USDA Economic Research Service
U.S. DEPARTMENT OF AGRICULTURE

Modeling Global Food Systems

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Scenarios of Global Food Consumption: Implications for Agriculture

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Research Questions

1. How do increasing population and income affect global demand for crops and food products through 2050?
2. What is the effect of agricultural productivity growth on food prices and cropland area expansion?
3. How do alternative assumptions about population growth affect the size of the world agricultural system in 2050?

https://www.ers.usda.gov/publications/pub-details?pubid=107473

Approach

Retrospective Analysis

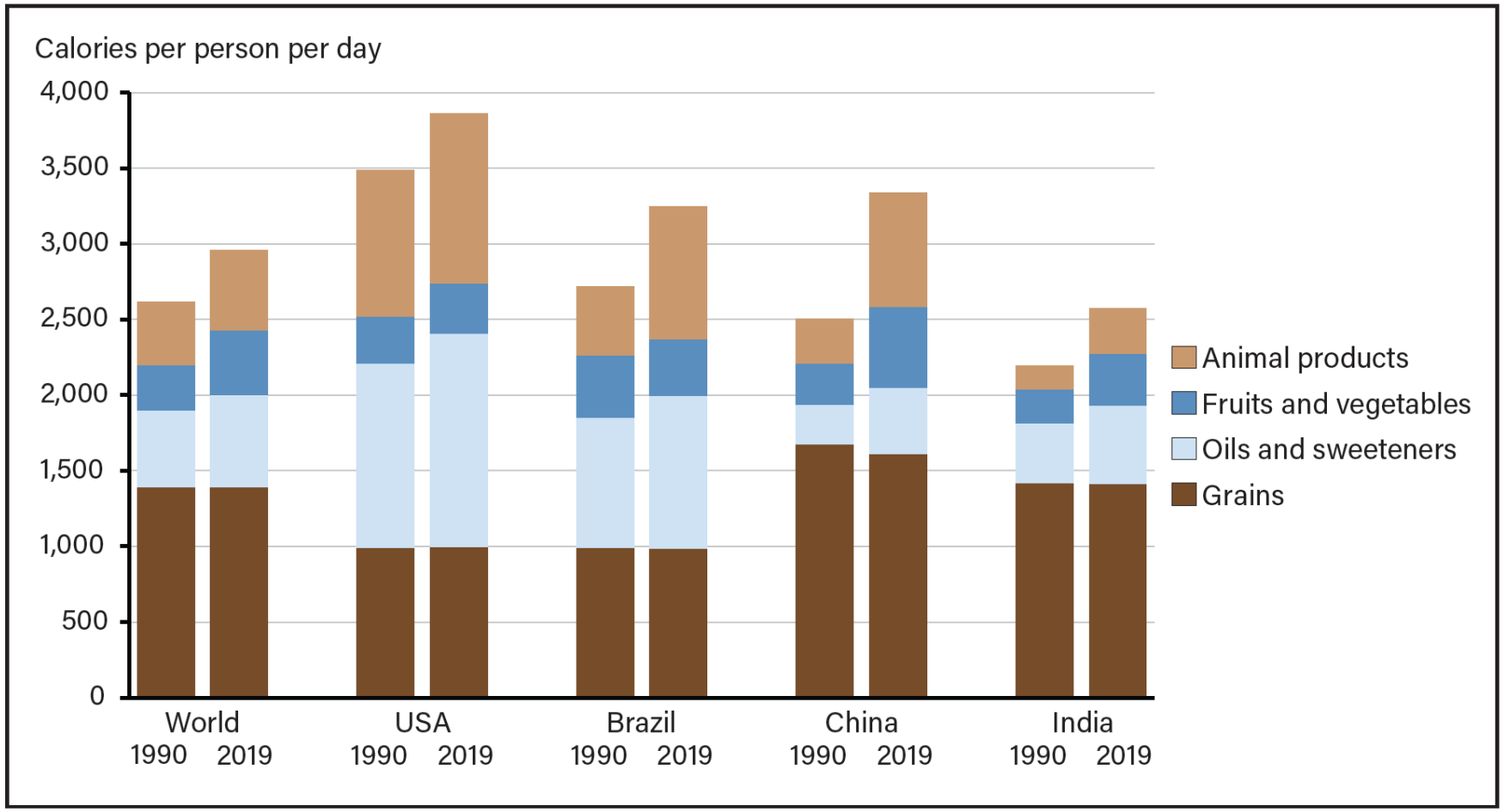
- Food Balance Sheets (FAO)
  - Domestic supply is the quantity of food produced, plus imports, less exports, adjusted for change in storage
  - Domestic use includes crops used for seed, animal feed, processed food, non-food uses, and waste during storage and transportation
  - Remainder is food available for consumption (food consumed plus post-retail food waste)
- International Comparison Program (ICP)
  - Coordinated by the World Bank
  - Measure the size of world economies based on surveys of the quantities of goods or services that can be purchased within each country

Prospective Analysis

- Future Agricultural Resources Model (FARM) developed at ERS
  - Global economic model
  - Simulates world agricultural and energy systems
  - Five-year time steps starting in 2011
- Drivers of global change into the future
  - population
  - per capita income growth
  - dietary preference
  - agricultural productivity

Figure 1

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



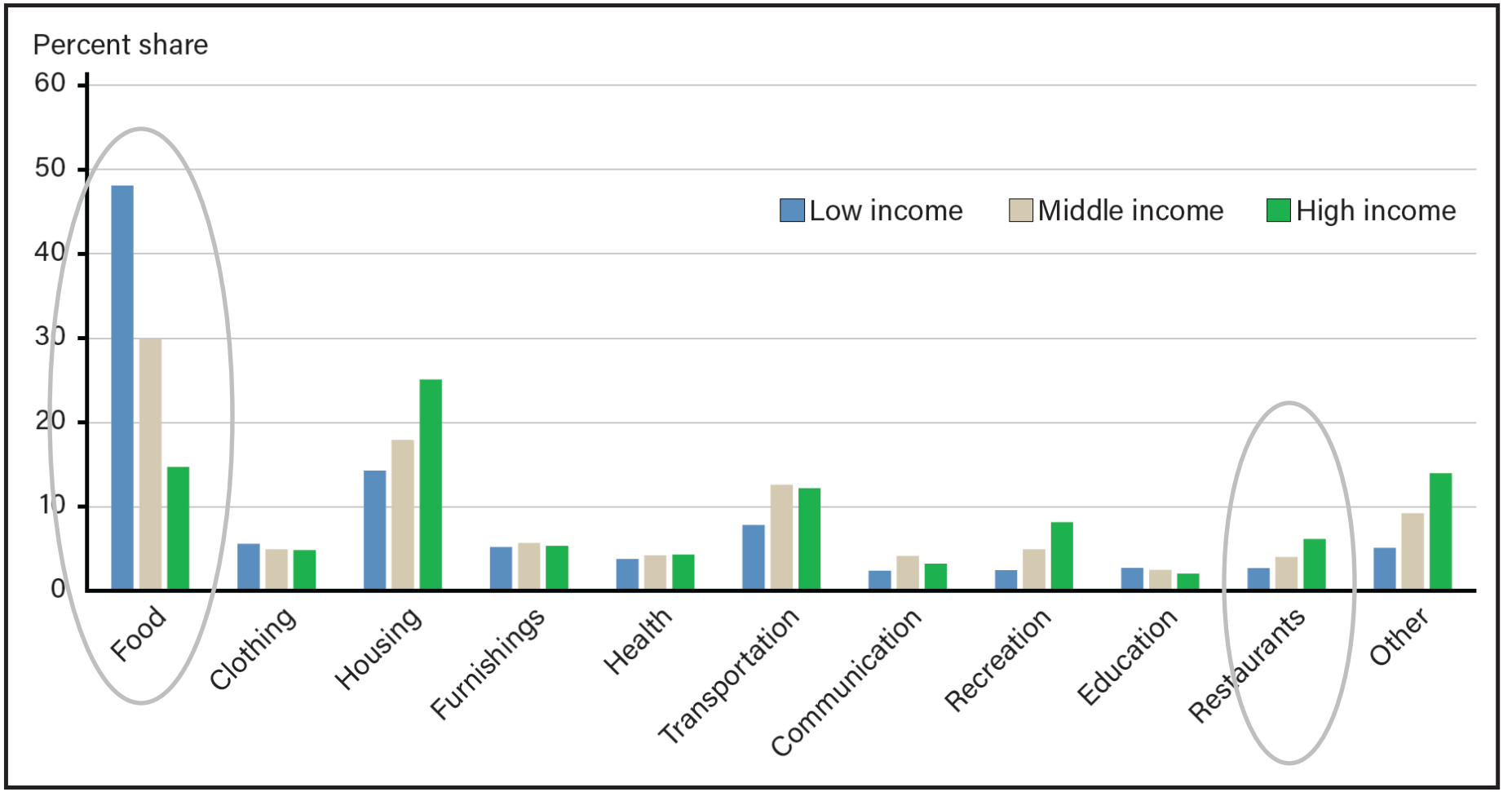
USA = United States of America.

Source: USDA, Economic Research Service using food balance sheets from the Food and Agriculture Organization of the United Nations.

- From 1990 through 2019, world population grew by 45 percent to 7.7 billion people, while calories available for food consumption increased by 61 percent
- The world average masks large differences across countries
- Calories available for consumption equal food consumed plus post-retail food loss and waste

Figure 2

Budget shares for broad consumption categories, 2011

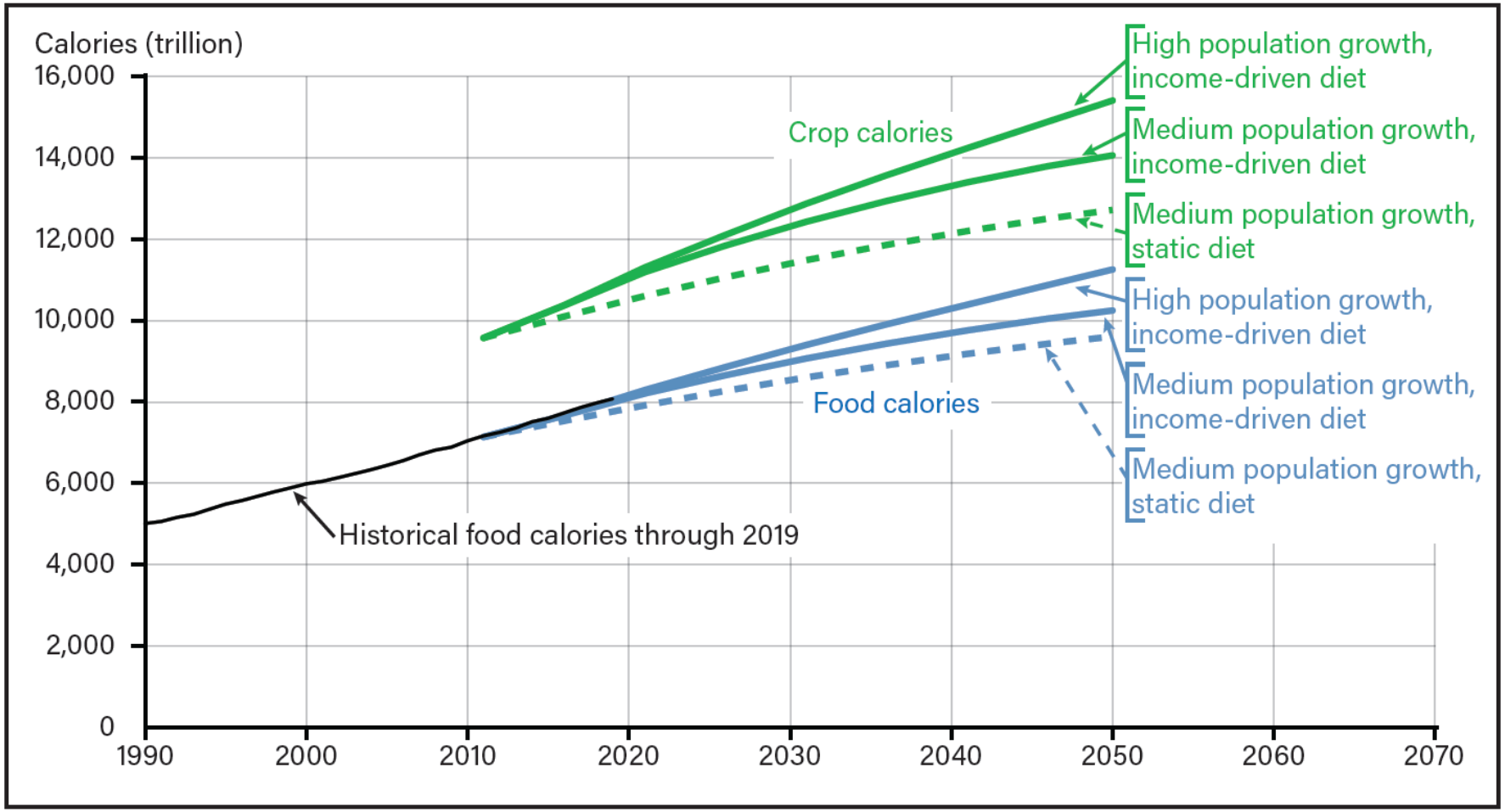


Note: Food away from home is included in Restaurants.

Source: USDA, Economic Research Service calculations based on the 2011 International Comparison Program.

- Food at home is by far the most important expenditure category for low- and middle-income economies
  - Average budget share of 48 percent in low-income economies
  - Average budget share of 30 percent in middle-income economies
- Food away from home, which increases with income, is included in restaurants

Population and Income Drive Projections of World Food Consumption

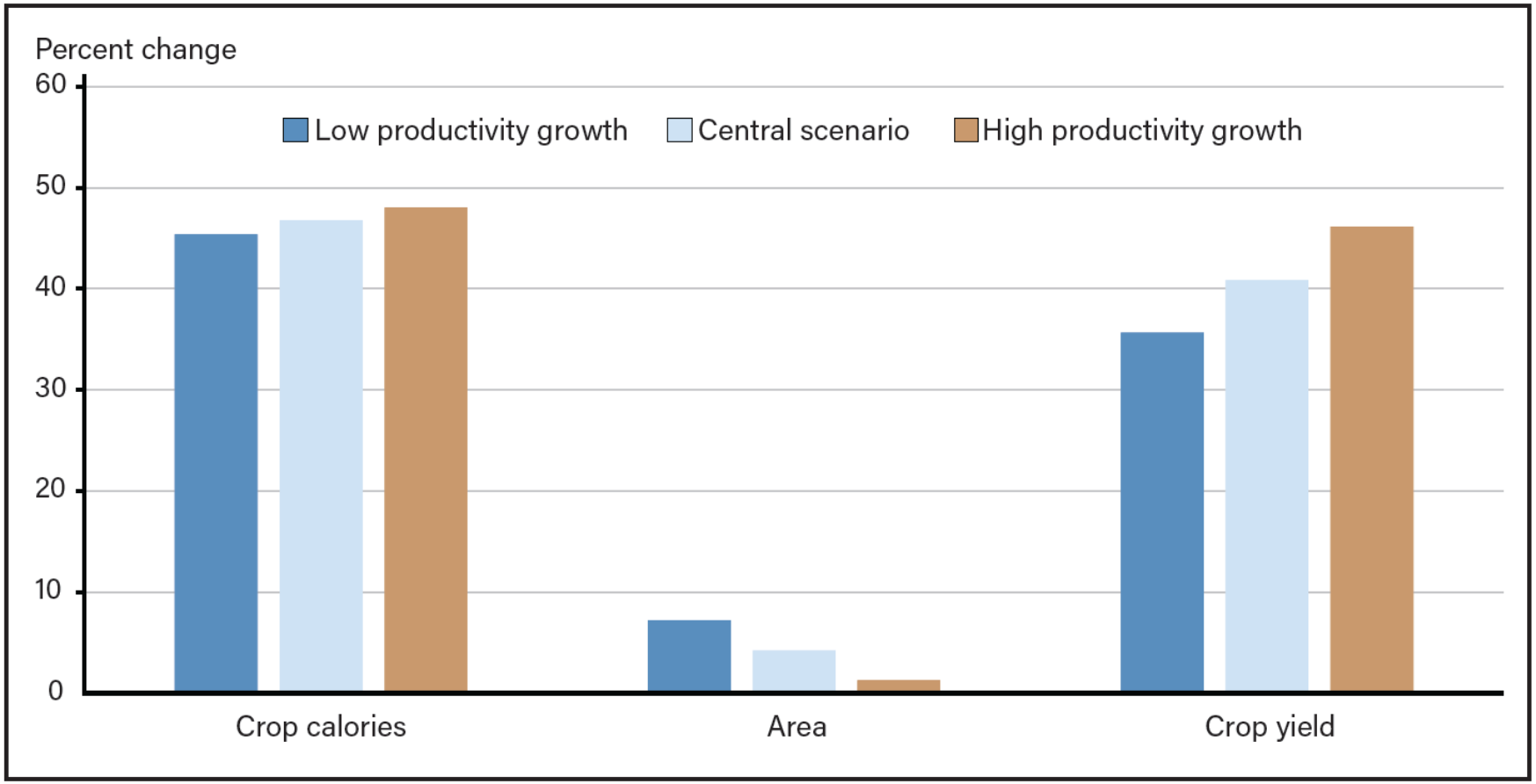


Notes: Three illustrative scenarios are shown: a static diet (per capita consumption of food calories remains constant at 2011 levels in all world regions) with medium population growth; an income-driven diet with medium population growth; and an income-driven diet with high population growth. The static diet is a point of comparison to quantify the effect of income growth on food consumption.

- A useful measure of the size of the world agricultural system is total calories from crops
- Rising per capita incomes have historically implied increasing consumption of
  - Total calories
  - Animal products
- Uncertainty is handled through scenarios

Figure 11

Agricultural productivity growth: Feedbacks under three scenarios to crop demand, land use, and crop yield, 2011–50

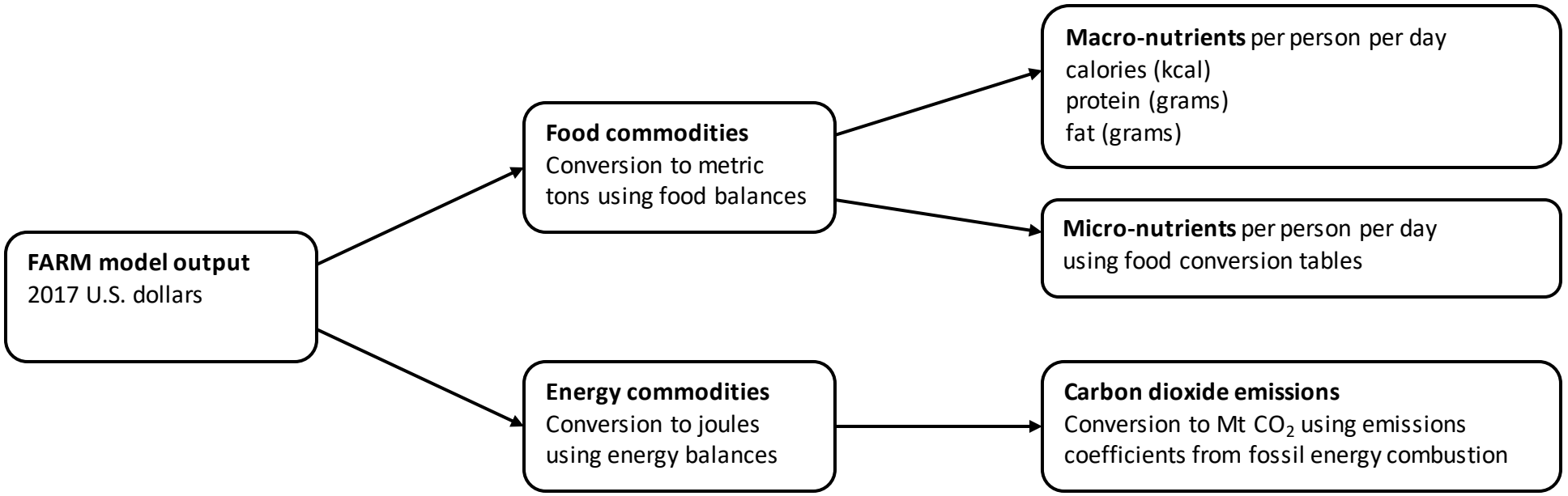


Note: Each indicator is shown as percent change relative to 2011 to allow comparison across indicators with different units. The feedback from agricultural productivity growth to demand for crop calories is indirect—productivity growth reduces food prices, and consumers increase food consumption. Without this feedback through food prices, demand for crop calories would be equal across productivity scenarios and the bars for crop calories would be the same height. All scenarios assume medium-fertility population growth and income-based food consumption.

Source: USDA, Economic Research Service simulations using the Future Agricultural Resources Model.

- Food prices are lower in high productivity scenarios than in other scenarios, which allows greater consumption of food
- If productivity growth were high enough, cropland area could decline
- Crop yield increases along with productivity growth

Unit conversions for food and energy commodities



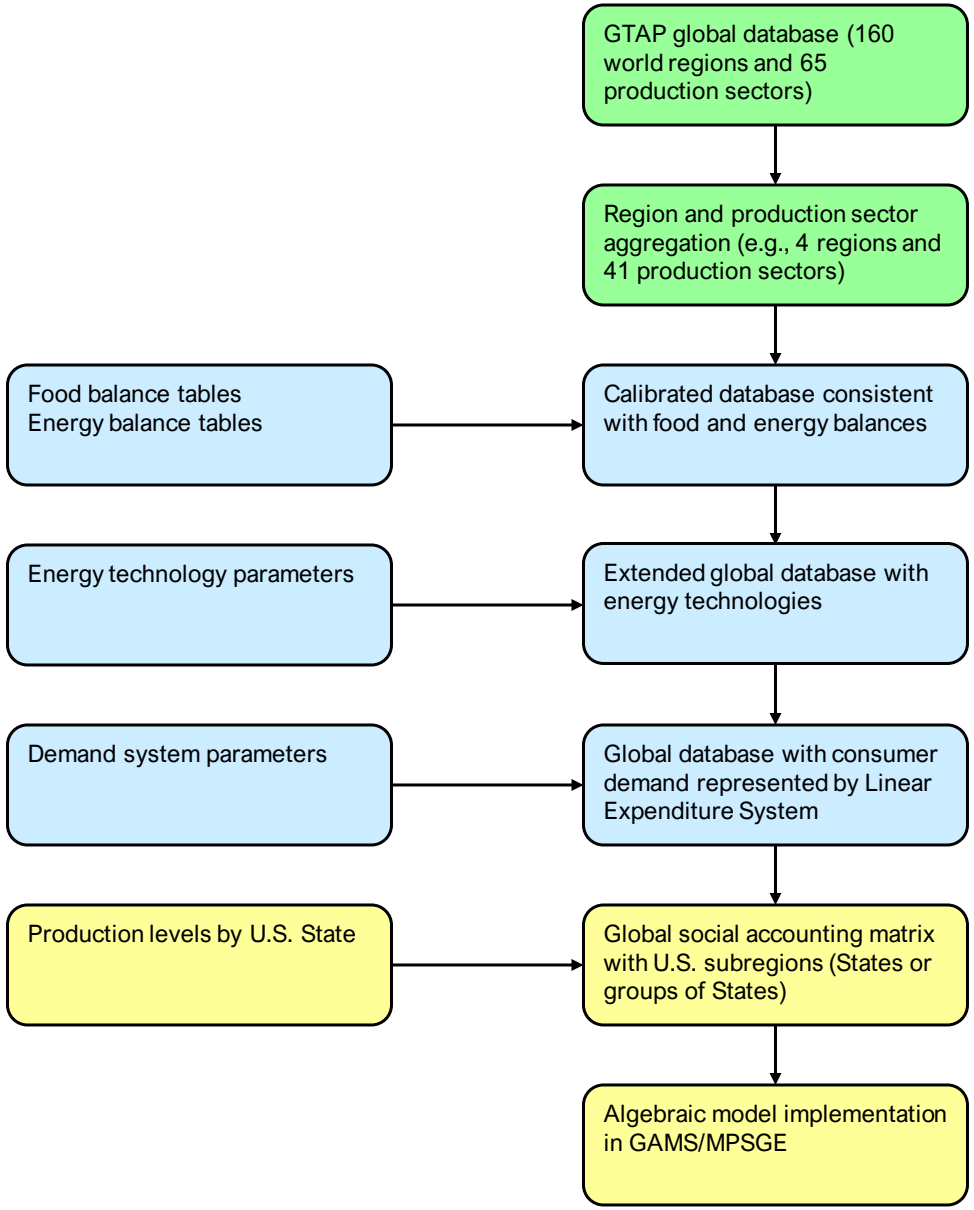
Notes: FARM model quantities are in real 2017 U.S. dollars. Conversion to physical quantities occurs with information from 2017 food balance tables, 2017 energy balance tables, and carbon dioxide emissions coefficients.

Sequential Data Construction

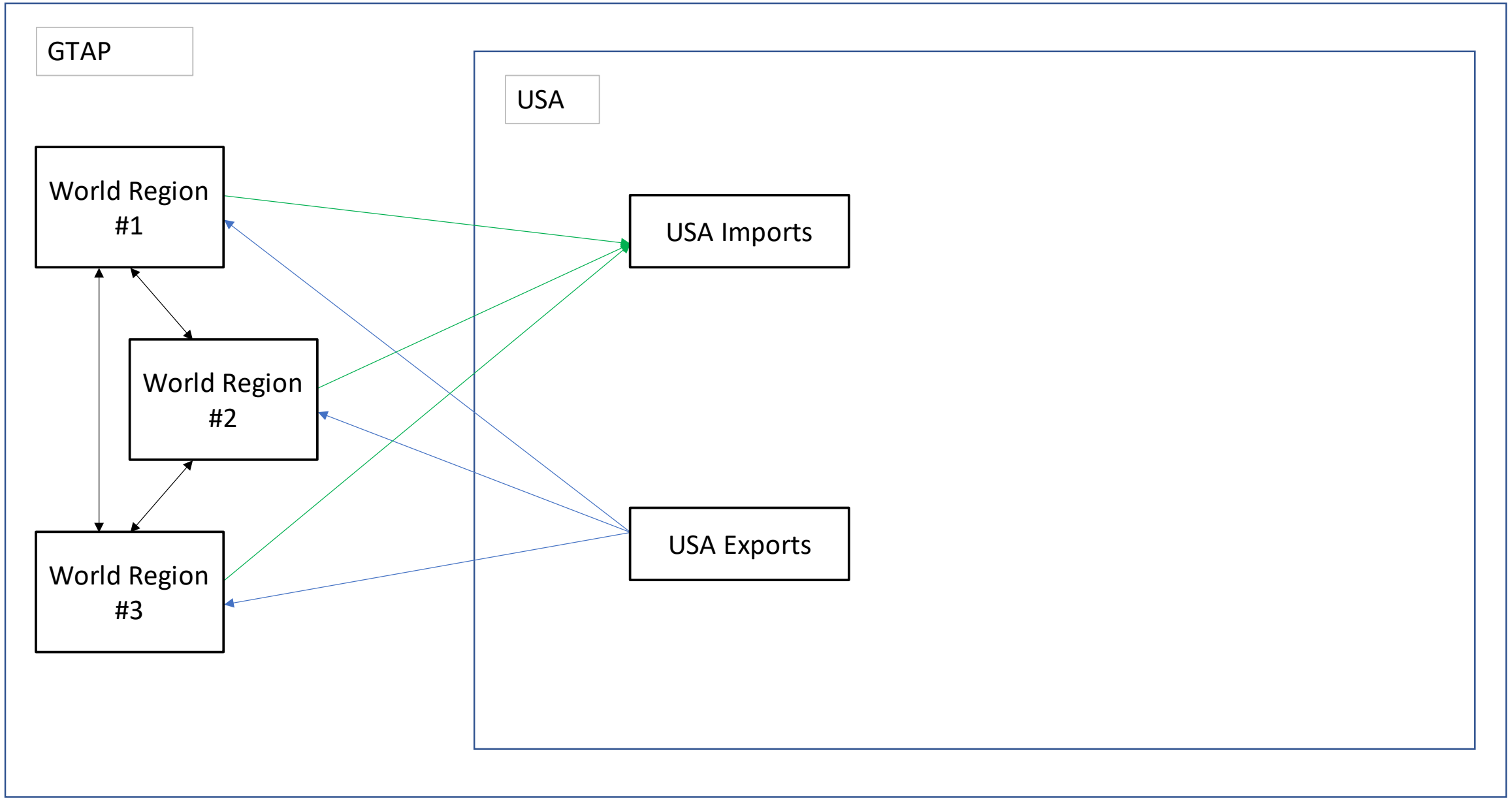
- Start with balanced and aggregated GTAP global database (top of diagram)
- Integration of food balances
- Construct energy technologies
- Set up consumer demand system

New in FARM 5 (yellow)

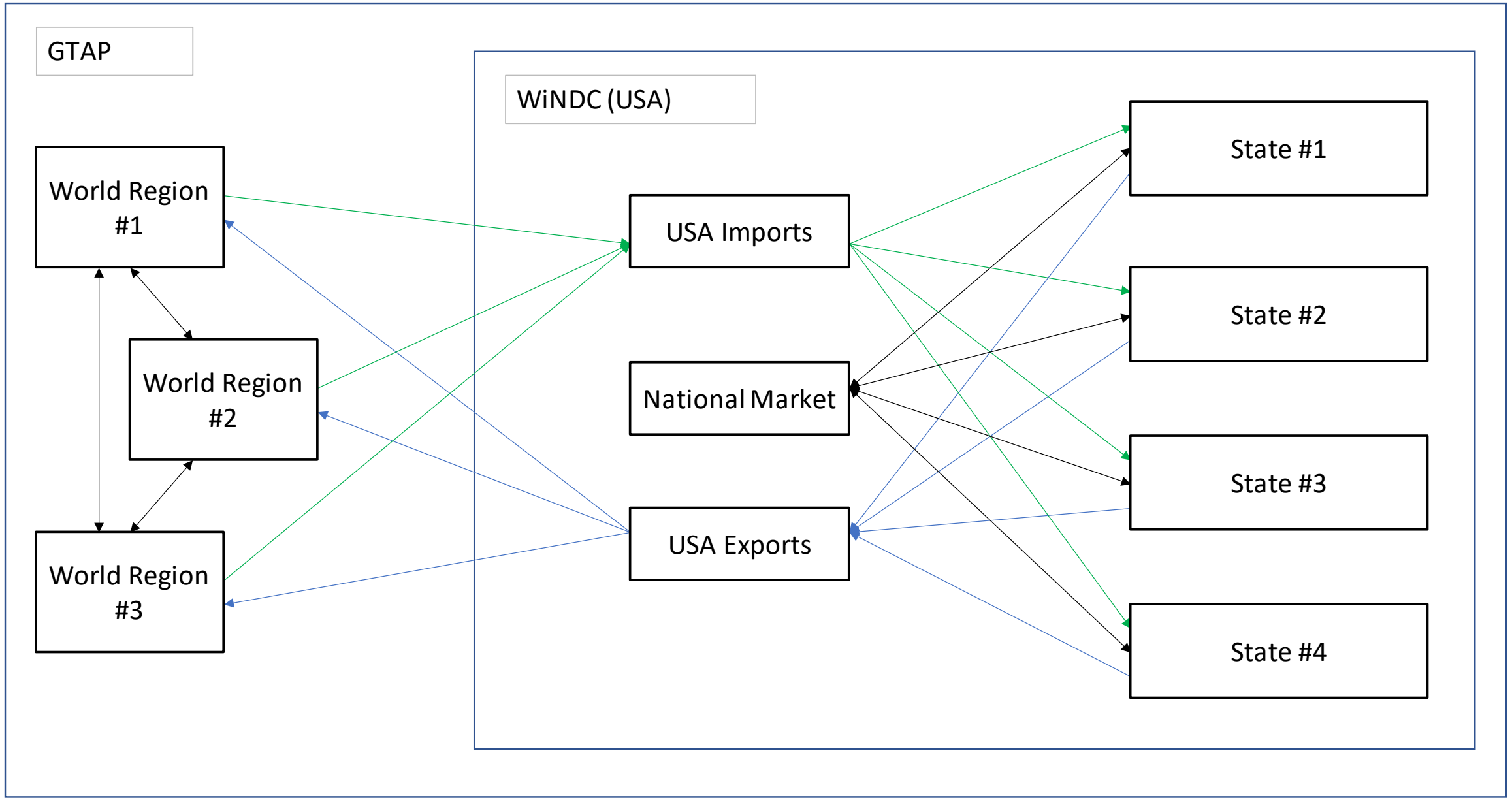
- Use production levels by U.S. State to algebraically downscale U.S. national data
- Input-output structure at the national level is retained for each U.S. State
- Complexity of model is more easily handled in GAMS/MPSGE than algebraic GAMS



FARM 4 model with international trade



FARM 5 model with links to U.S. states



Takeaways

- Calories are a convenient unit for representing the size of the world agricultural system
  - Calories available for food consumption equal food consumed plus food loss and waste
  - Total crop calories include animal feed and represent pressure on the land base
  - Conversion efficiency from crop calories to food calories
- Strong trend of food consumption increasing with per capita income
  - Total calories per person
  - Calories of animal products per person

- Food (at home) is the largest expenditure category for low- and middle-income economies
- Share of income spent on food at home decreases with per capita income
- Share of income spent on food away from home increases with per capita income
- The rate of future agricultural productivity growth affects
  - Crop yield
  - Demand for agricultural land
  - Food prices and demand for food