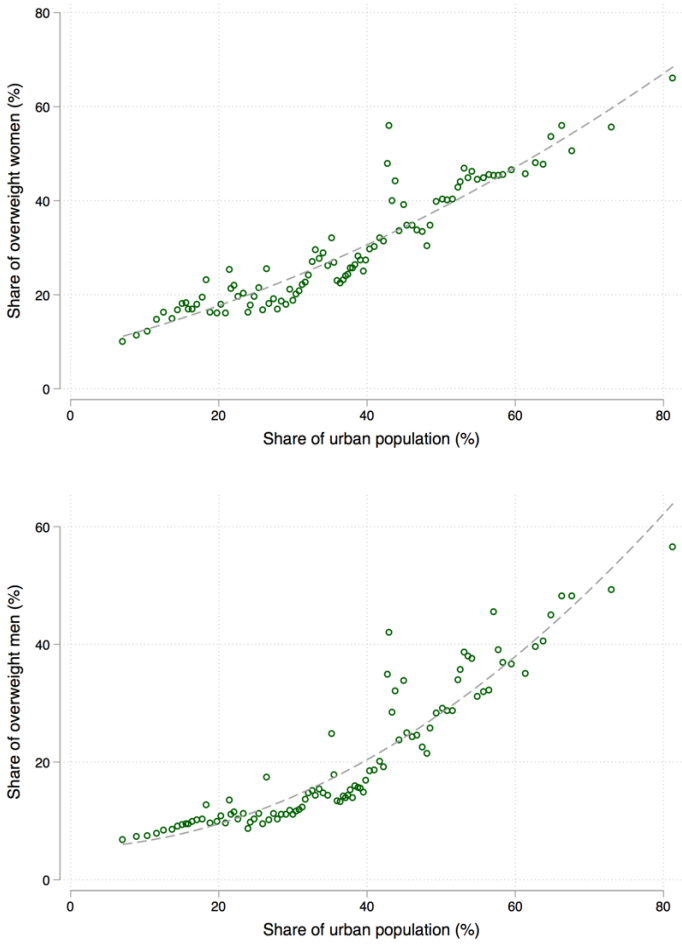
[9] Other countries where the population size is much higher than the rest are Indonesia, Bangladesh, Pakistan, Egypt, and Ethiopia.

URBANIZATION

The average share of urban population in the countries considered in the analysis is 37 percent. The mean and the median are roughly the same for this variable, which means that in half of the observations, urbanization is below 40 percent. In other words, in half of my sample I look at countries with more rural than urban population. Figures 10 and 11 in the Appendix show that this is the case in most Asian and African countries except for the Middle East and a few African countries where urbanization has increased above the sample mean. The figures also show that the general trend in most countries is a rising share of population that lives in urban areas. While in 1975, as much as 90 percent of the countries observed had more rural than urban population, by 2013 this reduced to 60 percent of the countries.

Figure 6 shows the positive relationship between the share of overweight women (men) and urbanization. This confirms the findings from previous research that urbanization is one of the main factors that can explain the rise in obesity worldwide (Goryakin et al. 2015). A quadratic function seems to describe best the relationship between overweight and urbanization, although unlike the case of income, it is a convex function and there does not seem to be a leveling off in the relationship between the two variables.

Figure 6: Share of overweight women (men) and urbanization



Note: The two figures show binned scatterplots to visualize the relationship between the share of overweight women/men (y-axis) and urbanization (x-axis). To facilitate visual interpretation, the plots create bins of 'similar' observations (visualized above as small circles) instead of showing every data point in the sample. These bins are created by grouping the observations into 100 equal-sized bins by 'Share of urban population', computing the mean of the x- and y-variables within each bin, and then creating a scatterplot of these data points. The grey dashed line is a quadratic fit line estimated using the underlying data.

SHARE OF THE MAIN CROP IN DOMESTIC FOOD PRODUCTION

The average share of the main crop in domestic food production is 32 percent in the sample, which means that over the observed 38 years, countries have dedicated, on average, a third of their food production to one crop. The numbers vary widely across countries and over time from a minimum of around 11 percent (Chad in 1991, growing sorghum as the main crop) to its highest value of 81 percent (Swaziland in 2010, growing sugar cane as the main crop). There are 23 different main crops in the sample, with sugar cane, rice and cassava being the most 'popular' ones. For each of these three crops, Figures 7 to 9 show, for every year between 1975 and 2013, the number of countries in which they were grown as the main crop. The figures also show the share of the respective crop in total domestic food production for the country where it reached its maximum value in a given year. For instance, as illustrated in Figure 7, there were 15 countries that produced sugar cane as the main crop in 2010, and among these 15 producers, the country where sugar cane reached the highest share of domestic food production dedicated 80 percent of the quantity of food produced on its territory to this crop. The maximum share of domestic production dedicated to sugar, rice and cassava has increased over time, while the number of producer countries has increased or remained relatively constant. In this sample, sugar is the most frequent main crop and clearly the winner among the dominant crops. The countries which dedicate a large share (60 percent and above) of their domestic food production to one single crop are almost without exception sugar cane producers.

Figure 7: Number of countries producing sugar cane as a main crop and maximum share of domestic production dedicated to sugar cane

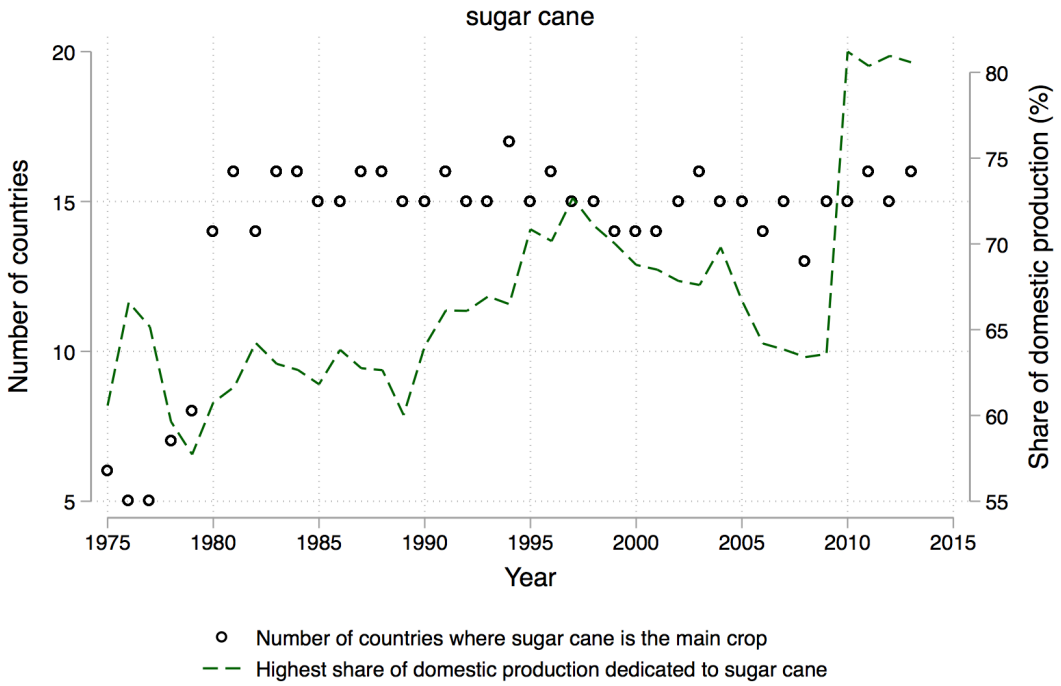


Figure 8: Number of countries producing rice as a main crop and maximum share of domestic production dedicated to rice

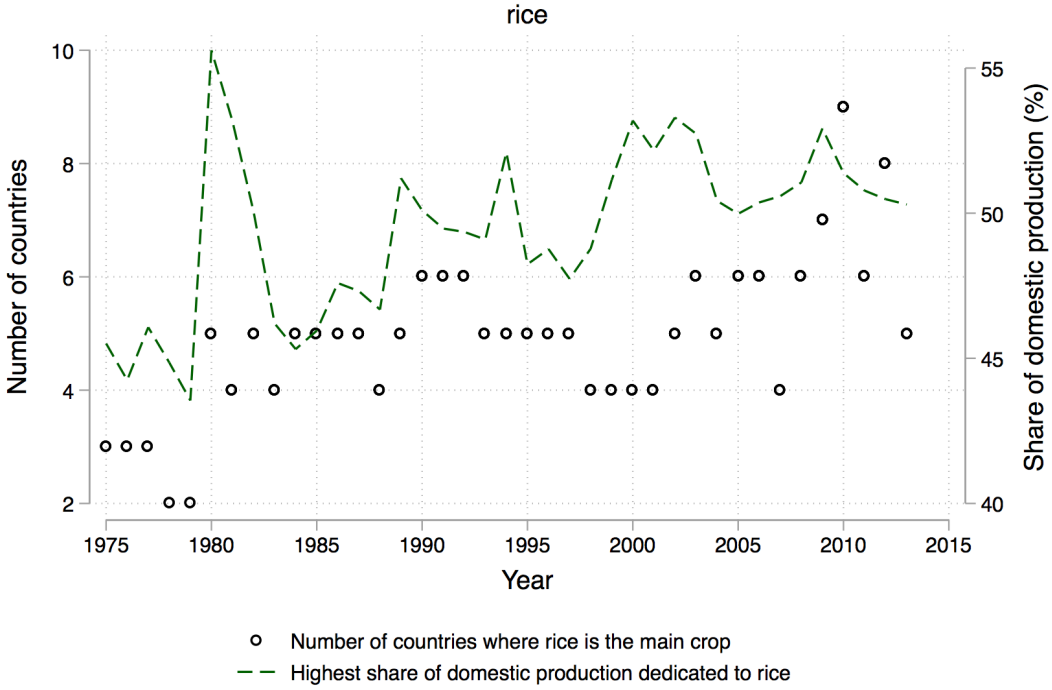


Figure 9: Number of countries producing cassava as a main crop and maximum share of domestic production dedicated to cassava

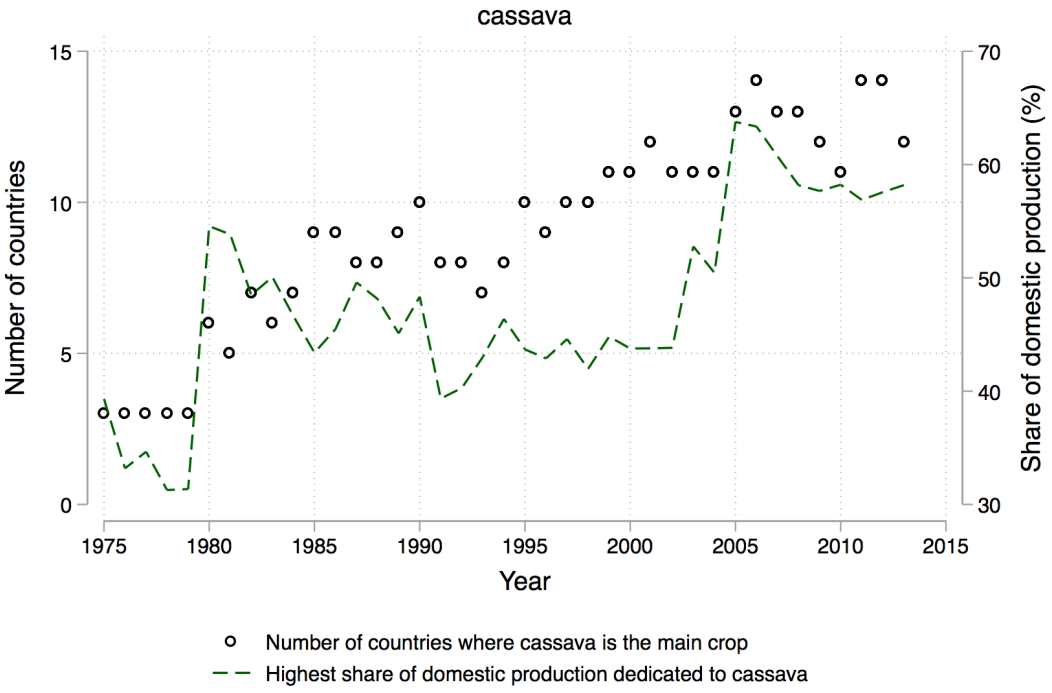
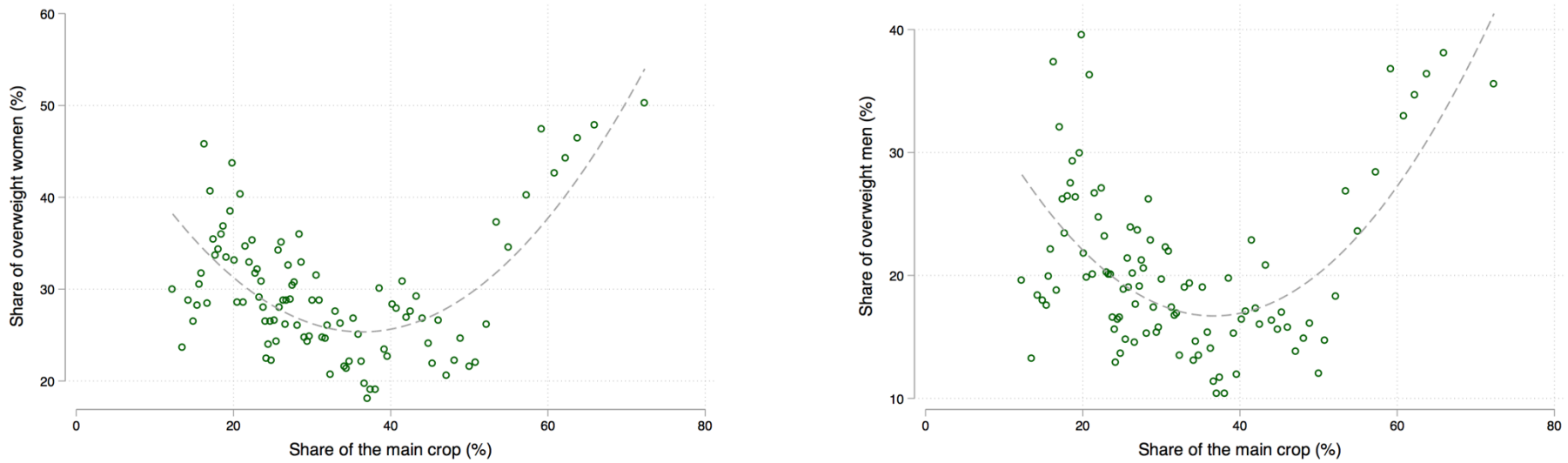


Figure 10 shows the correlation between the share of overweight women (men) and the share of the main crop in the food production of a country. The two plots in Panel A show that the relationship between the prevalence of overweight in the female (male) population and agricultural specialization can be described by a U-shaped function. In countries where the share of the main crop is below 40 percent of domestic food production, overweight and agricultural specialization are inversely related. When the share of the main crop exceeds 40 percent, this relationship becomes positive and countries with higher agricultural specialization also have a higher share of overweight people. This U-shaped functional form with a turning point at 40 percent holds for both the female and male population. Given this picture, it is a priori not clear whether agricultural specialization can be associated with higher or lower overweight in the population.

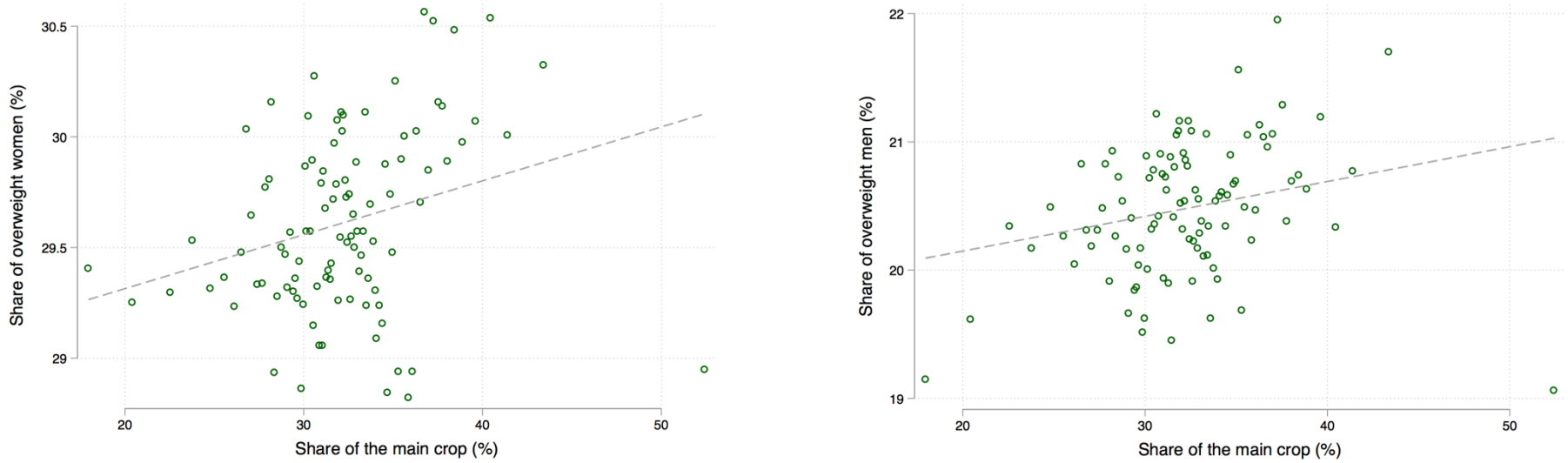
The relationship between overweight people and agricultural specialization depicted in Panel A does not control for any other relevant variables. As the two plots in Panel B show, the correlation between the share of overweight women (men) and the share of the main crop changes once I control for country and year dummies. The U-shape disappears and a positive relationship between the two variables emerges instead (stronger for women than for men), suggesting that the U-shape was partly driven by country characteristics that do not change over time, trends that affect all countries, or both. While the figures offer a rough indication of the fact that countries with a higher agricultural specialization have a larger share of overweight people, they also indicate that agricultural specialization is correlated with other country characteristics that are linked to the increase in overweight. Thus, in order to correctly investigate the link between agricultural specialization and overweight, other potentially relevant control variables, as well as country and year dummies, should be included in the regressions of the next section.

Figure 10 Panel A: Share of overweight women/men and the share of the main crop



Note: The two figures show binned scatterplots to visualize the relationship between the share of overweight women/men (y-variable) and the share of the main crop (x-variable). To facilitate visual interpretation, the plots create bins of 'similar' observations (visualized above as small circles) instead of showing every data point in the sample. These bins are created by grouping the observations into 100 equal-sized bins by the variable 'Share of the main crop', computing the mean of the x- and y-variables within each bin, and then creating a scatterplot of these data points. The grey dashed line is a quadratic fit line estimated using the underlying data.

Figure 10 Panel B: Share of overweight women/men and the share of the main crop (controlling for country and year dummies)



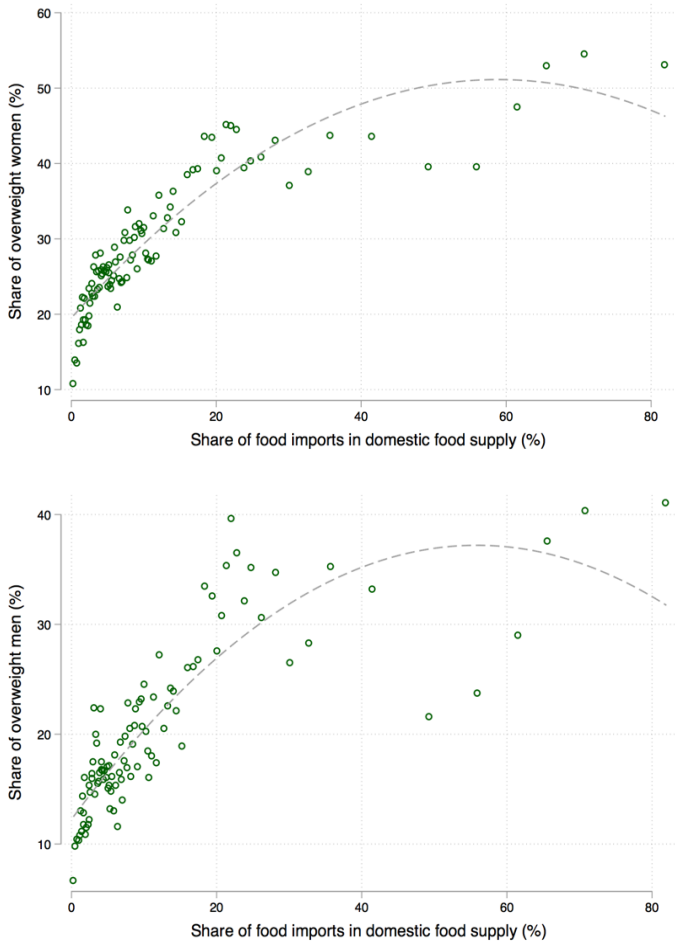
Note: The two figures show binned scatterplots to visualize the relationship between the share of overweight women/men (y-variable) and the share of the main crop (x-variable). To facilitate visual interpretation, the plots create bins of 'similar' observations (visualized above as small circles) instead of showing every data point in the sample. These bins are created by grouping the observations into 100 equal-sized bins by the variable 'Share of the main crop'. Before creating the bins, the x- and y-variables are residualized on country and year dummies. For this, each variable is regressed on the controls (country and year dummies), then the residuals are calculated and the sample mean of each variable is added back to its residuals. The observations are then grouped into 100 equal sized bins by the residualized x-variable, the mean of the x- and y-variables within each bin are calculated, and a scatterplot of these data points is created. The grey dashed line is a linear fit line estimated using the underlying residualized data.

SHARE OF FOOD IMPORTS IN TOTAL DOMESTIC FOOD SUPPLY

The average share of food imports in the domestic supply of food is 13 percent in the sample, but the figure differs widely across countries from close to zero to almost 100 percent. Figures 12 and 13 in the Appendix illustrate this high variation. India, for instance, is one of the countries with the lowest share of food imports in the domestic food supply, which averages less than 1 percent for the whole time period and never exceeds 2.2 percent. At the other end of the distribution is Jordan, which imports, on average, 72 percent of its domestic food supply. The high differences across countries are partly due to country characteristics such as natural resource endowment or climate which limit their capacity to grow their own food or diversify their production. Including country fixed effects in the regressions accounts for such country characteristics that do not change over time. The remaining variation in the share of food imports in total domestic food supply therefore captures changes in this variable which are country specific and change over time. This could be, for instance, an increase in food imports caused by a higher demand for food, by a drop in production due to a drought, or by a reduction in import barriers.

Figure 11 shows that over a certain range of the share of food imports in total domestic food supply, the higher the share of food imports, the higher the incidence of overweight

Figure 11: Share of overweight women (men) and the share of food imports in domestic food supply



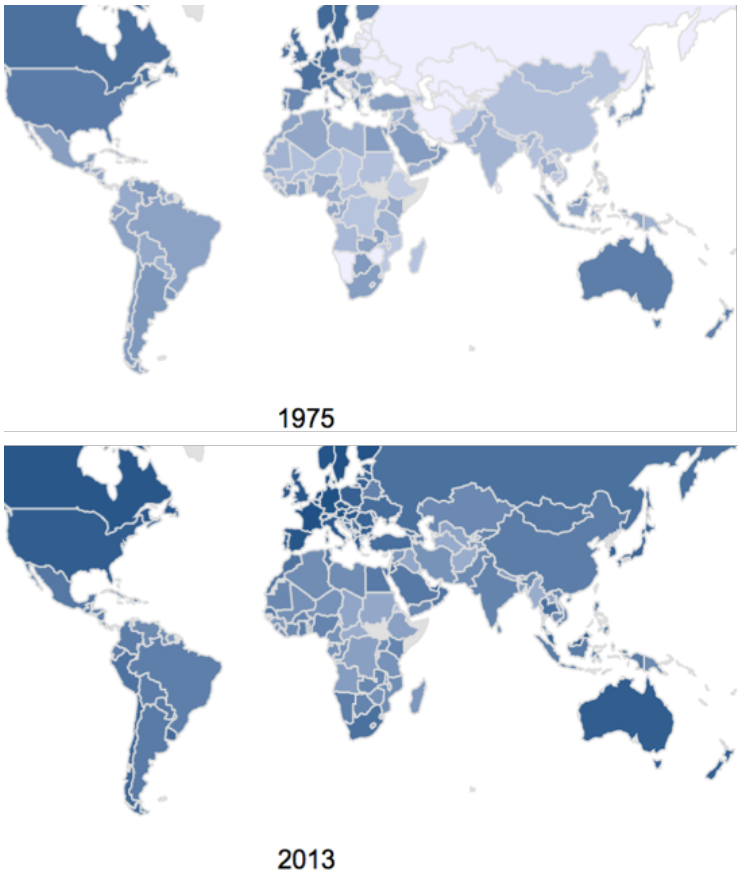
Note: The two figures show binned scatterplots to visualize the relationship between the share of overweight women/men (y-variable) and the share of food imports in total domestic food supply (x-variable). To facilitate visual interpretation, the plots create bins of 'similar' observations (visualized above as small circles) instead of showing every data point in the sample. These bins are created by grouping the observations into 100 equal-sized bins by the variable 'Share of food imports in domestic food supply', computing the mean of the x- and y-variables within each bin, and then creating a scatterplot of these data points. The grey dashed line is a quadratic fit line estimated using the underlying data.

in both female and male population. This positive correlation is strongest in the lower range of the share of food imports (between 0 and 20 percent), where most observations are, and in the upper range where food imports exceed 60 percent of domestic food supply. For the range in-between (20 to 60 percent share of food imports), the relationship turns negative for men and is roughly zero for women. While the two plots do not include any control variables and their interpretation should be cautious in terms of causality, they suggest that food imports might have different effects on obesity. They might, for instance, reduce obesity by diversifying the diets of people who would otherwise be restricted by the climate or natural resources of their countries. But the opposite is possible too, for example when countries import unhealthy foods.

GLOBALIZATION

All the world countries became more connected with one another between 1975 and 2013; this is illustrated in Figure 12 that maps 'Overall Globalization' as measured by the KOF Globalization Index. The darker the color of a country, the higher its Overall Globalization Index on a scale from 0 to 100. The map for 2013 is clearly darker than the map for 1975, and also more homogenous in color across countries. While globalization in the seventies was mainly concentrated among the richer economies (Western Europe, USA, Australia), by 2013 the rest of the world seems to have caught up. In my sample of low to middle income countries, half of the countries had an Overall Globalization Index below 30 in 1975), which is also the sample average for that year, and the maximum was 45 (for comparison, the highest value of the index in that year was 73 in Sweden). By 2013, less than one percent of the

Figure 12: Globalization - 1975 vs 2013

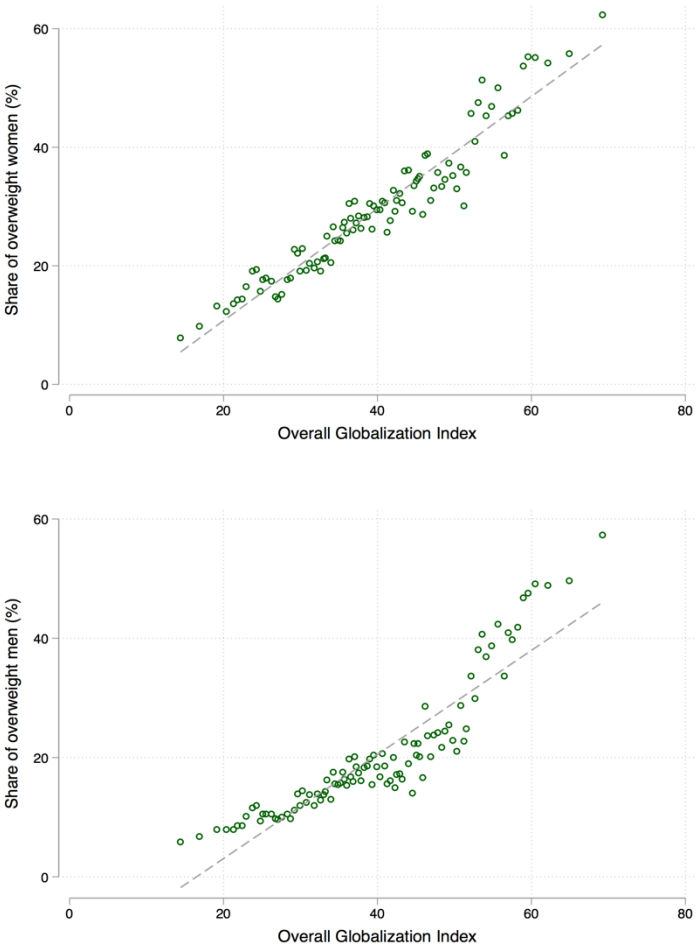


Source: KOF Globalization Index – KOF Swiss Economic Institute | ETH Zürich.
Retrieved from https://www.kof.ethz.ch/en/forecasts-and-indicators/indicators/kof-globalisation-index.html on February 6th, 2018.

countries in the sample had a globalization index below 36 and for half of them, the index was higher than 48, a value larger than the maximum globalization index achieved by a country in the beginning of the sample. Interestingly, among the three dimensions of globalization, the highest integration among countries is at the political level. This is shown in Figure 14 in the Appendix which compares the 10th, 50th, and 90th percentiles of the Overall Globalization Index and its three components in 1975 and 2013. Political globalization is followed by economic globalization, and both are consistently higher than social globalization. This suggests that in the sample analyzed, social norms and culture, which includes food culture, are quite deeply ingrained and show some resistance in front of external influences, even when a country is politically and economically integrated with the rest of the world. However, social globalization has also increased significantly from the beginning to the end of the analyzed period.

Figure 13 shows, for the sample observed, a clear positive correlation between the share of overweight women and men and the extent to which a country is globalized. This does not exclude, however, the possibility that the positive relationship disappears once other factors are controlled for.

Figure 13: Share of overweight women (men) and globalization



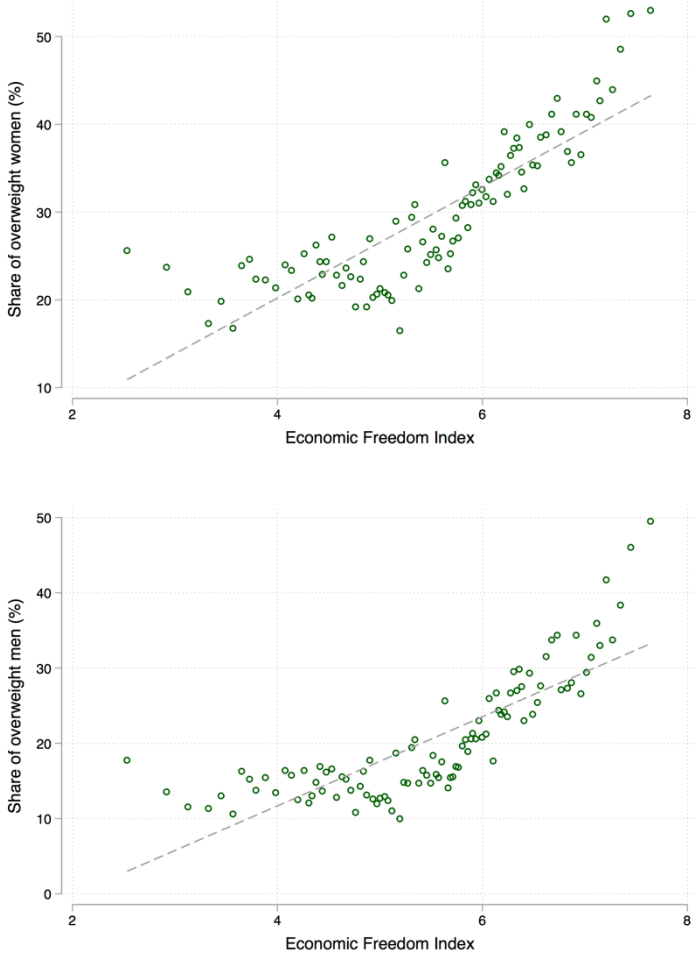
Note: The two figures show binned scatterplots to visualize the relationship between the share of overweight women/men (y-variable) and the Overall Globalization Index (x-variable). To facilitate visual interpretation, the plots create bins of 'similar' observations (visualized above as small circles) instead of showing every data point in the sample. These bins are created by grouping the observations into 100 equal-sized bins by the variable 'Overall Globalization Index', computing the mean of the x- and y-variables within each bin, and then creating a scatterplot of these data points. The grey dashed line is a fit line estimated using the underlying data.

FREE MARKET CAPITALISM

In terms of free market capitalism, as measured by the Economic Freedom Index, the sample average and median are roughly 5.5, which is just above the middle on a scale from 0 (lowest rating) to 10 (highest rating). However, most countries in the sample started 'outperforming' this average in the nineties and are converging towards a rating of 7 (for comparison, Hong Kong, the country ranked highest in 2013, scored 8.9). Figures 15 and 16 in the Appendix show how the score of each country in the sample has changed between 1975 and 2013. While there are some exceptions (mostly in African countries), the figures indicate that the economies in the sample tend towards being governed by the principles of free market capitalism.

More economic freedom of a country appears to be correlated with a higher prevalence of overweight women and men in its population, as Figure 14 shows. This seems to support the criticisms of free market capitalism that governments loosen regulation aimed at protecting consumers under the pressure of powerful food companies, which then affects the diets and health of the population. But once again, the figures need to be interpreted with caution since the relationship they show does not include any control variables. The positive correlation might just as well be due to other factors that

Figure 14: Share of overweight women (men) and the Economic Freedom Index



Note: The two figures show binned scatterplots to visualize the relationship between the share of overweight women/men (y-variable) and the Economic Freedom Index (x-variable). To facilitate visual interpretation, the plots create bins of 'similar' observations (visualized above as small circles) instead of showing every data point in the sample. These bins are created by grouping the observations into 100 equal-sized bins by the variable 'Economic Freedom Index', computing the mean of the x- and y-variables within each bin, and then creating a scatterplot of these data points. The grey dashed line is a fit line estimated using the underlying data.

are also related to economic freedom. For example, higher economic freedom might foster economic development[10] which could result in an increase in wealth and urbanization. These, in turn, are positively correlated with overweight, as shown in Figures 5 and 6.

4.2. REGRESSION RESULTS

This section attempts to answer the **first research question:**

> *What is the relationship between agricultural specialization and the prevalence of overweight people in low- and middle-income countries beyond the effect of socio-demographic, economic and political factors?*

Below, I present the results from estimating Model (1) using the data described above. First, the main result shows the relationship between agricultural specialization and the share of overweight people in the most simple setup with a minimum of control variables. Then, I verify whether this relationship is affected by including additional controls for globalization and free market capitalism.

MAIN RESULT

Table 2 reports the regression results for women and men in Panel A and B, respectively. I start with a specification without fixed effects (the first column), and then I gradually include year fixed effects (column (2)), country fixed effects (column (3)), and both (column (4)). In all regressions, the standard errors are clustered by country to allow for their correlation over time within a country.

In the female population, I find a positive correlation between agricultural specialization and the share of overweight women. This holds in both specifications where I include country fixed effects, i.e. when I control for country characteristics that do not change over time. The coefficient on the share of the main crop in total domestic food production is positive and statistically significant at the 5% level. The estimate in the preferred specification that includes country and year fixed effects (column (4)) implies that a 10 percent increase in the share of the main crop of a country[11] is associated with an increase of 4 per thousand (0.4 percent) in the share of overweight women. In the sample, 30 percent of the female population is on average overweight. This means that the increase in the share of overweight women that can be associated with a 10 percent increase in the share of the main crop corresponds to a 1.3 percent increase relative to the average. Alternatively put, the results suggest that if two countries with similar characteristics are compared, the one that is more specialized in its agricultural production will have a larger share of female population that is overweight.

The correlation between agricultural specialization and the share of overweight persons in the male population is also positive in three specifications, but not at a statistically significant level. The different result across genders is related to a study by Ludwig (2018) on the Indian

[10] See, for instance, De Haan and Sturm (2000).
[11] One standard deviation is 13 percent.

subcontinent where large parts of the population suffer from food and nutrition insecurity, the majority of them living in rural areas and growing a significant share of the food they consume. The study shows that women and children are particularly at risk and the diversity of production positively affects the diversity of food consumed by women.

Women and men are also differently affected by the share of food imports in domestic food supply: while the correlation with the share of overweight women is positive and statistically significant in most specifications, the opposite sign, albeit insignificant, shows up in the male population. This suggests that in countries which rely more on imported food to feed their population, there are more overweight women than in countries that are otherwise similar in terms of per capita GDP, population size, urbanization, and agricultural specialization. However, the magnitude and statistical significance of the estimate are strongly affected by year fixed effects. A comparison of columns (3) and (4) in Panel A shows that the coefficient becomes smaller in magnitude (from 10 to 4 percent) and its statistical significance is strongly reduced when year dummies are included in the regression. This means that the correlation between food imports and the share of overweight women is to a large extent due to time-varying factors that affect all countries in the sample at the same time and that are correlated to food imports. It could be, for instance, that an oversupply of an unhealthy food in global markets drives down its price to the extent that it becomes attractive relative to domestic crops in all the countries considered in this analysis, then eaten predominantly by women, who, due to this, become overweight.

Turning to demographics, urbanization is the most robust explanatory factor for both women and men: more urbanized countries have a larger share of overweight people, which is in line with existing evidence. Similarly, the richer the population of a country, the more overweight they are. However, the wealth effect becomes statistically insignificant once country and year fixed effects are included in the regression. Again, a result consistent with the findings from other papers.

Table 2: Agricultural specialization and the incidence of overweight in adult women and men

Panel A: Share of overweight women

	(1)	(2)	(3)	(4)
Share of the main crop in total domestic production	0.040	0.070	0.054**	0.039**
	(0.069)	(0.071)	(0.023)	(0.019)
Share of food imports in domestic food supply	0.106*	0.096	0.101***	0.042*
	(0.061)	(0.063)	(0.020)	(0.023)
Share of urban population	0.480***	0.413***	0.328***	0.239***
	(0.070)	(0.079)	(0.064)	(0.077)
Log per capita GDP	4.859***	4.912***	3.557***	1.292
	(1.299)	(1.355)	(1.041)	(0.959)
Log of population	-0.707	-1.037	14.179***	2.763
	(1.002)	(1.018)	(1.193)	(1.840)
Year FE	No	Yes	No	Yes
Country FE	No	No	Yes	Yes
Observations	1,663	1,663	1,663	1,663
Adjusted R-squared	0.672	0.711	0.990	0.993

Panel B: Share of overweight men

	(1)	(2)	(3)	(4)
Share of the main crop in total domestic production	-0.004	0.008	0.046	0.029
	(0.068)	(0.070)	(0.037)	(0.036)
Share of food imports in domestic food supply	-0.007	-0.016	0.048	-0.016
	(0.078)	(0.082)	(0.055)	(0.057)
Share of urban population	0.537***	0.518***	0.301***	0.192*
	(0.083)	(0.089)	(0.094)	(0.103)
Log per capita GDP	4.466***	4.281**	3.988***	1.456
	(1.622)	(1.694)	(1.212)	(1.207)
Log of population	-0.075	-0.234	6.010***	-7.594
	(0.870)	(0.888)	(1.645)	(4.588)
Year FE	No	Yes	No	Yes
Country FE	No	No	Yes	Yes
Observations	1,663	1,663	1,663	1,663
Adjusted R-squared	0.647	0.651	0.978	0.983

Note: The table reports the OLS estimation results of Model (1) for the female and male population in Panel A and Panel B, respectively. The dependent variable 'Share of overweight women (men)' is the ratio of women (men) who are overweight to total female (male) population. 'Share of the main crop in total domestic production' is calculated as the ratio of the domestic production quantity of the main crop of a country to total domestic food production of that country. The main crop of a country is the crop that represents, in terms of tons, the largest share of total domestic food production. 'Share of food imports in domestic food supply' is given by the ratio of food imported to total domestic food supply. The 'Share of urban population' is computed as the ratio between the number of people living in urban areas and total population. 'Log per capita GDP' is the natural logarithm of the GDP of a country divided by its population. 'Log of population' is the natural logarithm of the total population of a country. I use yearly country-level data for 65 countries during the period 1975 to 2013. The share of overweight women and men, and the share of urban population use the Health Nutrition and Population Statistics provided by the World Bank. Data on domestic food production, food imports, and domestic food supply, as well as GDP and population figures are from the FAO Food Balance Sheets and Macro Indicators. Standard errors clustered by country are reported in parentheses, where *** indicates significance at the 1% level, ** at the 5% level, and * at the 10% level.

WEALTH MATTERS

Existing research shows that poor or isolated communities are particularly dependent on the local diversity of their agriculture, since they rely upon supply chains which are not very well developed for fresh and healthy foods (Fanzo et al. 2013, Remans et al. 2014, Pingali 2015). Motivated by these findings, I investigate whether the wealth of a country's population, a proxy for well-functioning infrastructure, affects the positive relation between agricultural specialization and the share of overweight women and men. To this end, I include in the regression from model (1) an interaction term between the share of the main crop in domestic food production and log of per capita GDP:

$$
\begin{aligned}
&Share\ of\ overweight\ population_{c,t} = \\
&\quad \beta_1\ Share\ of\ main\ crop\ in\ domestic\ food\ production_{c,t} \\
&+ \beta_2\ Log\ per\ capita\ GDP_{c,t} * Share\ of\ main\ crop\ in\ domestic\ food\ production_{c,t} \\
&+ \beta_2\ Share\ of\ imported\ food\ in\ domestic\ food\ supply_{c,t} \\
&+ \beta_3\ Control\ variables_{c,t} \\
&+ \beta_4 \sum_c Country\ dummies_c + \beta_5 \sum_t Year\ dummies_t + \varepsilon_{c,t}
\end{aligned}
$$

To visualize how this relationship varies with different levels of wealth, I plot in Figure 15 the estimates of the combined coefficient on 'Share of main crop in domestic food production' for different percentiles of 'Log per capita GDP', $\beta_1 + \beta_2 * Log\ per\ capita\ GDP\ percentiles$, along with their 95% confidence intervals. Panel A shows the result for women and Panel B for men. The horizontal axis shows various levels of wealth – from the poorest 1 percent countries in the sample on the left-hand side to the richest 1 percent on the right-hand side – and the Y-axis plots the estimated coefficient on 'Share of main crop in domestic food production' as a function of per capita GDP percentiles. The estimated correlation coefficient between agricultural specialization and the share of overweight women in the poorest 1 percent countries, for instance, is positive and statistically significant. The coefficient of 0.13 implies that a 10 percent increase in the share of the main crop is associated with a 1.3 percent increase in the share of overweight women. The figure shows that for women, the correlation is positive and statistically significant for the poorest 50 percent of the countries in my sample, while for the richer half it is not different from zero at a statistically significant level. For men, the magnitude of the correlation also decreases with wealth, but the coefficient is never different form zero at a statistically significant level. The figure confirms my assumption that it is the poorest countries whose population is most vulnerable to a less diversified agricultural production, and women turn out to be the most affected.

Figure 15 Panel A: The correlation between agricultural specialization and the share of overweight women for varying levels of income

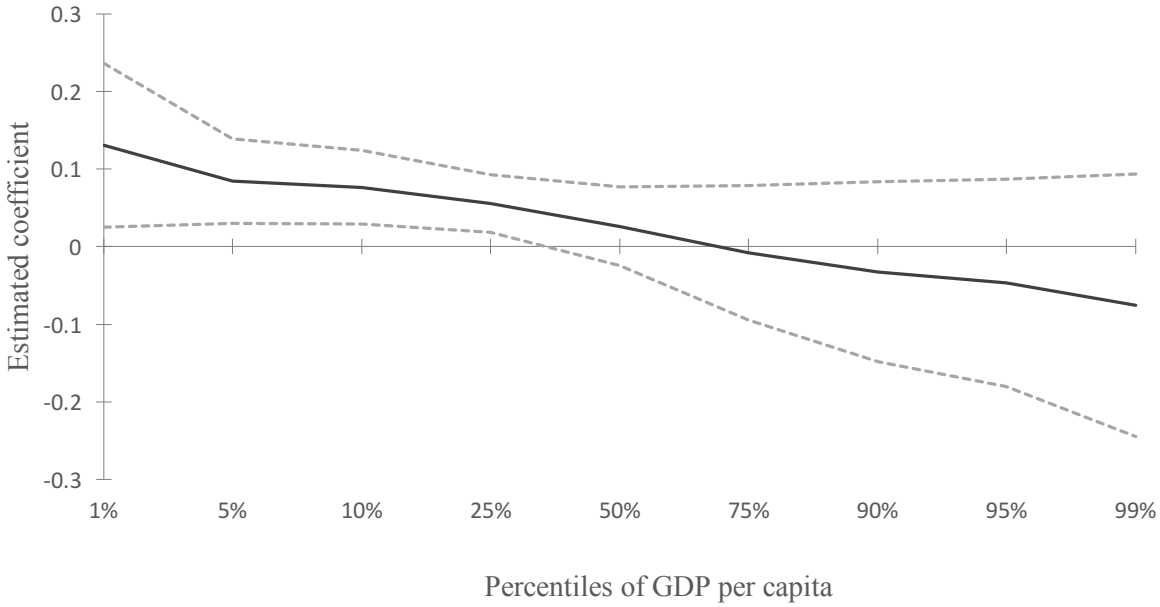
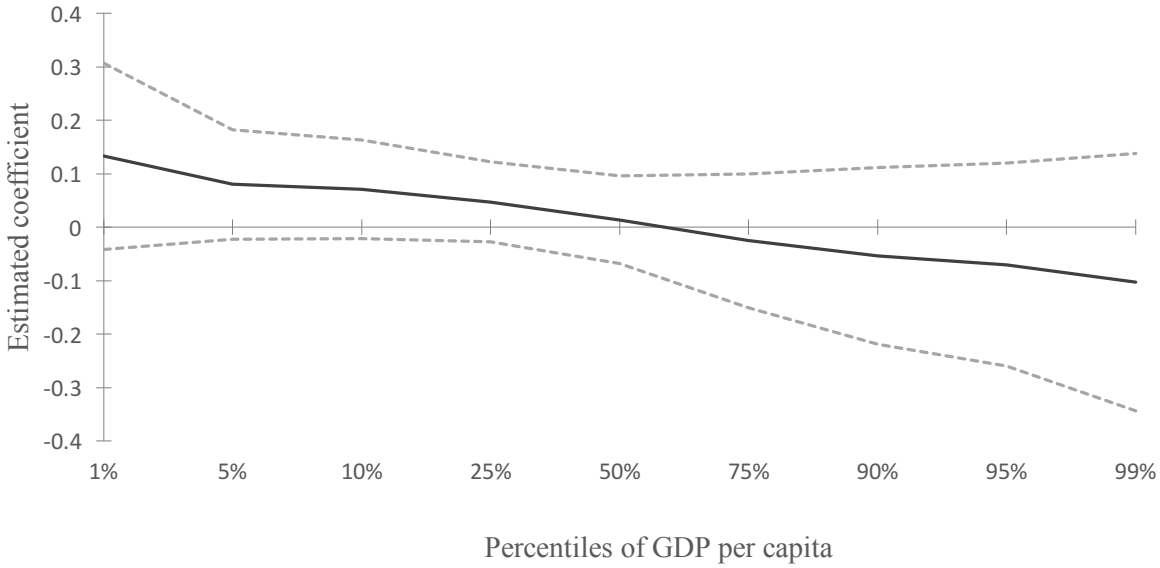


Figure 15 Panel B: The correlation between agricultural specialization and the share of overweight men for varying levels of income



Note: The chart shows the estimated combined coefficients from the regression of 'Share of overweight women' (Panel A) and 'Share of overweight men' (Panel B) on 'Share of the main crop in total domestic production' and their 95th confidence interval (dashed lines) for nine values (percentiles) of income per capita. The coefficients are estimated in the preferred specification of regression model (1) with country and year fixed effects that also includes an interaction term between 'Share of the main crop in domestic food production' and 'Log per capita GDP'.

GLOBALIZATION AND FREE MARKET CAPITALISM

Tables 3 and 4 report, for women and men, respectively, the estimation results from regressions which include globalization as a control variable in the preferred specification with year and country fixed effects. The three different dimensions of globalization defined in Section 2.3 are included in the regression one by one: economic, political, and social, as well as the Overall Globalization Index that aggregates the three. The results for women remain unchanged and none of the globalization variables has a statistically significant effect on the share of overweight women. For the male population, however, it turns out that globalization is related to an increase in the share of overweight men: the coefficient on the Overall Globalization Index in column (1) is positive and statistically significant at the 5 percent level. This is driven by social globalization, as the highly significant estimate in column (4) shows.

The results suggest that agricultural specialization and globalization are correlated with the share of overweight women and men in different ways. On the one hand, women appear to be affected by agricultural specialization, which increases their chances of becoming overweight, while globalization does not seem to play a significant role in the rising share of overweight women. On the other hand, agricultural specialization does not seem to be correlated with the share of overweight men, who are, in turn, more responsive to increasing globalization, in particular to the shift in cultural norms. One possible explanation would be that women, who are usually in charge of preparing the meals in a household, are also the guardians of culinary traditions, therefore more conservative in what concerns changing their food habits than men.

Finally, to account for the potentially confounding effect of free market capitalism, I also include the 'Economic Freedom Index' control variable. The regression results are reported in Table 5, for women in column (1) and for men in column (2). Free market capitalism does not turn out to be correlated with the share of overweight population, neither women nor men. Also, the results from the previous regressions remain robust to the inclusion of the 'Economic Freedom Index' control variable.

Table 3: Agricultural specialization and the incidence of overweight in adult women: controlling for globalization

	Share of overweight women			
	(1)	(2)	(3)	(4)
Share of the main crop in total domestic production	0.039**	0.040**	0.040**	0.040**
	(0.019)	(0.019)	(0.019)	(0.019)
Overall Globalization Index	-0.007			
	(0.039)			
Economic globalization		-0.013		
		(0.023)		
Political globalization			-0.004	
			(0.015)	
Social globalization				0.028
				(0.040)
Share of food imports in domestic food supply	0.042*	0.042*	0.042*	0.042*
	(0.023)	(0.023)	(0.024)	(0.022)
Share of urban population	0.239***	0.242***	0.238***	0.240***
	(0.076)	(0.076)	(0.077)	(0.076)
Log per capita GDP	1.329	1.359	1.312	1.120
	(0.984)	(0.991)	(0.960)	(0.896)
Log of population	2.766	2.708	2.826	2.927*
	(1.845)	(1.830)	(1.877)	(1.713)
Year FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Observations	1,663	1,663	1,663	1,663
Adjusted R-squared	0.993	0.993	0.993	0.993

Note: The table reports the OLS estimation results of Model (1) for the female population. The dependent variable 'Share of overweight women' is the ratio of women who are overweight to total female population. 'Share of the main crop in total domestic production' is calculated as the ratio of the domestic production quantity of the main crop of a country to total domestic food production of that country. The main crop of a country is the crop that represents, in terms of tons, the largest share of total domestic food production. 'Economic globalization', 'Social globalization', and 'Political globalization' are indices that measure the degree of integration of a country with the rest of the world along economic, social and political dimensions on a scale from 0 (lowest integration) to 100 (maximum integration). The KOF Globalization Index, called here 'Overall Globalization Index', is the weighted average of the three indices. The 'Share of food imports in domestic food supply' is given by the ratio of food imported to total domestic food supply. The 'Share of urban population' is computed as the ratio between the number of people living in urban areas and total population. 'Log per capita GDP' is the natural logarithm of the GDP of a country divided by its population. 'Log of population' is the natural logarithm of the total population of a country. I use yearly country-level data for 65 countries during the period 1975 to 2013. The share of overweight women, and the share of urban population use the Health Nutrition and Population Statistics provided by the World Bank. Data on domestic food production, food imports, and domestic food supply, as well as GDP and population figures are from the FAO Food Balance Sheets and Macro Indicators. For the Overall Globalization Index and its sub-indices, I use the KOF Globalization Index database available at http://globalization.kof.ethz.ch (accessed November 8th, 2017). Standard errors clustered by country are reported in parentheses, where *** indicates significance at the 1% level, ** at the 5% level, and * at the 10% level.

Table 4: Agricultural specialization and the incidence of overweight in adult men: controlling for globalization

	Share of overweight men			
	(1)	(2)	(3)	(4)
Share of the main crop in total domestic production	0.026	0.028	0.027	0.031
	(0.035)	(0.036)	(0.036)	(0.031)
Overall Globalization Index	0.168**			
	(0.071)			
Economic globalization		0.035		
		(0.033)		
Political globalization			0.026	
			(0.024)	
Social globalization				0.206***
				(0.068)
Share of food imports in domestic food supply	-0.013	-0.016	-0.015	-0.015
	(0.049)	(0.056)	(0.055)	(0.046)
Share of urban population	0.192**	0.186*	0.197*	0.198**
	(0.096)	(0.102)	(0.104)	(0.090)
Log per capita GDP	0.556	1.275	1.337	0.205
	(1.209)	(1.228)	(1.195)	(1.051)
Log of population	-7.656*	-7.444	-7.975*	-6.406
	(4.120)	(4.606)	(4.336)	(3.989)
Year FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Observations	1,663	1,663	1,663	1,663
Adjusted R-squared	0.984	0.983	0.983	0.985

Note: The table reports the OLS estimation results of Model (1) for the male population. The dependent variable 'Share of overweight men' is the ratio of men who are overweight to total male population. 'Share of the main crop in total domestic production' is calculated as the ratio of the domestic production quantity of the main crop of a country to total domestic food production of that country. The main crop of a country is the crop that represents, in terms of tons, the largest share of total domestic food production. 'Economic globalization', 'Social globalization', and 'Political globalization' are indices that measure the degree of integration of a country with the rest of the world along economic, social and political dimensions on a scale from 0 (lowest integration) to 100 (maximum integration). The KOF Globalization Index, called here 'Overall Globalization Index', is the weighted average of the three indices. The 'Share of food imports in domestic food supply' is given by the ratio of food imported to total domestic food supply. The 'Share of urban population' is computed as the ratio between the number of people living in urban areas and total population. 'Log per capita GDP' is the natural logarithm of the GDP of a country divided by its population. 'Log of population' is the natural logarithm of the total population of a country. I use yearly country-level data for 65 countries during the period 1975 to 2013. The share of overweight women, and the share of urban population use the Health Nutrition and Population Statistics provided by the World Bank. Data on domestic food production, food imports, and domestic food supply, as well as GDP and population figures are from the FAO Food Balance Sheets and Macro Indicators. For the Overall Globalization Index and its sub-indices, I use the KOF Globalization Index database available at http://globalization.kof.ethz.ch (accessed November 8th, 2017). Standard errors clustered by country are reported in parentheses, where *** indicates significance at the 1% level, ** at the 5% level, and * at the 10% level.

Table 5: Agricultural specialization and the incidence of overweight in adult women and men: controlling for free-market capitalism

	Share of overweight women	Share of overweight men
	(1)	(2)
Share of the main crop in total domestic production	0.039**	0.028
	(0.019)	(0.036)
Economic Freedom Index	0.071	0.118
	(0.187)	(0.281)
Share of food imports in domestic food supply	0.042*	-0.017
	(0.023)	(0.057)
Share of urban population	0.240***	0.193*
	(0.076)	(0.103)
Log per capita GDP	1.246	1.380
	(0.982)	(1.262)
Log of population	2.709	-7.685*
	(1.867)	(4.566)
Year FE	Yes	Yes
Country FE	Yes	Yes
Observations	1,663	1,663
Adjusted R-squared	0.993	0.983

Note: The table reports the OLS estimation results of Model (1) for the female and male population in columns (1) and (2), respectively. The dependent variable 'Share of overweight women (men)' is the ratio of women (men) who are overweight to total female (male) population. 'Share of the main crop in total domestic production' is calculated as the ratio of the domestic production quantity of the main crop of a country to total domestic food production of that country. The main crop of a country is the crop that represents, in terms of tons, the largest share of total domestic food production. The 'Economic Freedom Index' is a proxy for free market capitalism. It captures the extent to which the policies and institutions of a country are supportive of economic freedom and aggregates information from 42 variables from five areas: size of government, legal system and property rights, sound money, freedom to trade internationally, and regulation. The index is placed on a scale from 0 (lowest rating) to 10 (highest rating). The 'Share of food imports in domestic food supply' is given by the ratio of food imported to total domestic food supply. The 'Share of urban population' is computed as the ratio between the number of people living in urban areas and total population. 'Log per capita GDP' is the natural logarithm of the GDP of a country divided by its population. 'Log of population' is the natural logarithm of the total population of a country. I use yearly country-level data for 65 countries during the period 1975 to 2013. The share of overweight women and men, and the share of urban population use the Health Nutrition and Population Statistics provided by the World Bank. Data on domestic food production, food imports, and domestic food supply, as well as GDP and population figures are from the FAO Food Balance Sheets and Macro Indicators. The Economic Freedom Index is available online at https://www.fraserinstitute.org/economic-freedom (accessed November 9th, 2017). Standard errors clustered by country are reported in parentheses, where *** indicates significance at the 1% level, ** at the 5% level, and * at the 10% level.

DIFFERENCES ACROSS GENDERS

The summary statistics and the regression results presented above show that women and men are not affected by overweight to the same extent, neither do they respond to the different drivers of obesity considered here in the same way. First, the incidence of overweight is higher in the female population than in the male population, and this holds in my sample regardless of country or year. Second, sociodemographic factors such as income per capita and urbanization are positively correlated with the share of both overweight women and men. However, among the two variables, only urbanization remains statistically significant in the most comprehensive specification with fixed effects, and it does affect women more than men. Third, the correlations between agricultural specialization, food imports, and globalization and the share of overweight people diverge across genders. While the first two are positively associated with an increase in the share of overweight women, the latter only appears to positively affect men.

The differences between women and men found in this study can be related to a few interesting empirical observations on the differences in overweight across genders. One potential explanation for this phenomenon is cultural: some societies value larger body sizes of women as a symbol of social success and wealth. For instance, Holdsworth et al. (2004) show that this is especially true in developing countries where economic resources are scarce, and Rguibi and Belahsen (2006) find an appreciation of overweight in a survey of Moroccan women. This is related to another observation about food allocation within households: oftentimes, men have a better access than women to fats, protein and micronutrient-rich foods, while both have equal access to staple foods (Messer 1997). This suggests that in some societies, women have lower quality diets than men, which can impact their health and body weight. Another explanation can be that women generally engage in less physical activity than men (Caballero 2001). Finally, Case and Menendez (2009) examine several factors that could potentially explain the divergence between women and men, and find that childhood food deprivation and adult socio-economic status can fully explain the difference in obesity rates between men and women that they find in their South African sample.

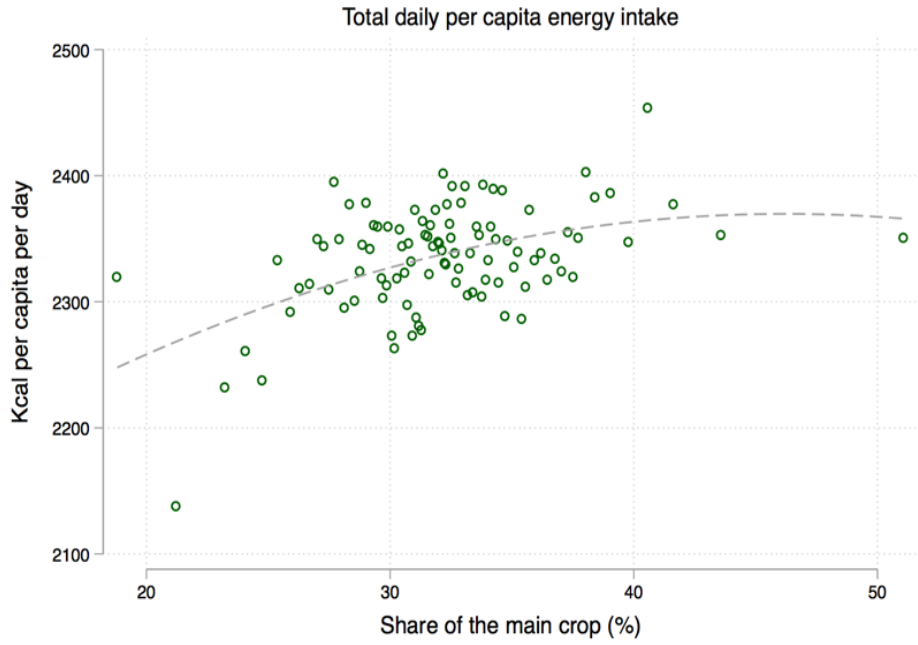
4.3. AGRICULTURAL SPECIALIZATION, DIETS, AND OVERWEIGHT PEOPLE

To investigate the mechanism that lies behind the positive link between agricultural specialization and the share of overweight women, I further look at how diets and agricultural specialization are related. An increase in overweight could be due to the *quantity* of food consumed, the *quality* (healthiness) of peoples' diets, or both.

To measure the effect of *quantity*, I investigate whether agricultural specialization is positively associated with an increased calorie intake once the effect of other confounding factors is taken out. Figure 16 shows the relationship between an average person's total daily energy intake (measured in kcal), and the share of the main crop in her country's domestic food production after controlling for all the other variables that have been included in the regressions of the

previous section (income per capita, urbanization, population size, share of food imports in domestic food supply, globalization, free market capitalism, country and year fixed effects). Again, the small circles stand for groups of countries that are similar in terms of the share they dedicate to their main crop. The plot reveals a slightly increasing relationship between the two, suggesting that the people in countries with a more specialized agriculture consume, on average, more calories than people in countries that are otherwise similar but are less specialized in growing a main crop. The limitation of this result relies in the fact that the energy intake per capita is an average across age groups and genders. Ideally, the figure should refer specifically to adult women, the population group for which agricultural specialization has been found to be correlated with overweight. Moreover, the figure shows that the average energy intake per person stays within the normal range, and can therefore hardly explain an increase in overweight.

Figure 16: Energy intake and agricultural specialization



Note: The figure shows a binned scatterplot to visualize the relationship between total daily kcal consumption per capita (y-variable) and the share of the main crop (x-variable). To facilitate visual interpretation, the plots create bins of 'similar' observations (visualized above as small circles) instead of showing every data point in the sample. These bins are created by grouping the observations into 100 equal-sized bins by the variable 'Share of the main crop'. Before creating the bins, the x- and y-variables are residualized on the control variables defined in Section 3 (income per capita, urbanization, population size, share of food imports in domestic food supply, globalization, free market capitalism, and country and year dummies). For this, each variable is regressed on the controls, then the residuals are calculated and the sample mean of each variable is added back to its residuals. The observations are then grouped into 100 equal sized bins by the residualized x-variable, the mean of the x- and y-variables within each bin are calculated, and a scatterplot of these data points is created. The grey dashed line is a quadratic fit line estimated using the underlying residualized data.

This leads to the next potential channel: the *quality* of diets. By 'quality', I refer here to the healthiness of diets in terms of their composition. I divide foods in five different groups ('sugar', 'cereals', 'oil', 'animal products', and 'fruit, vegetables, nuts and pulses'). To measure the consumption of a specific food group in a country in a given year, I take the domestic food supply of that particular food group and calculate its share in total domestic food supply. This reflects the composition of a country's food supply and thus expresses what food groups are available to the population of a country, and in which relative amounts. Although it takes into account imports, exports, animal feed and waste, this is only an approximate measure of what people actually consume, based on official national statistics.

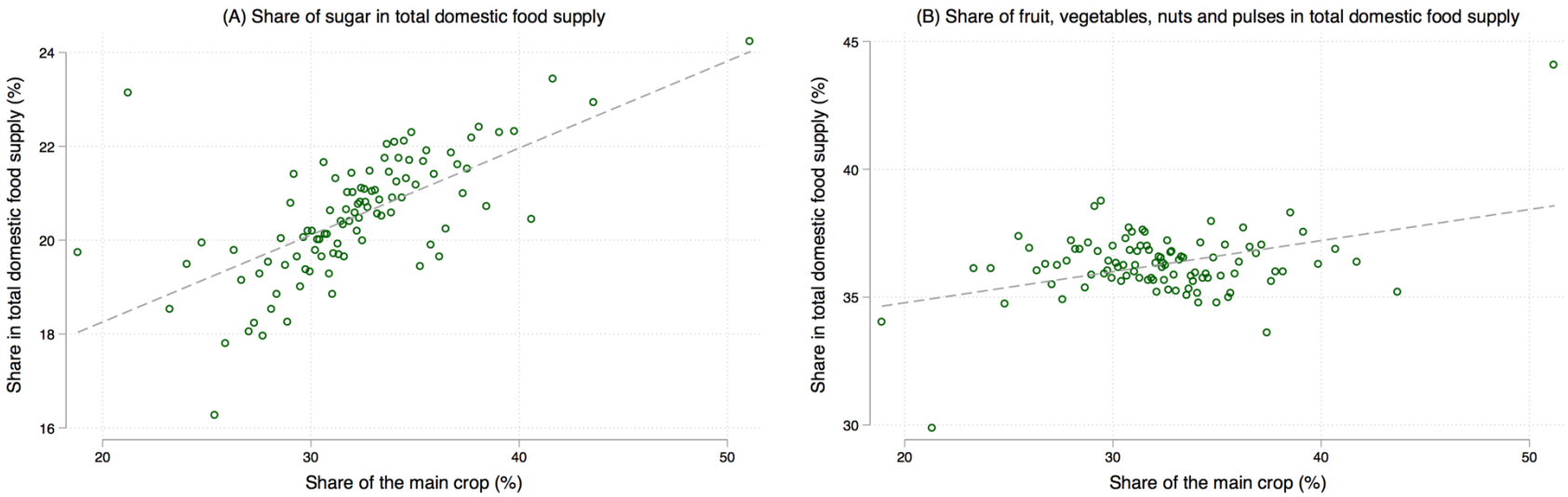
Thus I answer the **second research question**:

> *What is the relationship between agricultural specialization and the share of calorie-dense staples in the domestic food supply of low- and middle-income countries?*

Charts (A) to (E) in Figure 17 show the relationship between the share of the main crop in a country's total domestic food production and the share of five different food groups in that country's total domestic food supply. The depicted relationship is *after* controlling for income per capita, urbanization, population size, share of food imports in total domestic food supply, globalization, free market capitalism, and country and year fixed effects. The five charts reveal that agricultural specialization is related to the predominance of the five food groups in different ways. Sugar turns out to be the only food category that strongly increases in its relative importance in the domestic food supply with higher agricultural specialization. The share of fruit, vegetables, nuts and pulses, as well as that of cereals, have an almost zero correlation with the share of the main crop,[12] while the shares of oil crops and animal products in domestic food supply decrease with higher agricultural specialization. This suggests that sugar gains importance in the diets of people who reside in countries with a more specialized agriculture, to the detriment of other food groups. Note that the figures isolate the relationship between agricultural specialization and the relative importance of different food groups once other factors have been taken out. This means that overall, the consumption of animal products or other food categories might still increase due to other reasons, such as higher incomes or urbanization.

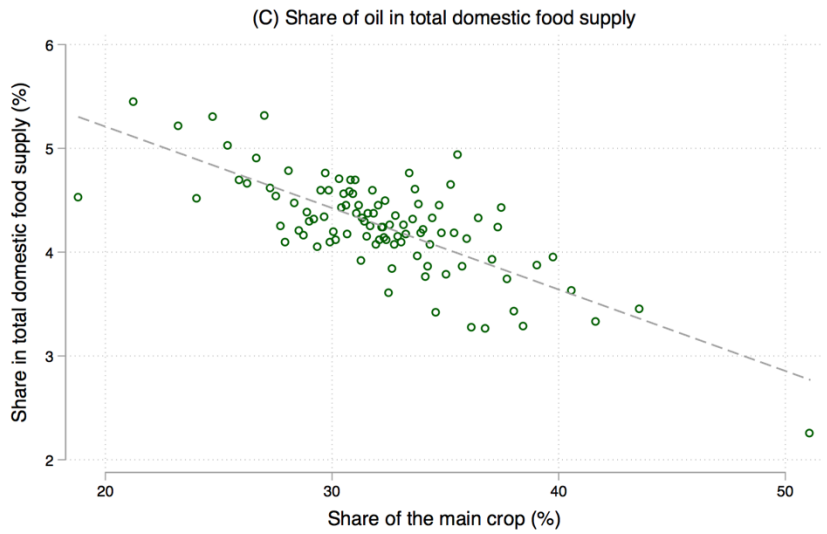
[12] Unreported regressions show a coefficient that is not different from zero at any level of statistical significance.

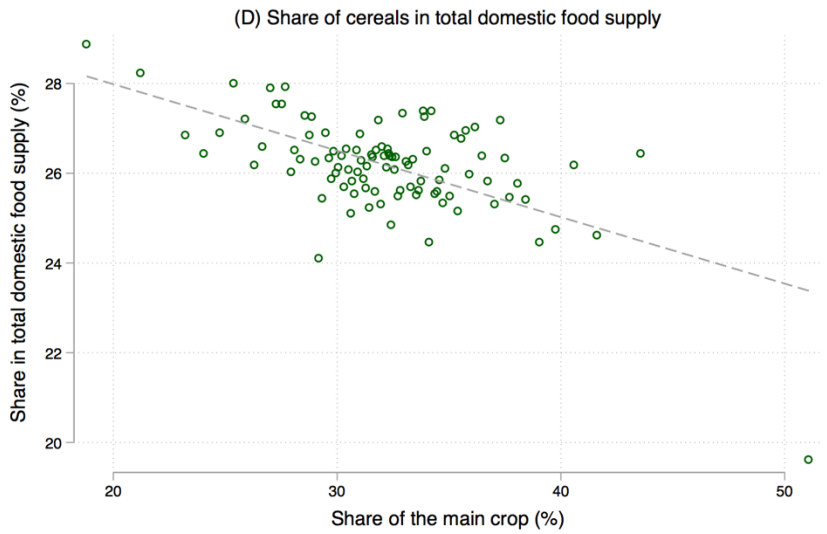
Figure 17: Share of different food groups in total domestic food supply and agricultural specialization

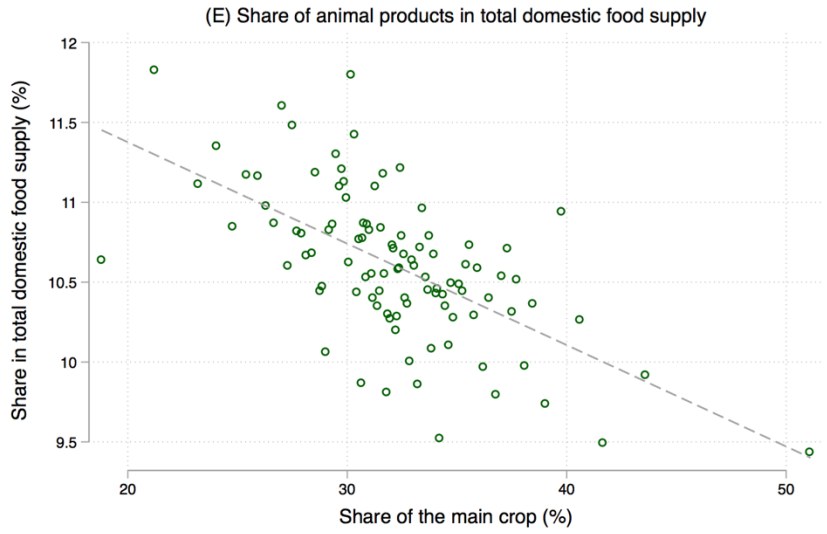


Note: The figures show binned scatterplots to visualize the relationship between the share of the main crop (x-variable) and the share in total domestic food supply of the food groups: (A) sugar, (B) fruit, vegetables, nuts, and pulses, (C) oil, (D) cereals, and (E) animal products (y-variable). To facilitate visual interpretation, the plots create bins of 'similar' observations (visualized above as small circles) instead of showing every data point in the sample. These bins are created by grouping the observations into 100 equal-sized bins by the variable 'Share of the main crop'. Before creating the bins, the x- and y-variables are residualized on the control variables defined in section 3 (income per capita, urbanization, population size, share of food imports in domestic food supply, globalization, free market capitalism, and country and year dummies). For this, each variable is regressed on the controls, then the residuals are calculated and the sample mean of each variable is added back to its residuals. The observations are then grouped into 100 equal sized bins by the residualized x-variable, the mean of the x- and y-variables within each bin are calculated, and a scatterplot of these data points is created. The grey dashed line is a fit line estimated using the underlying residualized data.

Figure 17 (continued): Share of different food groups in total domestic food supply and agricultural specialization







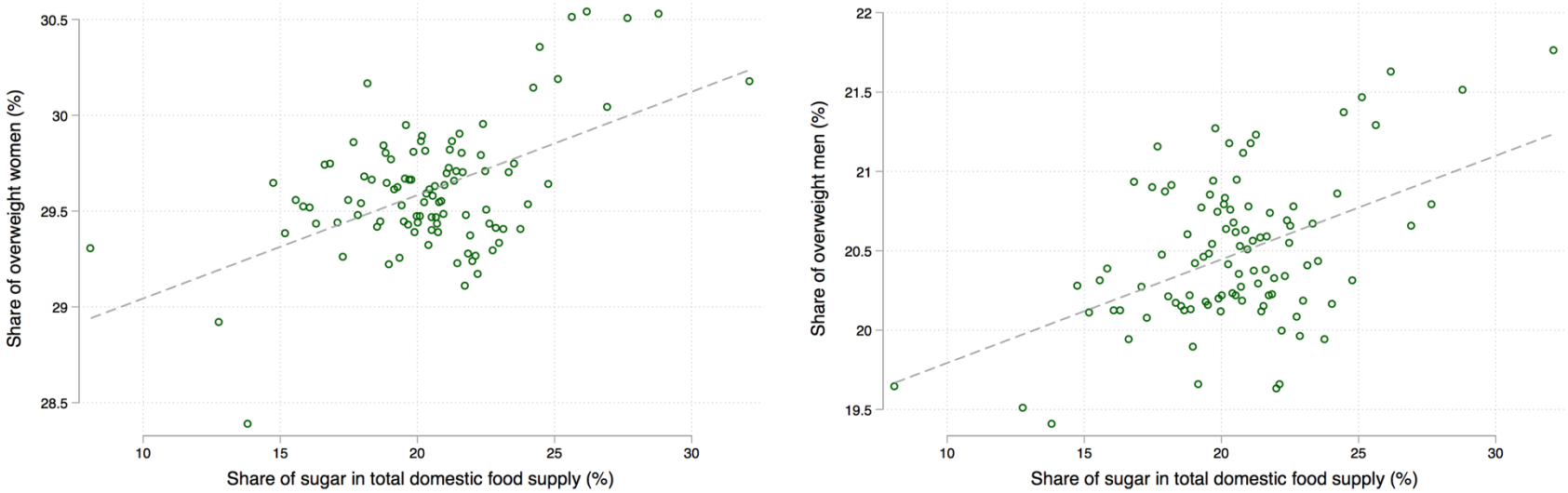
Finally, I answer the **third research question**:

What is the relationship between the share of overweight people and the domestic supply of calorie-dense staples in low- and middle-income countries?

Diets rich in sugar arguably lead to weight gain, which suggests that it could be the higher availability of sugar in the domestic food supply associated with higher agricultural specialization that drives the increase in the share of overweight women. I test whether this is the case. The charts in Figure 18 show the relationship between the share of overweight women (men) and the share of sugar in total domestic food supply after controlling for income per capita, urbanization, population size, share of food imports in total domestic food supply, globalization, free market capitalism, and country and year fixed effects. For both women and men, the figures show that countries with a higher proportion of sugar in their total domestic food supply have more overweight people. The effect is stronger for women than for men, which could partly explain why the main result from Section 4.2 only holds for the female population.

Putting all the pieces together, for the sample of 65 countries studied and over the period 1975 to 2013, the empirical evidence points to a positive relationship between agricultural specialization and the share of overweight adult women which can partly be explained by the higher availability of sugar in the domestic food supply relative to other food groups.

Figure 18: The share of overweight women (men) and the relative importance of sugar in the domestic food supply



Note: The figure shows a binned scatterplot to visualize the relationship between the share of overweight women/men (y-variable) and the share of sugar in total domestic food supply (x-variable). To facilitate visual interpretation, the plots create bins of 'similar' observations (visualized above as small circles) instead of showing every data point in the sample. These bins are created by grouping the observations into 100 equal-sized bins by the variable 'Share of sugar in total domestic food supply'. Before creating the bins, the x- and y-variables are residualized on the control variables defined in Section 3 (income per capita, urbanization, population size, share of food imports in domestic food supply, globalization, free market capitalism, and country and year dummies). For this, each variable is regressed on the controls, then the residuals are calculated and the sample mean of each variable is added back to its residuals. The observations are then grouped into 100 equal sized bins by the residualized x-variable, the mean of the x- and y-variables within each bin are calculated, and a scatterplot of these data points is created. The grey dashed line is a fit line estimated using the underlying residualized data.

5. DISCUSSION

There is a widespread belief that the productivity gains of industrial agriculture provide the solution to feeding the world. But what if the focus of modern agriculture to maximize agricultural output comes at a substantial cost for humanity? The gains in efficiency have partly been achieved by increasing the scale of production and decreasing the complexity of cropping systems (IPES-Food 2016). Over time, this resulted in a more homogenous food supply dominated by just a few 'global crops'. However, a homogeneous food system is contrary to a basic axiom shared by ecology and nutrition that diversity fosters the health of biological systems (Khoury et al. 2014).

Indeed, a number of case studies carried out in various developing countries find that in many regions of the world, the dietary quality and diversity of individual households from rural, poor or isolated communities is directly related to the diversity of local agricultural production. However, due to their specificity, the results from such studies cannot simply be extrapolated beyond the communities surveyed. It is plausible that trade or urbanization increase the dietary quality and diversity for other households in the same country, which obscures the overall effect of country's policy of agricultural specialization. In short, these interesting case studies are unlikely to be representative for entire countries.

Moreover, the rise in obesity by itself has received much attention in the scientific community and among policy makers. Several empirical studies have shown that economic growth and urbanization are major drivers of obesity (Subramanian 2011, Dinsa et al. 2012, Goryakin and Suhrcke 2014), and there is an ongoing debate both in research and in the popular media about the role of globalization and free market capitalism in promoting unhealthy diets that lead to an increase in overweight (Goryakin et al. 2015, de Soysa and de Soysa 2017, The New York Times 2017). However, the possible link between obesity and agricultural specialization has not been examined in a cross-country setting.

This study attempts to fill this missing link by investigating empirically whether, and how, the diversity of agricultural production is related to the share of overweight population in low- and middle-income countries. It applies regression analysis to panel data on 65 countries over four decades (1975 to 2013) to establish a statistical relationship that supplements existing qualitative evidence. The main finding is that higher agricultural specialization is positively associated with the share of overweight women, and this positive link is strongest in poorer countries. The results are different for the male population, where no statistically significant correlation could be found in the data. The uneven results across genders add to the body of literature showing that in some countries, especially on the African continent, the access of women to foods of higher nutritional quality is limited, often based on their social valuation. This can have intergenerational consequences, and is highly relevant in the context of well-documented micronutrient deficiencies and obesity found especially in women and children (HLPE 2017).

It should be stressed that the analysis has limitations. The first one is posed by the aggregate nature of the data used. Since the data is available at the national level, the comparisons made are across countries and time. For this reason, the analysis cannot make any claims on what happens across different households within a specific country, but the results need to be interpreted as what happens on average in the population of a country. Second, the study might suffer from measurement error. All the variables on domestic food production and supply, food imports, and kcal consumption use FAO statistics which offer a rough estimate of the foods actually consumed by the population. The data does not include, for instance, gifted or foraged foods which can be an important component of diets for rural households in many regions (Sibhatu and Qaim 2016). Third, given that we never know what 'the true model' is, the empirical model might be misspecified. For instance, the estimation might suffer from omitted variable bias if not all relevant control variables are included. Also, endogeneity is a potential problem: in this context it is possible that the share of overweight people in a given year is correlated with the share of overweight people in the past. Due to the limitations of the analysis I remain cautious about interpreting my results in terms of causality.

Further research is needed to make more precise claims about the relationship between agricultural specialization and individual outcomes related to overweight. Ideally, the analysis would be using individual or household level data with national coverage from surveys. This would reduce the measurement error due to the omission of certain foods in national statistics. More granular data would also allow to include time-varying country fixed effects in the regressions, which would reduce potentially time-varying omitted variables and thereby improve the quality of the estimates. Altogether, these suggestions are aimed at encouraging future research on the topic that could hopefully claim causality and draw more attention from policy makers on the importance of diversity in agriculture for the health of the population.

6. CONCLUSION

The aim of my thesis is to investigate the potential consequences of agricultural specialization for the increase in overweight population in low- and middle-income countries. My first hypothesis is that, apart from socio-demographic, economic and political factors, the increase of overweight in these countries is related to agricultural specialization.

I find that the share of overweight adult women and men has increased over time in all 65 countries in the sample. My results further suggest that for the female population, this increase is associated with higher agricultural specialization, which supports my first hypothesis. The results do not confirm this hypothesis for the male population. I also find that the positive correlation between the share of overweight women and agricultural specialization varies by wealth: the poorer a country, the higher the correlation. Furthermore, the results continue to hold once the effects of urbanization, wealth, food imports, globalization, and free market capitalism on overweight are accounted for, and are robust to the inclusion of country and year fixed effects.

To pin down the channel by which agricultural specialization is related to overweight, I look

at the change over time in quality and quantity of diets across countries. Agricultural specialization changes the quality and quantity of diets, and my first hypothesis asserts that the former is related to obesity. Indeed, I find that the average intake of calories per person only slightly increases with agricultural specialization, suggesting that it is the quality of diets that makes the difference.

My second hypothesis is that in low- and middle-income countries with higher agricultural specialization, calorie-dense staples are more common relative to healthy fresh foods like fruit and vegetables. I find that the relative importance of different food categories in the domestic food supply varies with agricultural specialization: while the share of cereals, animal products, and oil in the domestic food supply decreases; and the share of fruit, vegetables, nuts, and pulses remains relatively constant; the share of sugar in the domestic supply of food strongly increases with higher agricultural specialization. This partly confirms my second hypothesis, but leaves open some questions such as why it is precisely sugar that becomes relatively more available while the share of other staples is decreasing.

Since a higher availability of sugar seems to be one of the main mechanisms that are driving my results, I test my third hypothesis that low- and middle-income countries where calorie-dense staples are more common relative to healthy fresh foods have a larger share of overweight people. This is confirmed for the female population in the sample, where a higher share of sugar in domestic food supply is positively correlated with the share of overweight women. For the male population, I find a positive but less strong relationship.

Agricultural modernization – which implies specialization – is encouraged in low- and middle-income countries. My results suggest that there are potential negative implications of specialization on the health of their population, which might outweigh the increase in yields as a consequence of modernization. This does by no means imply that all modernization is bad – in fact, many Western countries provide quite successful examples where malnutrition is almost eradicated and the rate of obesity started stagnating. Further questions arise about the importance of infrastructure, and the development of food supply chains and well-functioning markets for fresh and perishable foods. All might affect the link between agricultural specialization, nutrition and obesity. Thus, the findings of this study serve as a starting point for further research and intend to contribute to a debate about a food-systems approach that strikes a healthy balance between modernization and diversity.

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Table 1: Countries included in the regressions and years of available data

Country	Years of available data
Bangladesh	39
Egypt, Arab Rep.	39
Ghana	39
Guatemala	39
India	39
Indonesia	39
Jordan	39
Kenya	39
Malawi	39
Mali	39
Morocco	39
Nigeria	39
Pakistan	39
Philippines	39
Sierra Leone	39
Tanzania	39
Tunisia	39
Zambia	39
Benin	34
Bolivia	34
Botswana	34
Cameroon	34
Congo, Rep.	34
Cote d'Ivoire	34
El Salvador	34
Haiti	34
Honduras	34
Madagascar	34
Myanmar	34
Nepal	34
Nicaragua	34
Niger	34
Paraguay	34
Senegal	34
Togo	34
Uganda	34
Zimbabwe	34
Central African Republic	29
Chad	29
Guinea-Bissau	24
Rwanda	24
Ukraine	19
Sri Lanka	16
Georgia	11
Macedonia, FYR	11
Mozambique	11
Vietnam	11
Armenia	10
Azerbaijan	10
Mongolia	10
Angola	9
Burkina Faso	9
Ethiopia	9
Kazakhstan	9
Kyrgyz Republic	9
Lesotho	9
Mauritania	9
Moldova	9
Cabo Verde	4
Cambodia	4
Gambia, The	4
Swaziland	4
Tajikistan	4
Timor-Leste	4
Yemen, Rep.	4

Table 2: The KOF Globalization Index

	SUB-INDICES AND VARIABLES	WEIGHTS
A.	ECONOMIC GLOBALIZATION	**[36%]**
	i) **Actual Flows**	(50%)
	Trade (percent of GDP)	(21%)
	Foreign Direct Investment, stocks (percent of GDP)	(28%)
	Portfolio Investment (percent of GDP)	(24%)
	Income Payments to Foreign Nationals (percent of GDP)	(27%)
	ii) **Restrictions**	(50%)
	Hidden Import Barriers	(22%)
	Mean Tariff Rate	(28%)
	Taxes on International Trade (percent of current revenue)	(26%)
	Capital Account Restrictions	(24%)
B.	SOCIAL GLOBALIZATION	**[37%]**
	i) **Data on Personal Contact**	(33%)
	Telephone Traffic	(25%)
	Transfers (percent of GDP)	(2%)
	International Tourism	(26%)
	Foreign Population (percent of total population)	(21%)
	International letters (per capita)	(25%)
	ii) **Data on Information Flows**	(36%)
	Internet Users (per 1000 people)	(37%)
	Television (per 1000 people)	(39%)
	Trade in Newspapers (percent of GDP)	(25%)
	iii) **Data on Cultural Proximity**	(32%)
	Number of McDonald's Restaurants (per capita)	(47%)
	Number of Ikea (per capita)	(47%)
	Trade in books (percent of GDP)	(6%)
C.	POLITICAL GLOBALIZATION	**[27%]**
	Embassies in Country	(25%)
	Membership in International Organizations	(27%)
	Participation in U.N. Security Council Missions	(22%)
	International Treaties	(26%)

Source: Dreher, Axel, 2006, Does Globalization Affect Growth? Empirical Evidence from a New Index, Applied Economics 38, 10: 1091-1110.
Updated in: Dreher, Axel; Noel Gaston and Pim Martens, 2008, Measuring Globalization - Gauging its Consequence, New York: Springer.

Table 3: The Economic Freedom Index

COMPONENTS OF THE INDEX
AREA 1 SIZE OF GOVERNMENT
A. Government Consumption **B. Transfers and subsidies** **C. Government enterprises and investment** **D. Top marginal tax rate** Top marginal income tax rate Top marginal income and payroll tax rate
AREA 2 LEGAL SYSTEM & PROPERTY RIGHTS
A. Judicial independence **B. Impartial courts** **C. Protection of property rights** **D. Military interference in rule of law and politics** **E. Integrity of the legal system** **F. Legal enforcement of contracts** **G. Regulatory restrictions on the sale of real property** **H. Reliability of police** **I. Business costs of crime**
AREA 3 SOUND MONEY
A. Money growth **B. Standard deviation of inflation** **C. Inflation: Most recent year** **D. Freedom to own foreign currency bank accounts**
AREA 4 FREEDOM TO TRADE INTERNATIONALLY
A. Tariffs Revenue from trade taxes (% of trade sector) Mean tariff rate Standard deviation of tariff rates **B. Regulatory trade barriers** Non-tariff trade barriers Compliance costs of importing and exporting **C. Black market exchange rates** **D. Controls of the movement of capital and people** Foreign ownership/investment restrictions Capital controls Freedom of foreigners to visit

AREA 5 REGULATION
A. Credit market regulations
Ownership of banks
Private sector credit
Interest rate controls/negative real interest rates)
B. Labor market regulations
Hiring regulations and minimum wage
Hiring and firing regulations
Centralized collective bargaining
Hours Regulations
Mandated cost of worker dismissal
Conscription
C. Business regulations
Administrative requirements
Bureaucracy costs
Starting a business
Extra payments/bribes/favoritism
Licensing restrictions
Tax compliance

Source: Fraser Institute (2017)

Figure 1: Share of overweight women and men in Europe and Asia

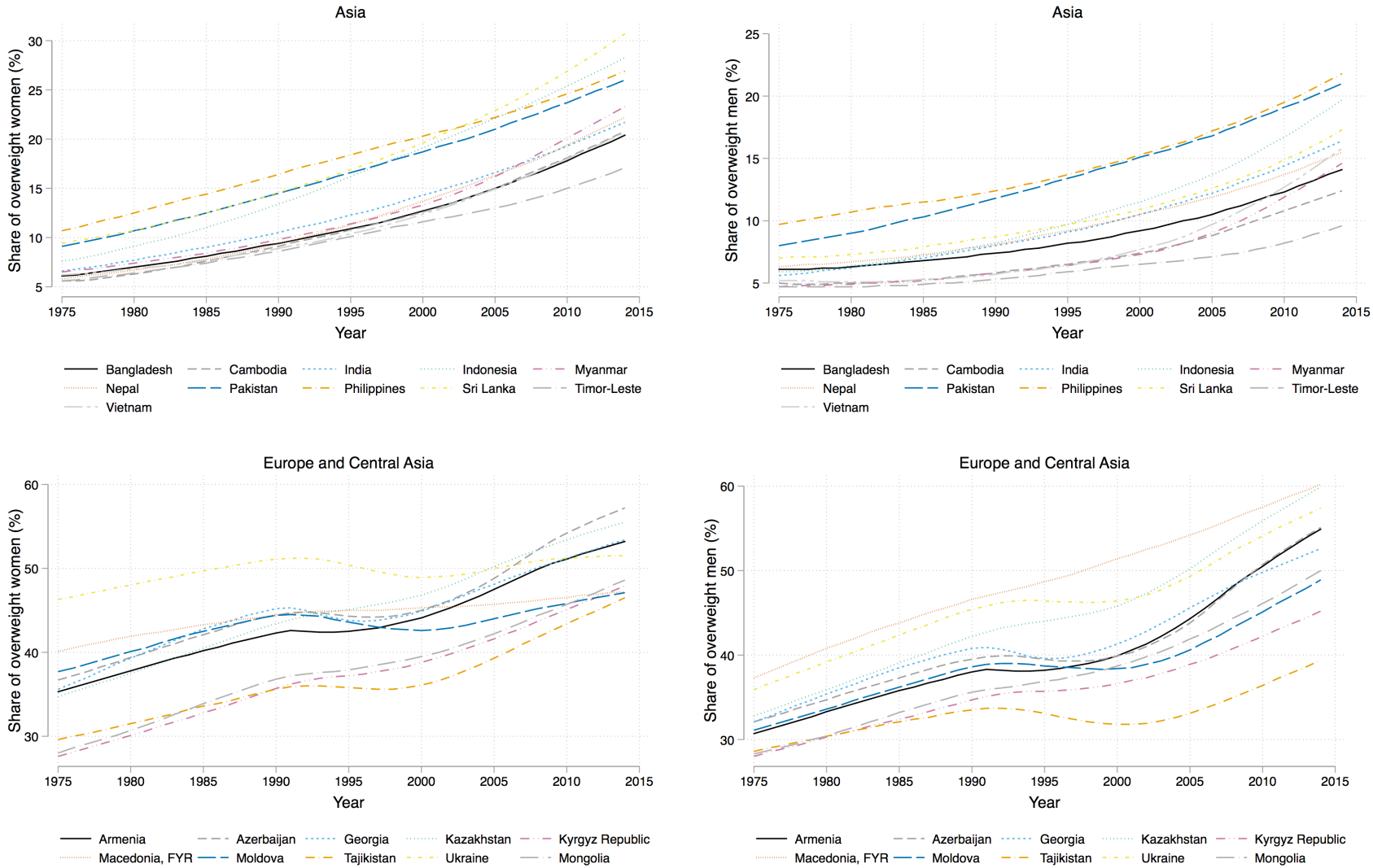


Figure 2: Share of overweight women and men in Latin America and the Caribbean

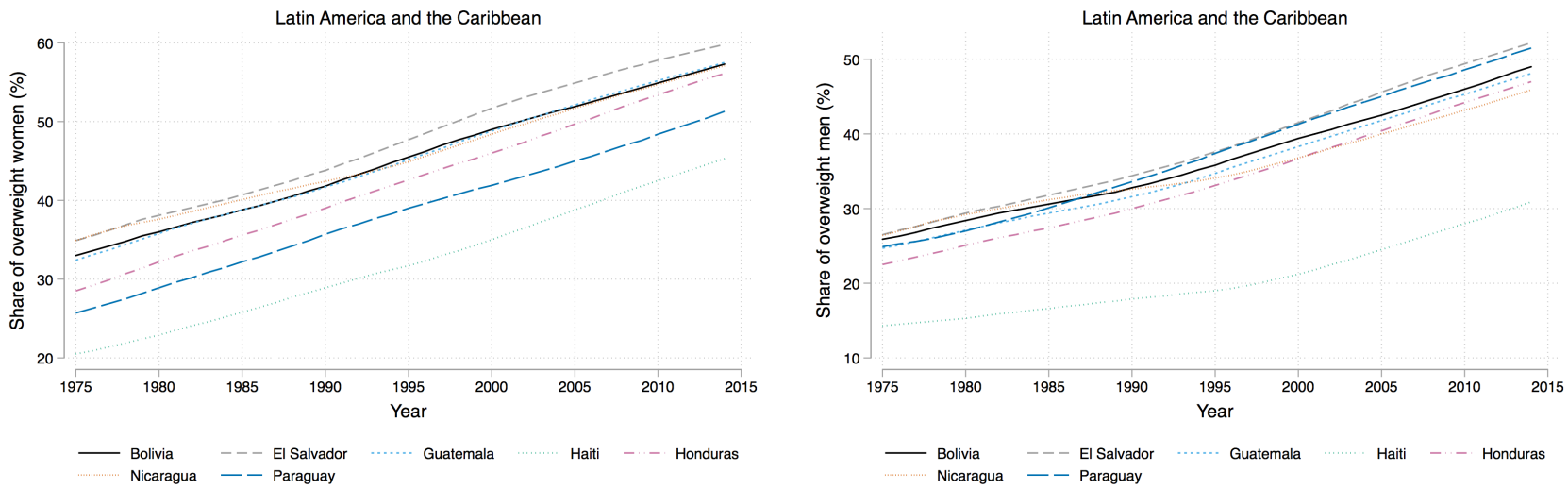


Figure 3: Share of overweight women and men in N and S Africa

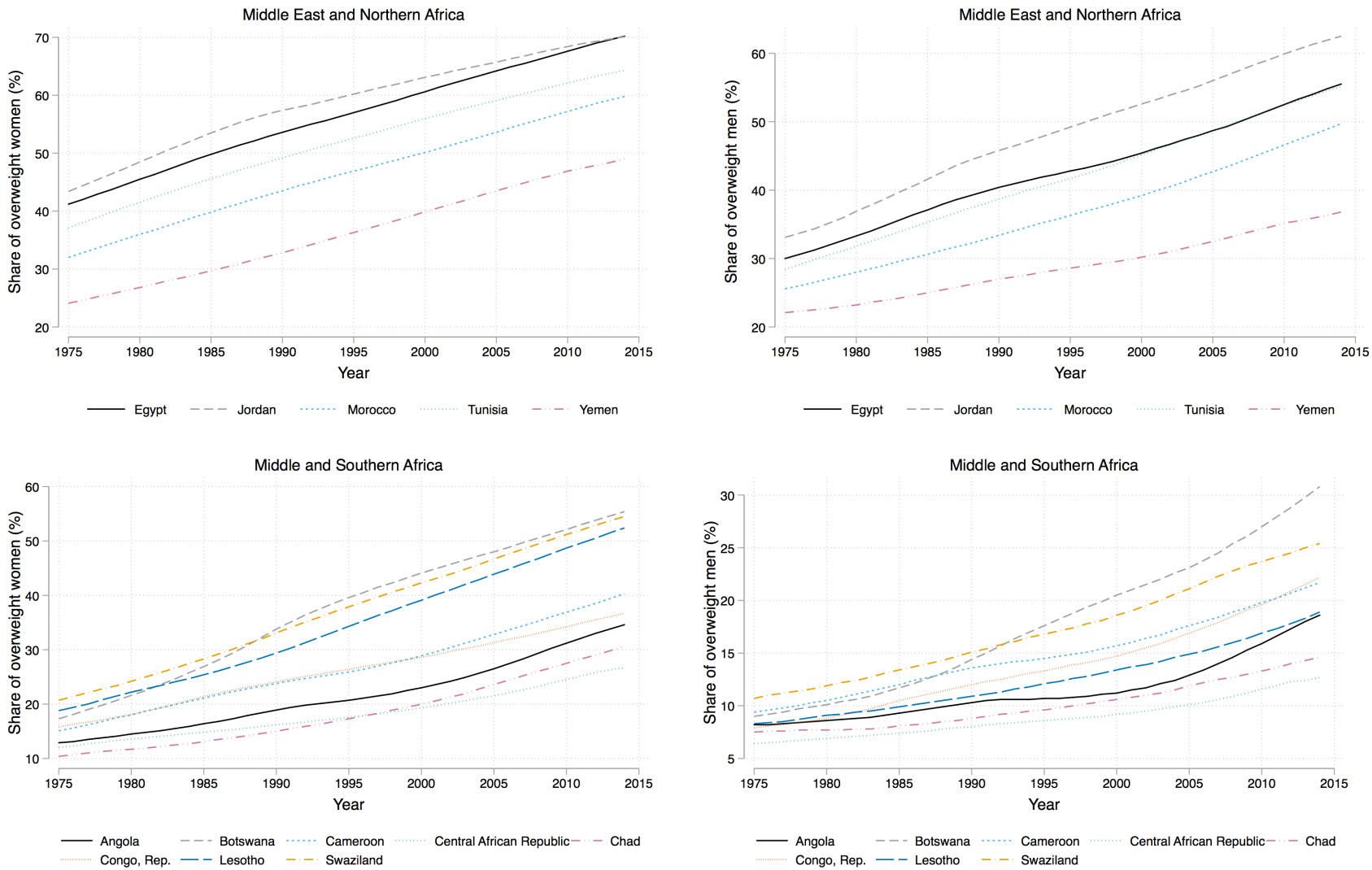


Figure 4: Share of overweight women and men in East and West Africa

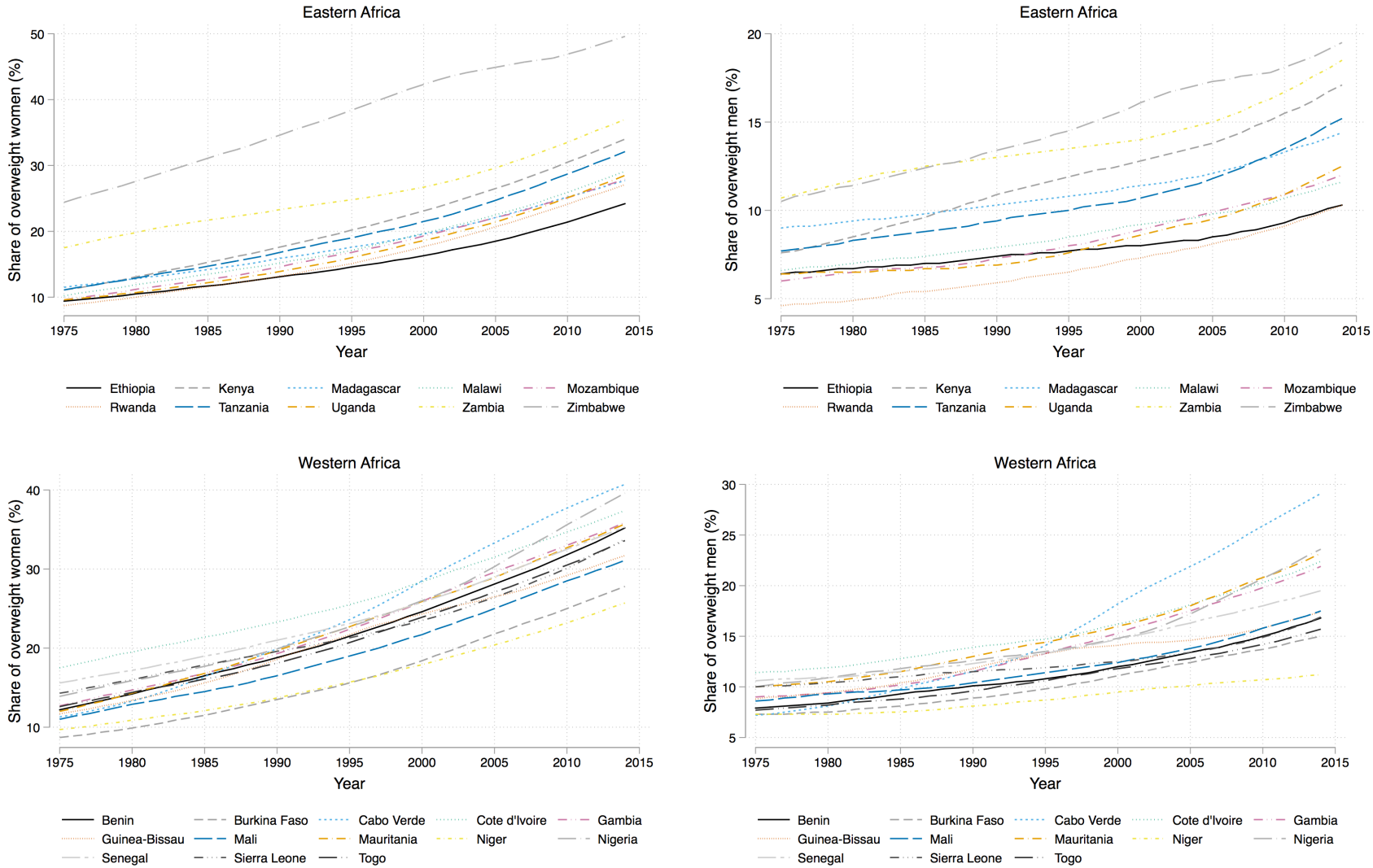
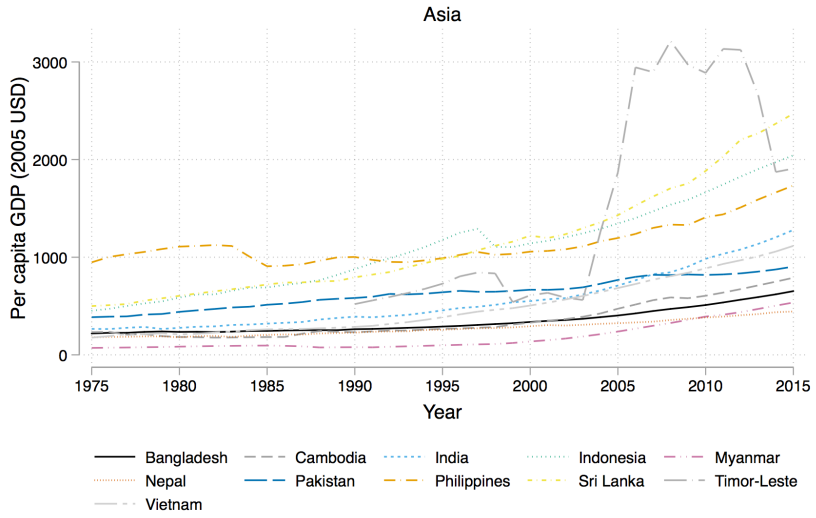
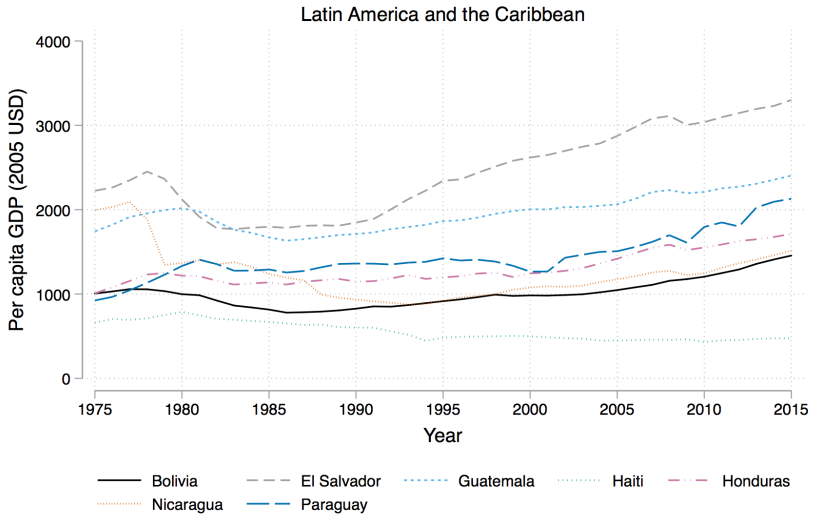


Figure 5: Per capita income in Asia, Europe, and the Americas





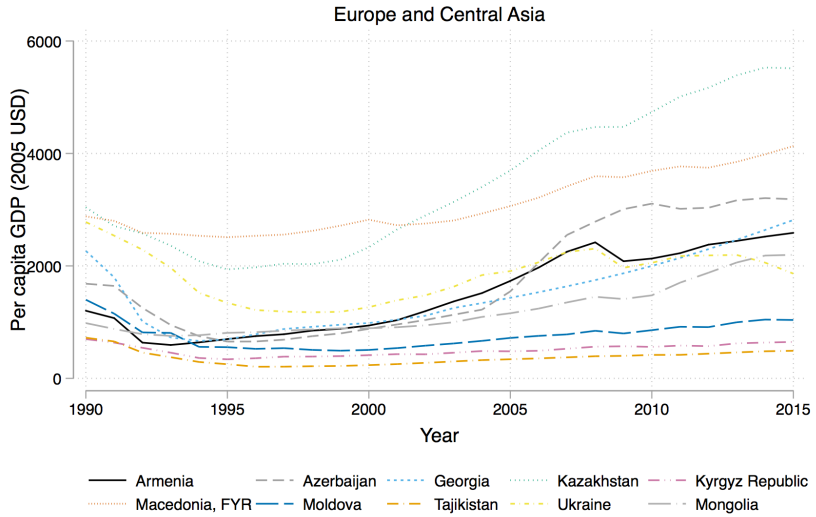


Figure 6: Per capita income in African countries

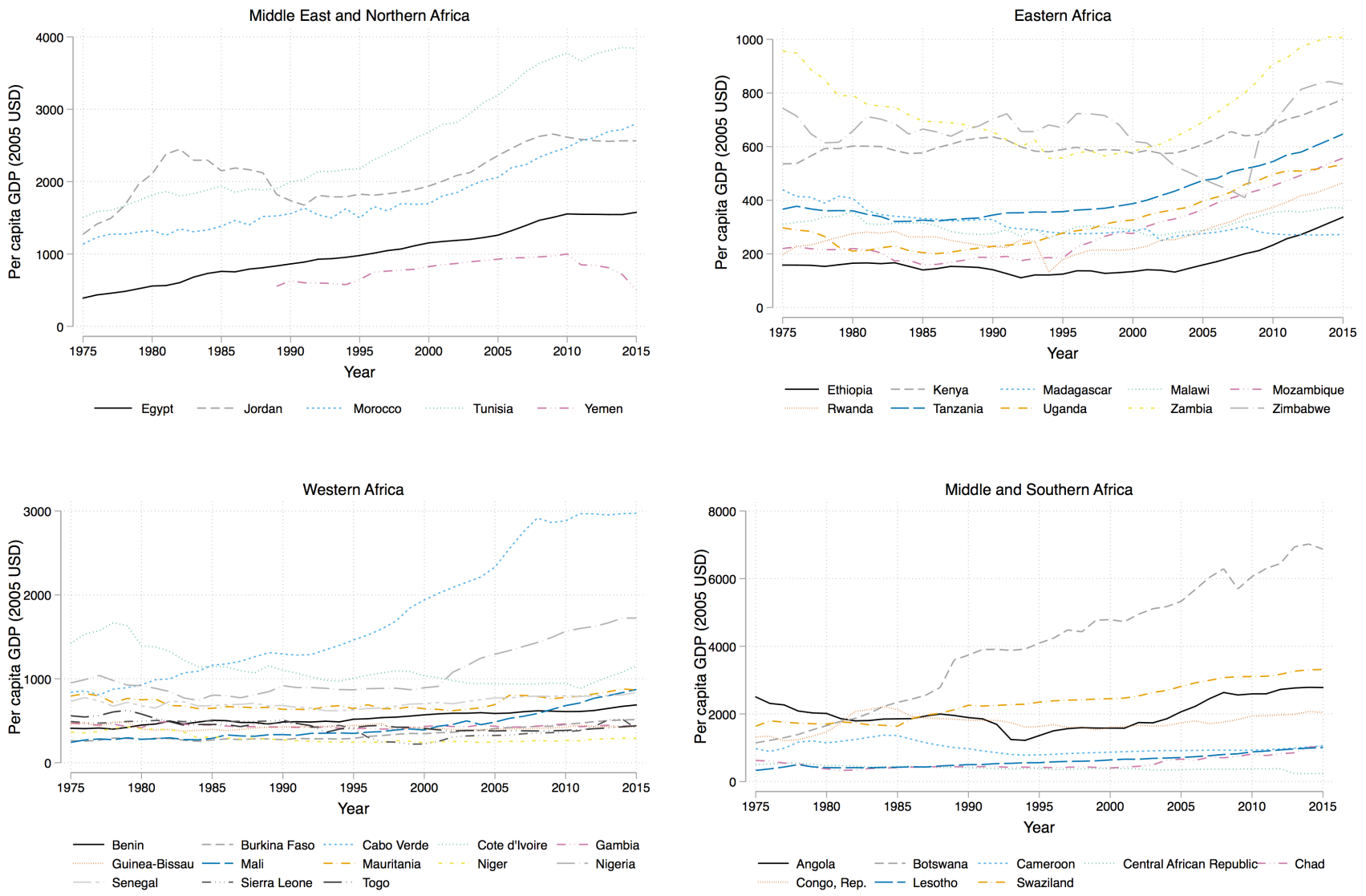
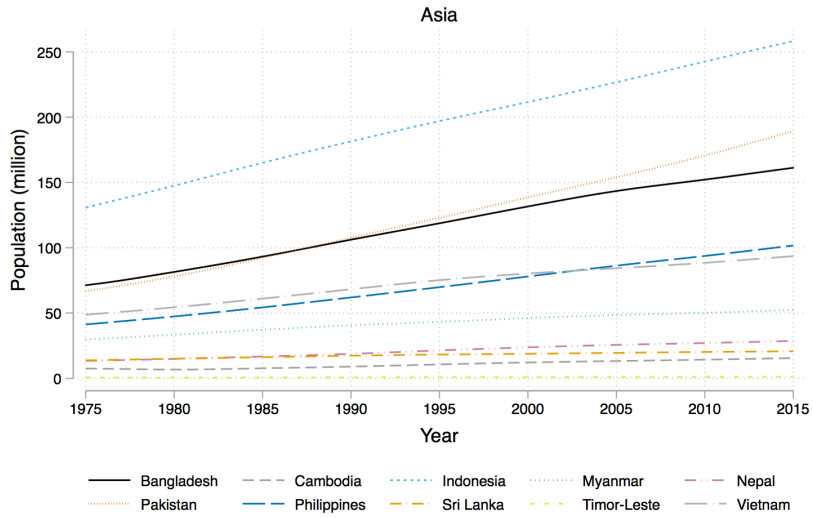
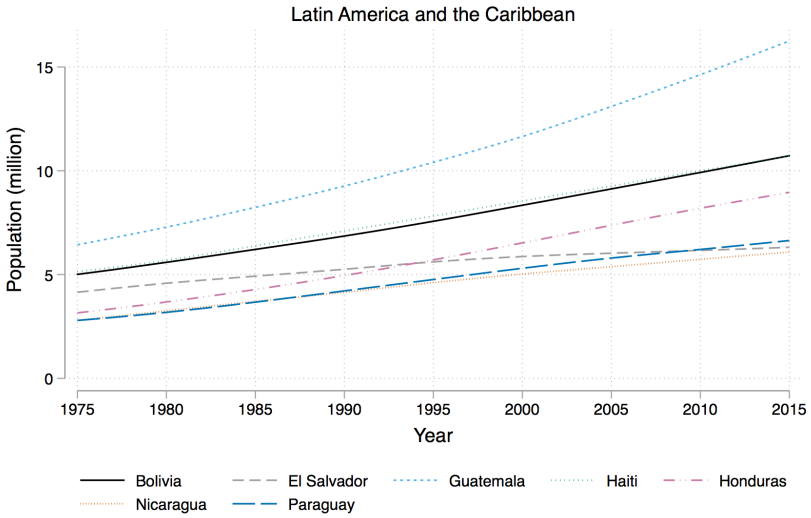


Figure 7: Population in Asia, Europe, and the Americas





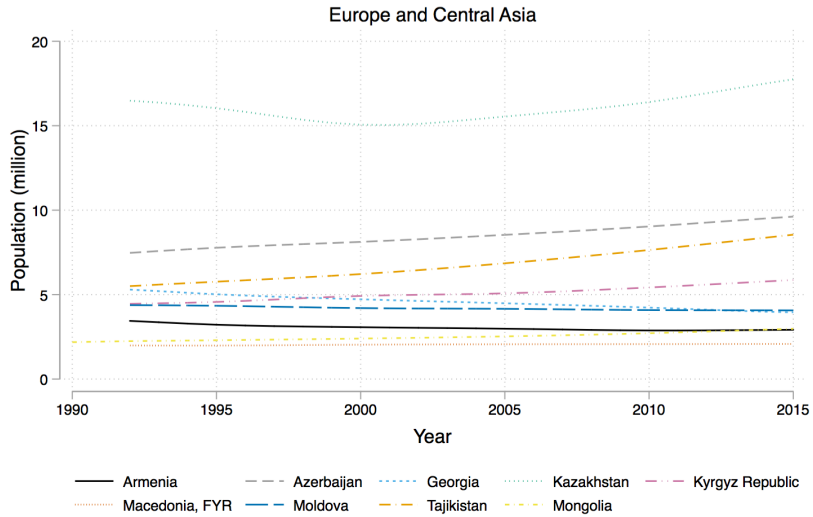


Figure 8: Population in African countries

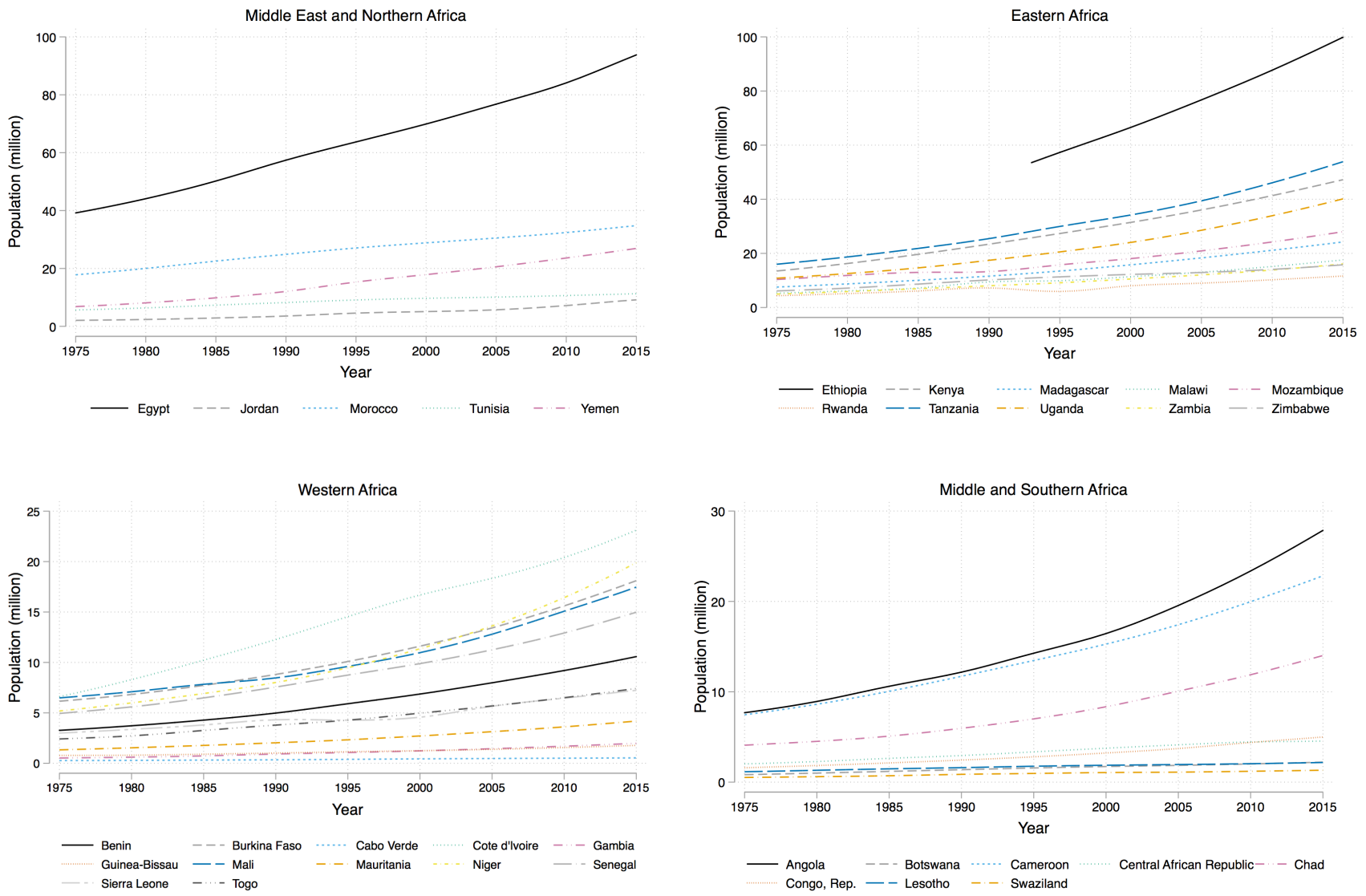


Figure 9: Population in India, Ukraine and Nigeria

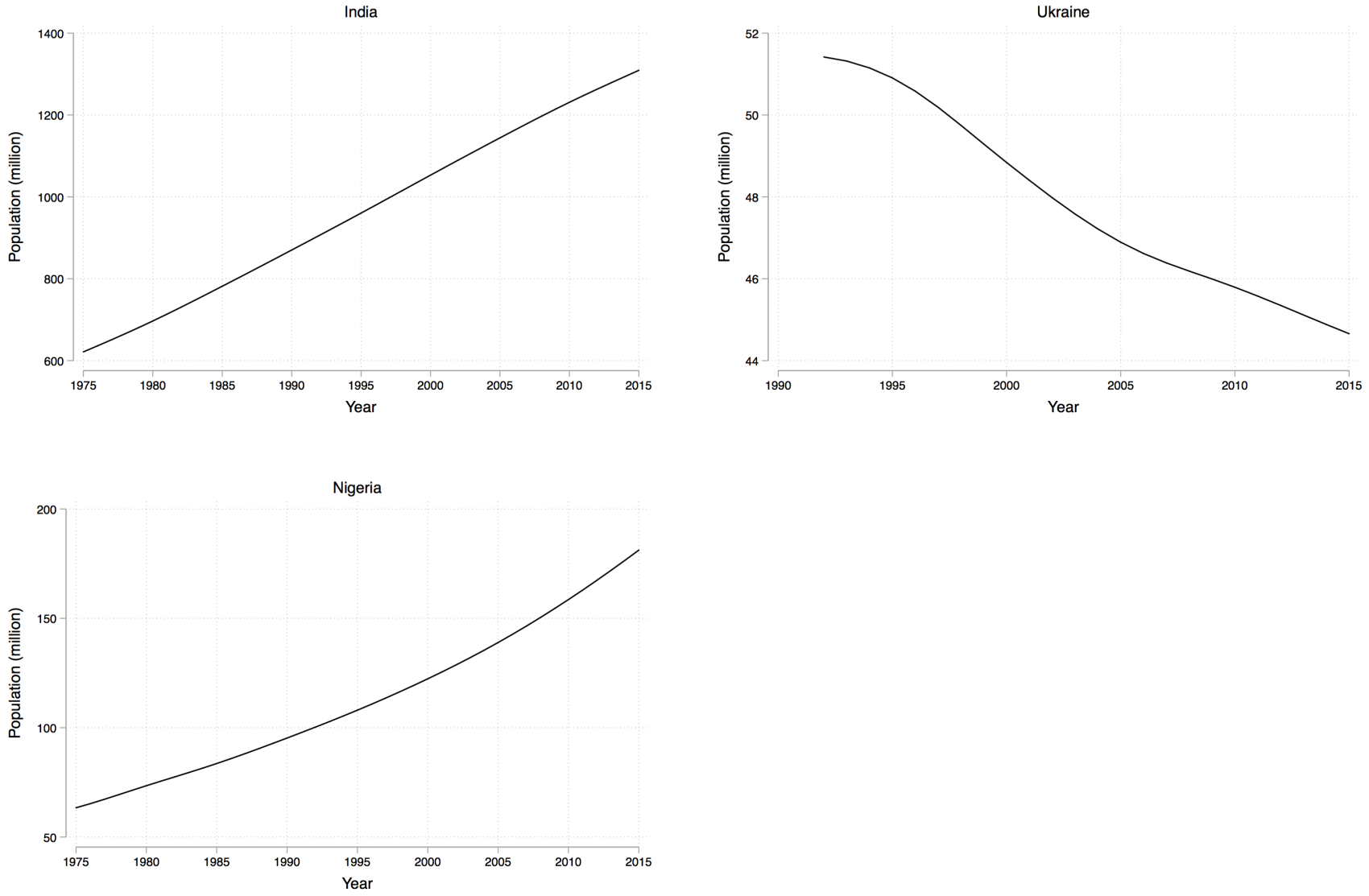
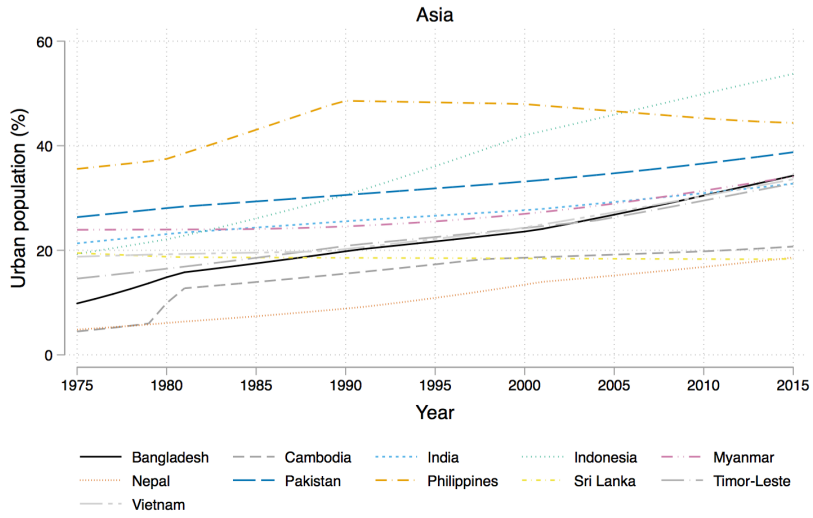
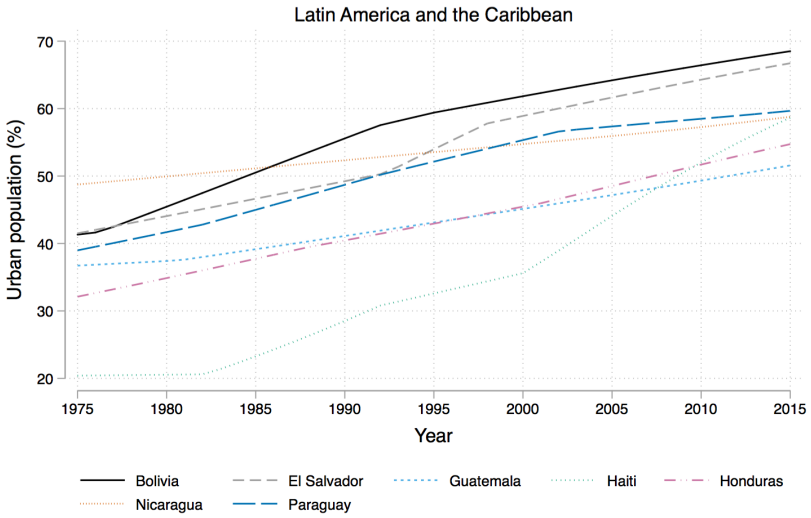


Figure 10: Urbanization in Asia, Europe, and the Americas





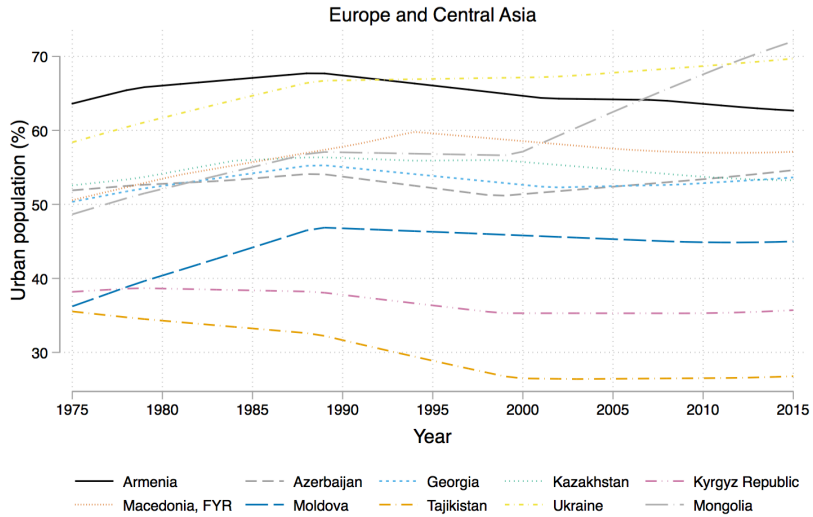


Figure 11: Urbanization in African countries

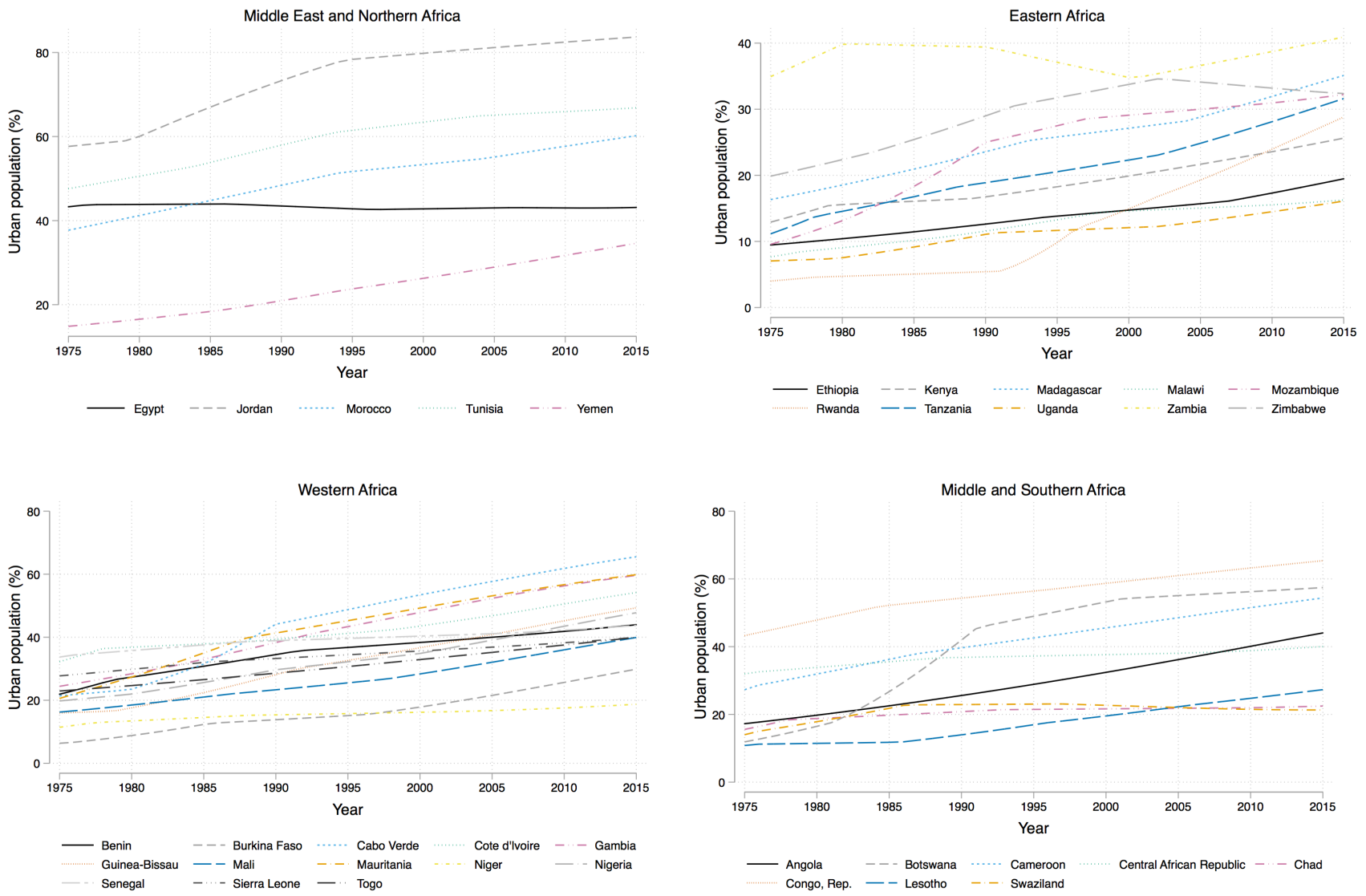
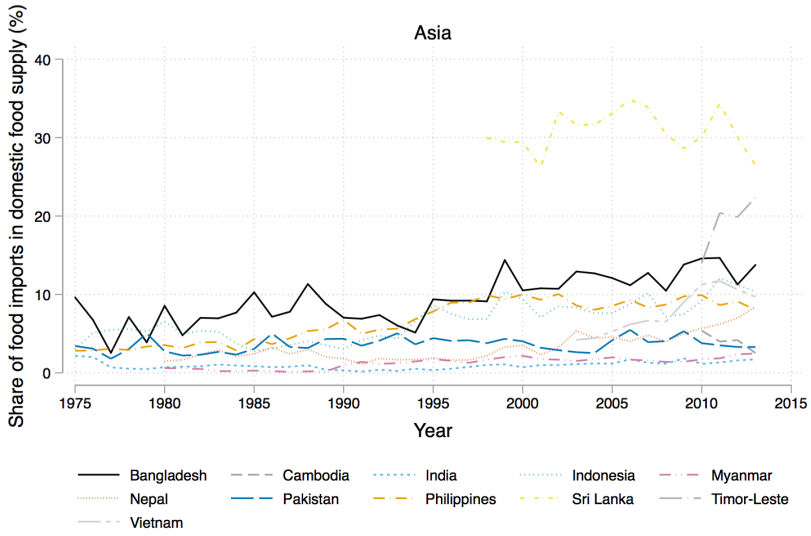
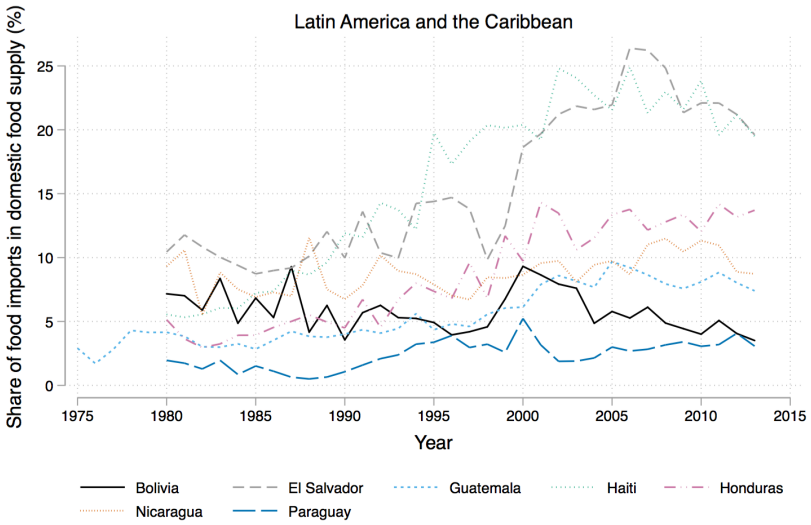


Figure 12: Food Imports in Asia, Europe, and the Americas





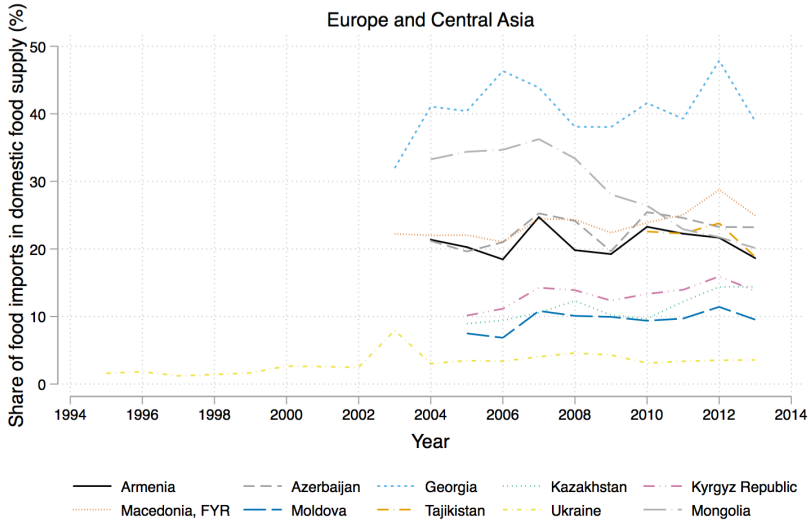


Figure 13: Food Imports in African countries

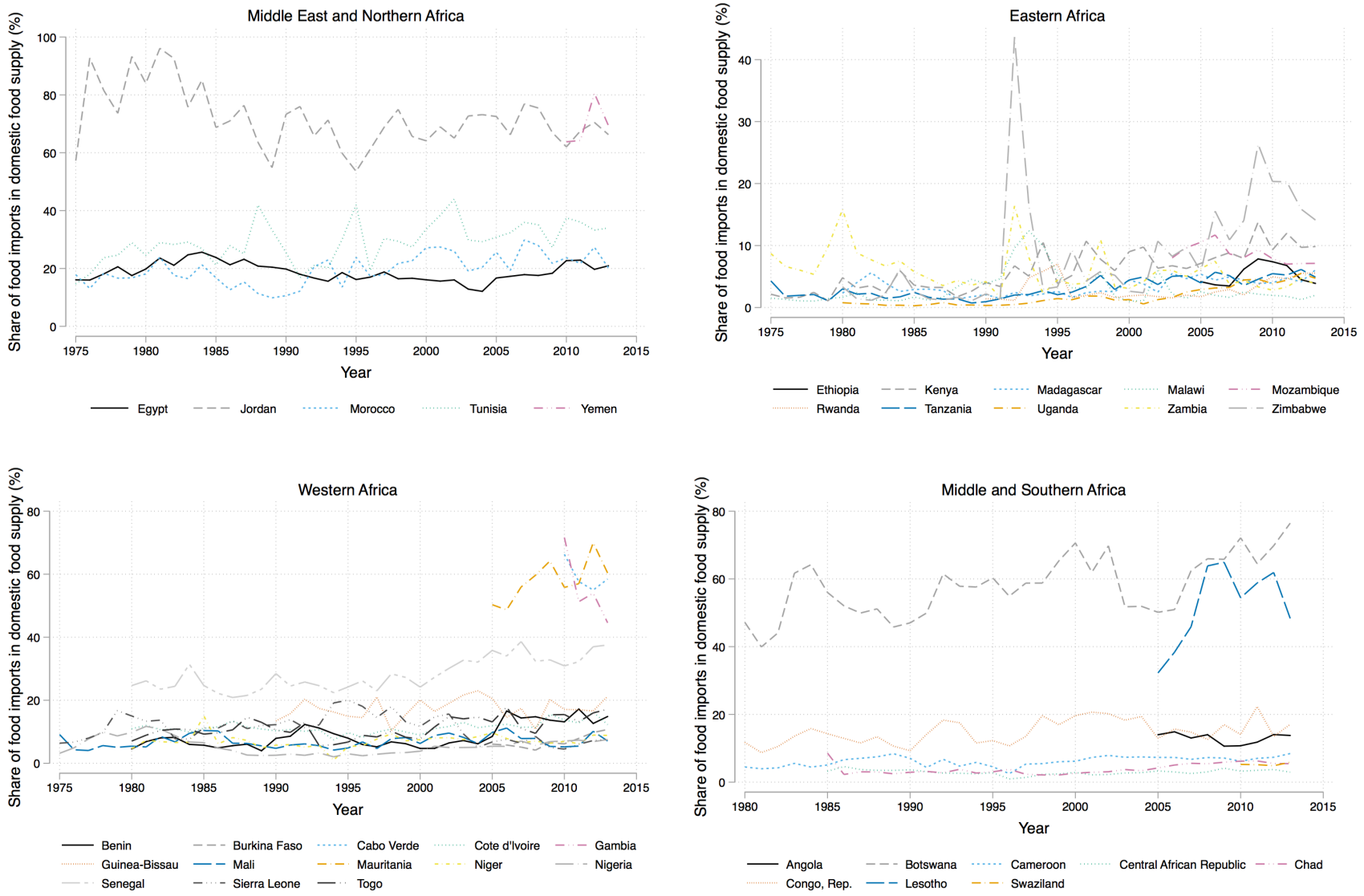


Figure 14: 10th, 50th and 90th Quantiles of the Globalization Indices - 1975 vs 2013

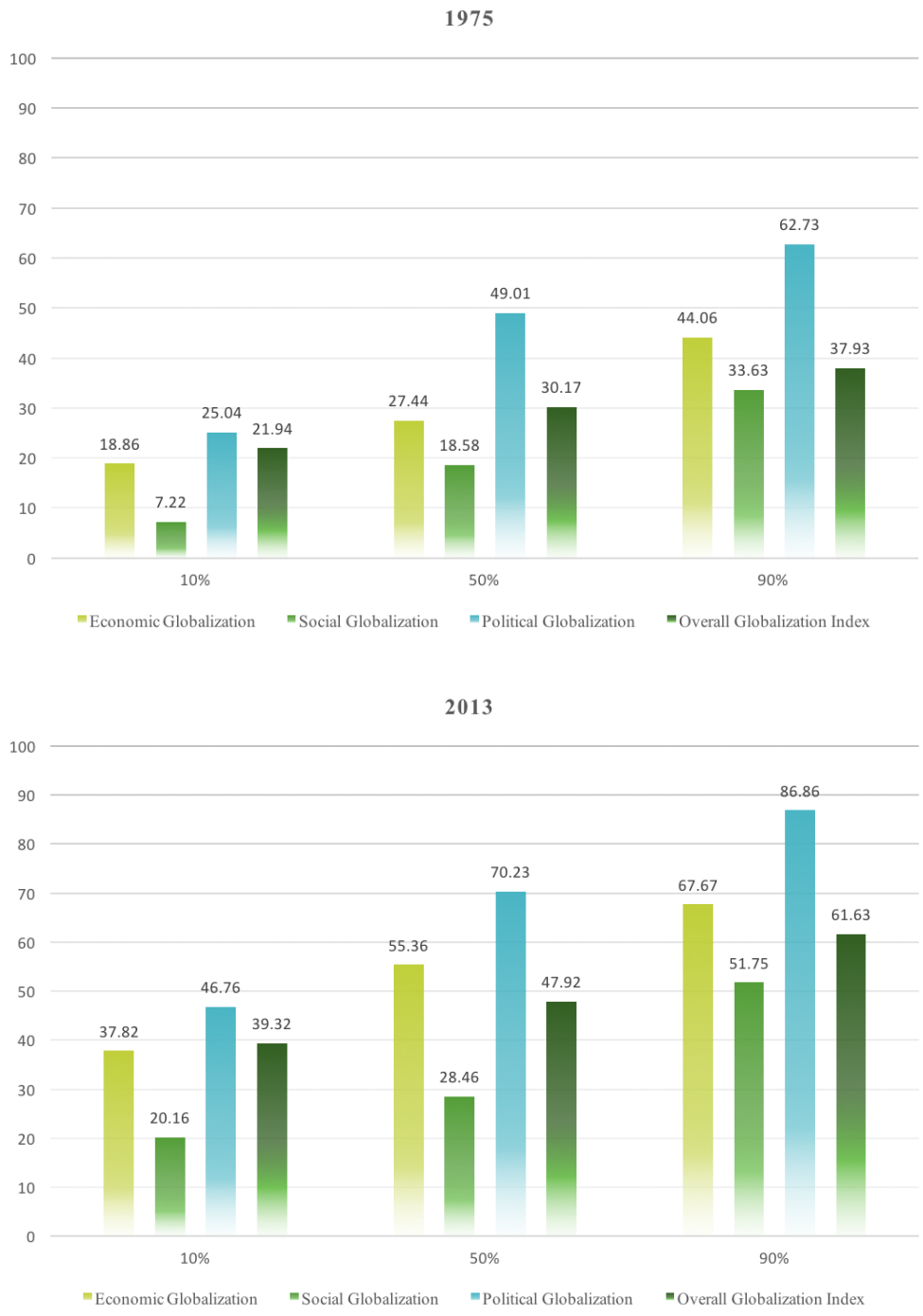
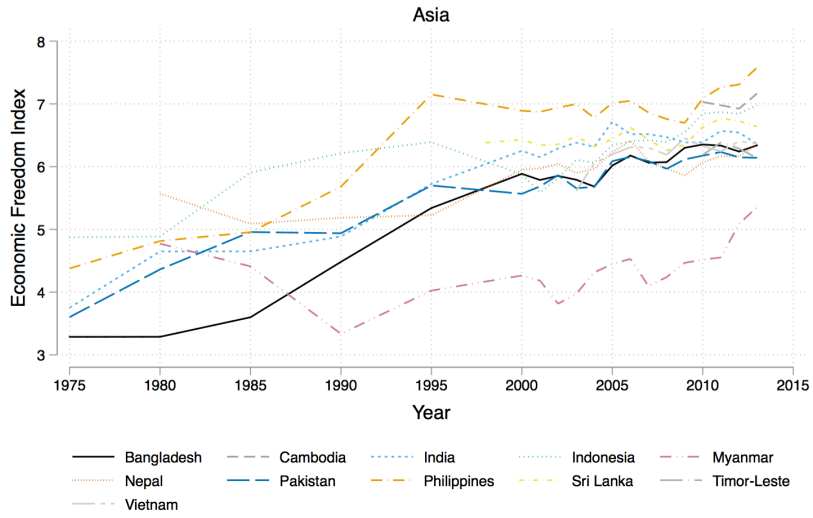
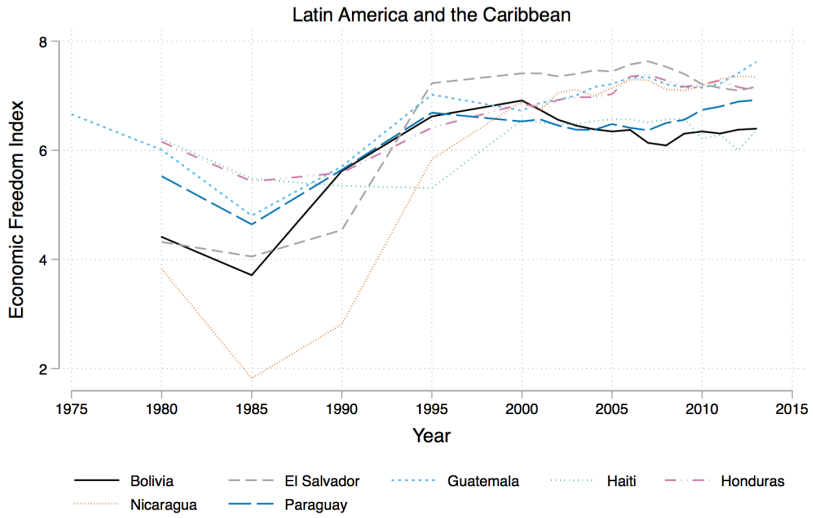


Figure 15: Economic Freedom in Asia, Europe, and the Americas





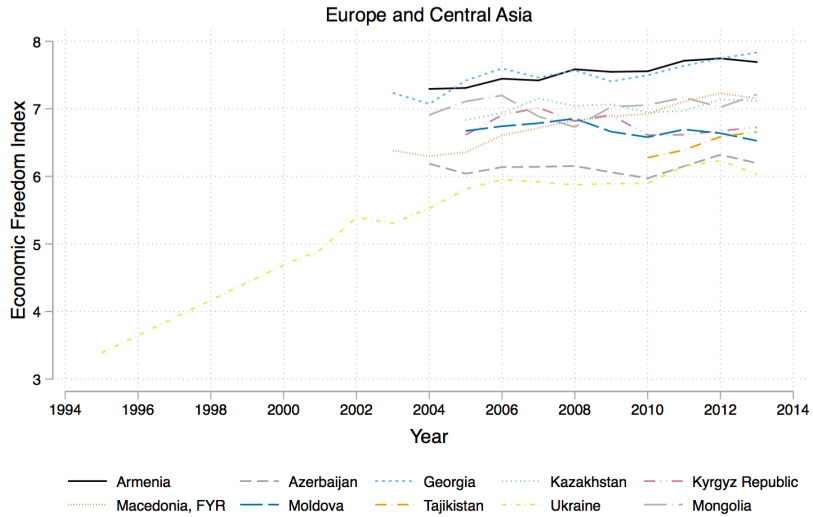


Figure 16: Economic Freedom in African countries