Backcasting and the Global Dietary Shift

Historical dietary shift

Food balance sheets from the Food and Agriculture Organization (FAO) of the United Nations document a historical dietary shift in per capita calories available for consumption. A common trend shows up in the four large countries in Figure 1: total calorie consumption by individuals increased from 1990 through 2019, and the composition of those calories shifted toward consumption of animal products.

Figure 1

1990 and 2019 per capita calories available for consumption (selected countries)

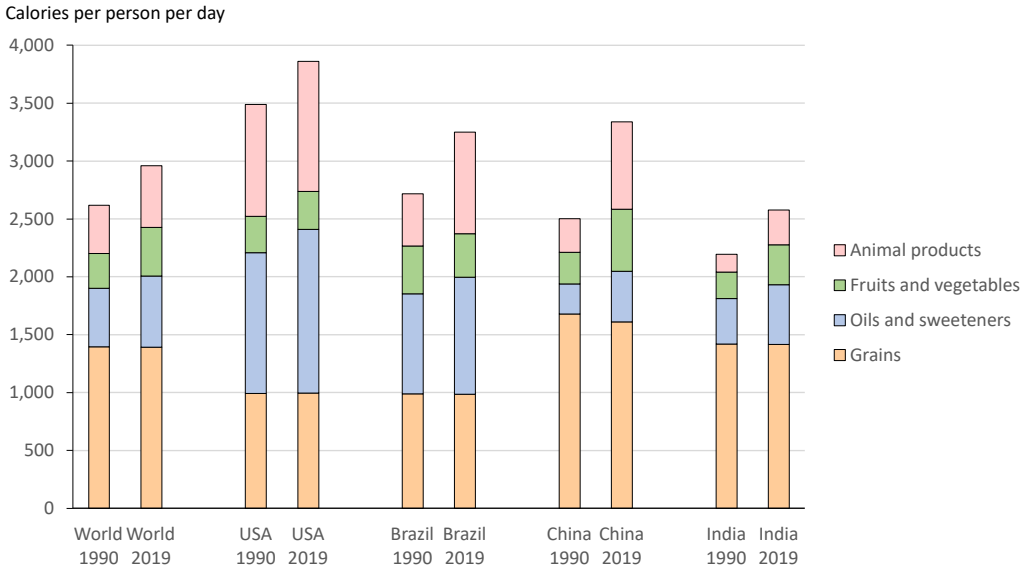
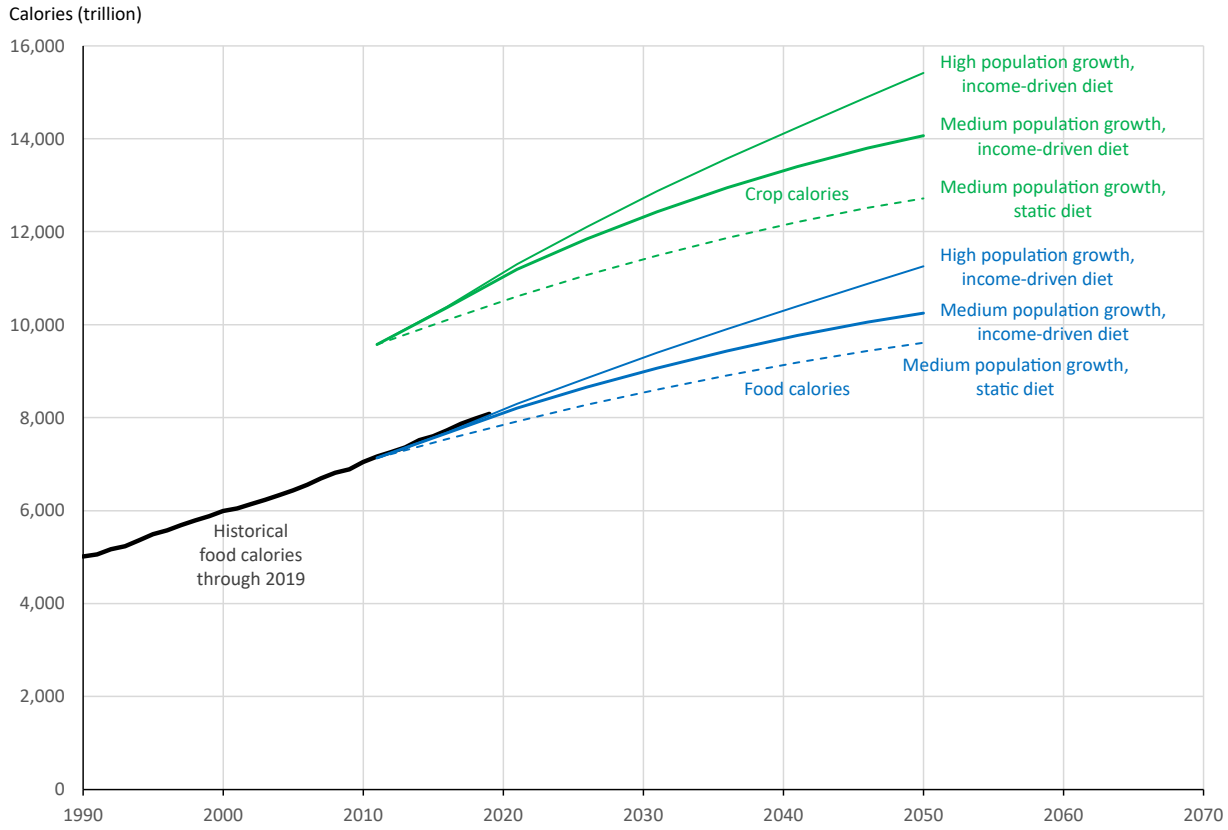


Figure 2 provides a simulation of total food calories at the world level, along with associated production of crop calories, from the GTAP base year of 2011 through 2050. Although the main purpose of the scenarios in Figure 2 was projecting world calories into the future, it also turned out to be an inadvertent backcasting exercise from 2011 to 2019. The first thing to note in Figure 2 is that simulated world food calories are a good match to historical world food calories in 2011, the model base year, and through 2019. However, global results can mask differences in underlying countries.

Figure 2

Projections of world food calories and crop calories, 2011–50



Notes: Three illustrative scenarios are shown: a static diet (per capita consumption of food calories remains constant at 2011 levels in all world regions) with medium population growth; an income-driven diet with medium population growth; and an income-driven diet with high population growth. The static diet is a point of comparison to quantify the effect of income growth on food consumption. Historical food calories in 2019 are slightly higher than the medium-population scenario in the Future Agricultural Resources Model (FARM). This indicates that food consumption continues to respond strongly to increases in per capita income. FARM simulations begin in 2011.

Source: Sands, R.D., B. Meade, J.L. Seale, Jr., S. Robinson, and R. Seeger (September 2023). *Scenarios of Global Food Consumption: Implications for Agriculture* (Report No. ERR-323). U.S. Department of Agriculture, Economic Research Service.

Moving the model base year back to 2004

It is common practice in general equilibrium modeling to use the most recent GTAP base year. However, moving the base year back in time can provide insights into model performance over historical years. In this study, we will use the GTAP dataset for 2004 as a base year to simulate world agriculture through 2050 for 13 world regions. The simulations will be similar to those in Figure 2, except the base year will be moved from 2011 back to 2004. The time frame for comparison to historical data on food consumption will be from 2004 to the latest year that FAO food balances are available (2023). This provides 20 years for comparison of model output to historical data, longer than the nine years for comparison in Figure 2.

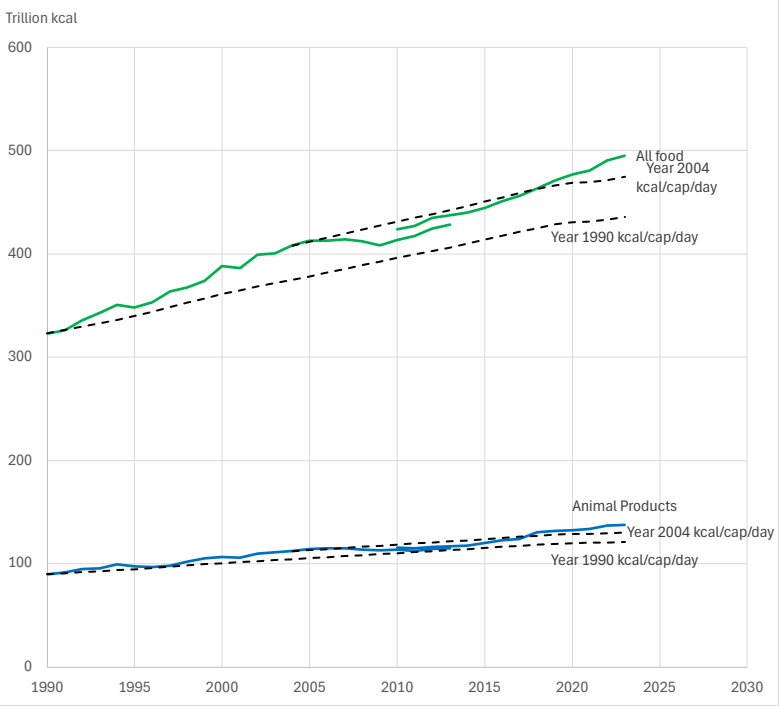
Expected results

The first point of comparison is simulated world food calories to historical FAO data in 2004, the simulation base year. This is essentially a check of base-year calibration, at the world level and for world regions. Calibration is not trivial, as it requires integrating FAO food balances into the benchmark social accounting matrix.

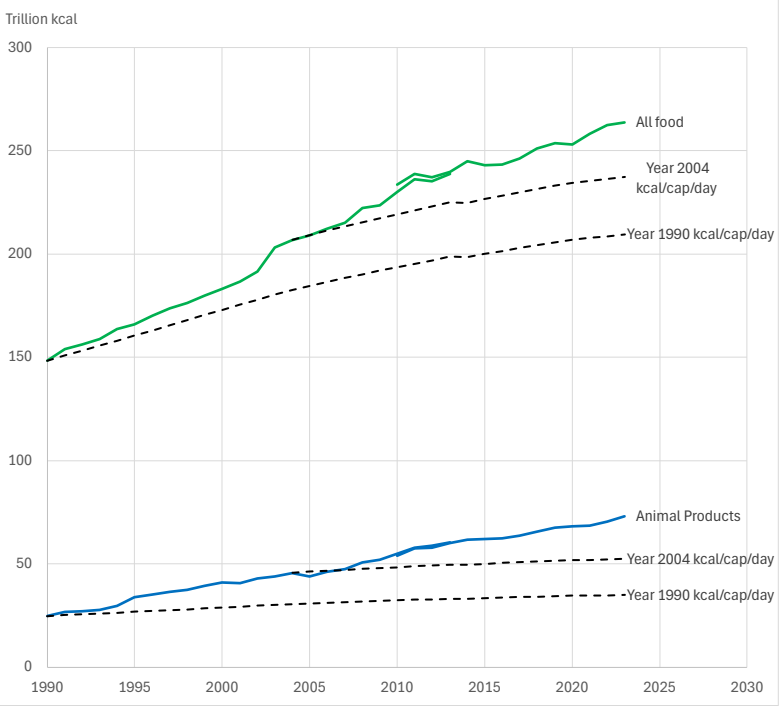
A second point of comparison is the time path of food calories from 2004 through 2023, at the world level and for world regions. Many model parameters and assumptions affect this comparison, including the choice of consumer demand system, income elasticities of demand, and income growth. Population growth in the model is exogenous and is calibrated to United Nations population projections. Income is endogenous in our model, and OECD data developed for the Shared Socioeconomic Pathways provide targets for income growth. Productivity assumptions, especially labor productivity, are the main determinant of income growth in our model.

A third point of comparison is the demand in world regions for the four food groups shown in Figure 1, and perhaps at a finer level. This tests the performance of the consumer demand system, and how it responds to growth in per-capita income over time. Simulations in Figure 2 were run with a two-stage consumer demand system, with the Linear Expenditure System as the first stage and constant-elasticity-of-substitution (CES) as the second stage. Although this backcasting exercise is focused on food calories, it could be expanded to other model output such as energy consumption.

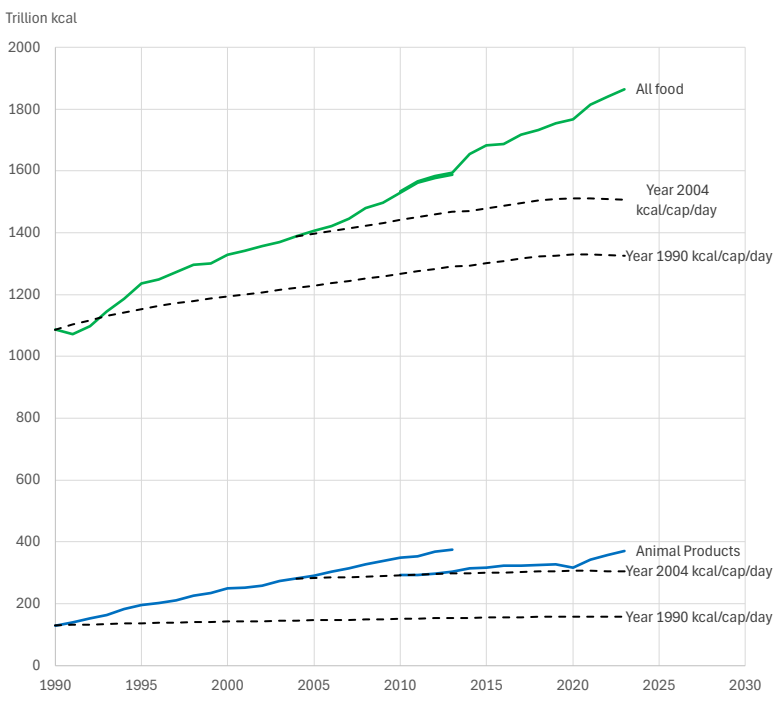
USA food calorie consumption, 1990-2023



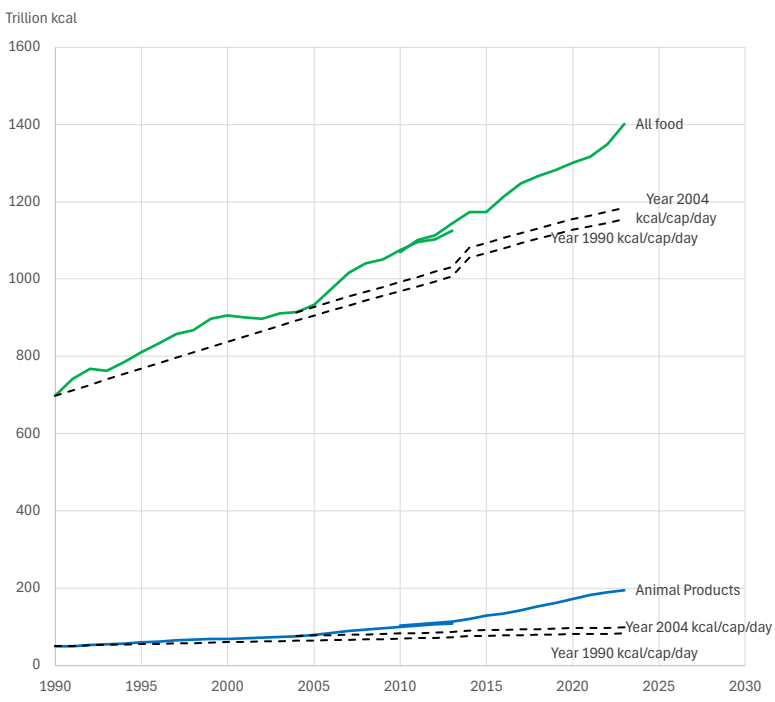
Brazil food calorie consumption, 1990-2023



China food calorie consumption, 1990-2023



India food calorie consumption, 1990-2023



Agricultural production sectors and first-stage mapping for demand system

Group	Subgroup	Product	Grains	Veg. oils	Sugar	Veg. and fruit	Other crops	Animal products	Forest products
Primary agriculture	Crops	Wheat	X						
		Paddy rice	X						
		Other grains	X						
		Oilseeds		X					
		Sugar (cane and beet)			X				
		Vegetables and fruit				X			
		Plant fibers					X		
		Other crops					X		
	Fisheries	Fish						X	
	Forestry	Forestry							X
	Ruminant	Cattle and other ruminants						X	
		Raw milk						X	
		Wool						X	
	Non-ruminant	Other animal products						X	
Food processing		Vegetable oils		X					
		Processed rice	X						
		Sugar			X				
		Beverages and tobacco products					X		
		Other food					X		
		Meat from cattle and other ruminants						X	
		Dairy products						X	
		Other meat products						X	

Data construction