Food economics: Teaching about the private sector in agriculture and food systems

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This chapter builds on Carl Pray's professional contributions by addressing how we teach about innovation and the private sector in agriculture and food systems. We explore why and how the economics of food can be taught more effectively by describing the interaction between private enterprises and public-sector organizations, with a focus on the development and eventual adoption of technological and institutional innovations by food-related businesses. Towards that goal we introduce our new textbook, *Food Economics: Agriculture, Nutrition, and Health* (Masters and Finaret 2024), intended as an introduction to the field for use by advanced undergraduates and graduate students, building on insights from Carl Pray's work regarding agricultural history, technological innovation, and the role of food-related businesses interacting with family farmers and food consumers.

Students bring a lifetime of personal experience, narratives and prior beliefs to the classroom

The fraction of each year's incoming students who grew up on farms is declining around the world, as a delayed echo of the economic transformation to nonfarm employment experienced in prior generations. Students' direct personal experience with agriculture and food businesses is increasingly diverse, leading to a wide range of beliefs about how the food system works. Students also bring a wide range of educational preparation in terms of disciplinary skills and topical knowledge, as many those interested in the economics of food no longer have any prior training in agriculture or in economics. This chapter describes how such students can be introduced to the methods and findings of specialized researchers, and thereby acquire knowledge and skills needed for a successful career improving food systems around the world.

Students approaching food economics from other fields often enter class with negative views of how both for-profit corporations and government policies shape the food system, and positive perceptions of family farms that are thought to work in harmony with nature and sell time-tested, traditional foods that meet longstanding needs. From this approach, described as the "naturalist" paradigm by Rausser, Sexton and Zilberman (2019), it is easy for students to imagine that corporate profits generally come at the expense of farmers, harm the ecosystem and worsen public health, enabled by government agencies that are seen as beholden to commercial interests in contrast to the population's non-market needs. Specific concerns include how lobbying leads to policies that help the largest incumbent firms at the expense of everyone else, how new technologies are often used to exploit information asymmetries and use up common-property resources, and how even an initially beneficial innovation will lead one company to have sufficient market share to exercise market power in ways that worsen disparities.

Whatever their background, all students also bring to the classroom a lifetime of experience with their own food choices, shaped by family stories and media narratives that often lead to strongly

held views about what people should eat. In our experience, student beliefs about food cut across the political spectrum, across the rural-urban divide, across international borders and generational lines. What students have in common is that they already have views about is healthy and sustainable, and these views are often deeply felt convictions based on their specific experiences and stories they have heard. These highly personal stakes make teaching food economics rewarding but also challenging, as students' beliefs about food are sometimes contradicted by evidence presented in class. We can use those moments to help students see how confirmation bias and motivated reasoning may have reinforced an initial understanding that is not actually correct. We can then use that experience to offer students a broader view, based on economic principles and a systematic approach to using all available data. These aha moments give students an opportunity to begin thinking like an economist, updating their prior beliefs and acquiring a new set of intuitions based on the analytical tools and data visualizations provided in the book.

An introductory survey of food economics can address ancient concerns and meet modern needs

The production and consumption of food is among the oldest topics in economics, dating back to Adam Smith (1776) and many other classic authors debating the role of agriculture in wealth creation and societal development. As the global population continues to grow and face both old and new kinds of resource scarcity, understanding the economics of food becomes increasingly vital in the context of increasingly rapid changes in climatic, technological and social conditions. These challenges are top of mind for many agricultural and applied economists today (Dorfman et al. 2024).

Modern food economics addresses how the production, distribution, and consumption of food is shaped by geographic, demographic, and macroeconomic conditions, government interventions and technological change, and how choices relating to food influence those broader environmental and social outcomes. The teaching materials discussed in this book chapter allow students to learn the basic principles of economics as taught graphically through analytical diagrams and learn basic facts about food through data visualizations about what, where, when, how and by whom food production and consumption occurs around the world and in the United States. The logic of analytical diagrams provides qualitative insights into cause and effect mechanisms behind current events, and the data visualizations give students a quantitative sense of how food relates to nutrition and health, natural resources and climate change, income distribution and poverty among other topics.

The teaching materials described in this chapter are designed for advanced undergraduates and graduate students, providing a high-level introduction to food economics for students. The approach aims to attract and engage students with wildly divergent prior beliefs and varied personal backgrounds. Focusing on graphical principles makes the course accessible to students with limited algebra and no calculus, while leading to many of the same insights that are demonstrated more rigorously in more advanced classes. Looking at lots of data in carefully designed scatterplots, line graphs and bar charts is also crucial, helping overcome selection effects and confirmation bias in what students have previously experienced or heard from other people.

Seeing food businesses as central actors provides a helpful new perspective

Traditional views of the food system often focus on farmers and governments, as if the food sector consisted primarily of raw farm output being produced, traded, and consumed. In traditional usage, the term "agribusiness" typically refers to enterprises that buy or sell from farmers, leading to a focus on agricultural commodities sold through terminal markets to global destinations, as well as horticultural products and higher-value produce sold direct to consumers. That type of food value chain is important, but value added and job creation in the food sector increasingly involves enterprises that buy ingredients from distributors and specialize in the formulation and marketing of packaged products or meal preparation, food service and delivery. Learning food economics allows students to understand how the available jobs and the food businesses with which they interact every day relate to farm production and government policies, providing a more useful perspective for students who are not primarily engaged in farm production and trade in agricultural commodities.

Our approach to the food system sees food businesses as central actors, interacting with farmers and consumers as well as government through the exchange of goods and services, financial transactions, and the use of natural resources and labor. Innovation and investment in these food businesses offers consumers a broader diversity of food at more stable prices than would be possible using only local production that varies with climatic and agroecological conditions. Growth of food businesses is also the sector's primary form of job growth that contributes to each region's overall economic activity, driven by innovation and adoption of new techniques that improve efficiency, reducing input use in meeting consumer demand (Reardon and Vos 2021).

New teaching materials that focus on the interaction between public policy and private enterprises shows how innovation can save natural resources and improve sustainability, while also improving public health and wellbeing. The private sector can facilitate the commercialization and dissemination of agricultural and food innovations, but access to modern technologies for farmers around the world is still unequal and the technological advancements require the right policy environment to succeed (Nagarajan, Naseem and Pray 2019). Private companies can help increase food production, reduce environmental impact, and support the livelihoods of millions of farmers globally, but incentives need to be in place to facilitate this and address problematic market concentration (Alston and Pardey 2021).

Understanding the private sector's role in food systems involves recognizing its relationship with government policies and global markets, driven by the flow of cost-reducing new technologies that create economic value for adopters as shown for example in China by Deng et. al (2021), and globally by Fuglie and Echeverria (2024). Only some of the value created by new technologies can be captured by the seller, with the degree of value capture and hence incentives for innovation depending on both the inherent difficulty for free-riders to benefit, and also the creation and enforcement of intellectual property rights as shown by Ferrari, da Silveira and Dal-Poz (2021). When returns to research cannot be captured through product sales, tax revenue can be used instead, but public funding is politically and administratively difficult to sustain especially for international research as shown by Lynam, Byerlee and Moock (2024). Government interventions, such as subsidies, taxes, and direct regulations, significantly influence the activities and performance of private sector entities, and lead companies to invest heavily in efforts to influence

policy even in low and middle-income countries, as shown for a public health example by Mialon et al. 2021). Through strategic partnerships and investments, private companies can also support infrastructure development, such as transportation networks and storage facilities, which are crucial for the smooth functioning of global agricultural trade. In any of these areas, students should find that small changes can lead to great improvements if the incentives and regulations are aligned.

Teaching food economics to students with diverse backgrounds and different skill levels

The teaching materials described in this chapter aim to serve diverse students whose backgrounds and career interests often lie outside of agriculture, in nutrition and health sciences, environmental studies and natural sciences, or business and policy studies. Some students come to food economics with high-level insights and skills developed in their primary fields, while others come with less advanced preparation. This diversity of backgrounds and levels calls for a textbook and teaching materials that provide a gentle introduction to insights normally taught only after several semesters of graduate study. Our materials are built to be skimmed quickly, allowing a student to jump around and have an accessible window into each topic, while also offering depth for those students who can devote more time and attention to their reading. Our goal is a textbook that can be used over the range of programs needed to reach current and future students including adult learners and midcareer professionals seeking micro-credentials (Nayga et al. 2024).

To provide a gentle introduction to economic principles that leads to deeper insights we represent all of economic theory in two-dimensional diagrams. These simplest possible models can be solved visually for points of tangency to capture the optimization used to explain each individual person's choices, and points of intersection to capture the equilibrium among optimizing individuals. To help students get started using these diagrams to their full potential, we standardize the notation so that quantities for the thing of interest are along the horizontal axis, as Q_x, and the vertical axis can show the aggregate quantity of all other goods and services (for individual choices) or the price of X in terms of all other goods and services (for market outcomes).

For students who want only a quick introduction to economics, being able to sketch and interpret even the simplest of our analytical diagrams is a powerful skill. For students who spend more time with each diagram, they can use two-dimensional geometry to gain insights that are normally taught only with multivariate calculus and real analysis. Throughout the book, the use of each line, curve and point or area on the diagrams is taught using real-world examples from agriculture, food and health. In our courses, weekly exercises and exams have students match each type of diagram to news stories about that situation in real life. In the weekly exercises, students find news stories that would illustrate each week's diagrams (for example, finding news stories about monopolies and monopsonies after the class session on market power), and in the exams students are given a news story for which they must draw the relevant diagram. This matching of news to diagrams helps build students' ability to visualize and explain economic phenomena and give students agency in terms of searching for and writing about stories that interest them (Wilson 2023).

The book explains economic principles and describes the food system using only two-dimensional analytical diagrams and data visualizations. Students can understand these pictures using elementary concepts of analytical geometry, without any algebra or calculus. They also learn how to describe patterns in the data in words, without any statistics or hypothesis testing. To help students understand figures quickly we adopt standardized notation and approach to data visualization.

Most of our interest concerns how food systems change with development, so we almost always put either time or income along the horizontal axis. We also avoid cherry-picking by showing all available data. This helps students learn to find, organize, and make charts with authoritative data sources about the food system, and thereby build computational skills. Data visualization assignments involve using data sources such as the USDA Economic Research Service, Federal Reserve Economic Data, World Bank Open Data, and FAOSTAT. These assignments help students develop competency in data analysis and interpretation, making complex information accessible and understandable. Instructors in different settings must tailor these assignments to the distribution of skills in the class.

Course design for the era of generative artificial intelligence

The analytical skills developed in the course are intended to help students in the age of software tools based on generative pretrained transformers such as ChatGPT. These artificial intelligence tools are "generative" in the sense that they create original content in response to the chat prompt, using "pretrained transformers" designed to return the probability that a particular element will occur adjacent to other elements in the training data that are semantically related to the prompt. This allows the software to respond with newly created original content that is usually plausible, similar but different from the training data, like an approximate average of what's been done before. Generative AI creates content by imitation, augmented by randomness in its responses. The textbook and course materials focus on what AI lacks, which is human judgment about right and wrong using theories about cause and effect as well as subjective valuation of alternative outcomes.

Our first week's warm-up exercise is called "keeping up with AI", designed to help students use AI tools successfully and see more clearly the kind of human intelligence they can build in our course. In this opening homework assignment, we ask students to use ChatGPT or similar service to generate three kinds of output: a paragraph of text with academic citations, a table of data, and an image, all regarding any aspect of the food system of interest to them. We also ask students to experiment with their prompts that try to make AI-generated content illustrate three typical errors:
(1) content that is factually incorrect, commonly known as the generative AI's hallucinations,
(2) content that is logically inconsistent, when the generative AI contradicts itself, and
(3) content that is undesirable, given human values and preferences.

Typical examples of AI output that students can see is superficially plausible but wrong include academic citations to non-existent publications, or tables that include some made-up data. Those arise because ChatGPT is not (yet) designed to validate answers with exact information from authoritative specific sources. Statements that show ChatGPT's lack of logical consistency include references to how much gluten is in gluten-free bread, or similar lack of ability to validate answers against formal definitions and logical rules. Examples of undesirable output includes some of the images drawn by generative AI when asked to draw people, thereby revealing that it lacks a conscience or ability to see how the image might be misinterpreted or misused. These three kinds of mistakes reveal how generative AI is designed to create original content that remixes its training data into plausible but not necessarily correct responses to each prompt, requiring a separate step to distinguish between right and wrong.

The human intelligence needed to keep up with AI is among the core competencies to be taught in higher education today (Naumova 2024). Our "keeping up with AI" exercise is useful because it

shows clearly the kind of skills that students will need to succeed in an era when anyone can use AI to generate plausible-looking content. To keep up with AI, students need to build their skills at fact-checking, verifying whether statements are logically consistent, and assessing whether something is desirable for people. The course then focuses on precisely that, using economic principles to explain, predict and evaluate events. To practice using economic principles, students must match each news story to the corresponding economic model, drawing the appropriate kind of analytical diagram to show the causes and effects of change. Then to describe the food system in the U.S. and globally, students must take downloaded data and use Excel to make tables, scatterplots, line graphs and bar charts that show the magnitudes of differences and changes over time. For each exercise students write brief descriptions of their analytical diagrams and data visualizations, thereby learning to explain the logic of economics in plain English.

The textbook and our course activities are intentionally designed around human skills that generative AI cannot yet be made to do. Logical structures that represent human values and understanding of cause and effect are increasingly being imposed as guardrails on AI software tools. As AI tools evolve, they will become more accurate and useful, but only in the ways and to the extent that human programmers have imposed their own understanding and preferences on the software. The content of our Food Economics book and related courses aim to teach higher-level skills that software companies do not yet provide. We and other instructors will need to continue developing new course materials to help students keep up with AI, just as farmers and other professionals learn the skills needed to use all other kinds of new technology.

Sequence of topics and terminology for teaching food economics

The course materials described here are taught quickly in a single semester, with careful sequencing so that concepts are introduced only when needed to address the next topic. When used in this way, students can skim the book to see the material from class in a broader context. The first half of the book corresponds to economic principles shown using analytical diagrams, while the second half describes the food system using data visualization of observations that could potentially be explained, predicted and assessed using economic models. Each chapter is divided into two sections, for ease of aligning readings over with class sessions over a standard semester. The entire book could also be taught in greater depth as a two-semester sequence, or subsets of the book can be used for courses on specific topics. In the table below, we present the full list of chapters and the main sections within each chapter.

Table 1. Topics covered in *Food Economics*

Chapter title and section heading

1. **Introduction**
    - *1.1 From farming to eating, research and teaching*
    - *1.2 Why study food through economics, and economics through food?*
2. **Individual choices**: Explaining food consumption and production
    - *2.1 Consumer choices: Food preferences and dietary intake*
    - *2.2 Producer choices: Agriculture and food manufacturing*
3. **Societal outcomes**: Predicting food market prices and quantities
    - *3.1 Market equilibrium with perfectly competitive interactions*
    - *3.2 Market elasticities: Measuring how people respond to change*
4. **Social welfare**: Evaluating change in food markets
    - *4.1 Economic surplus: Who gains from market transactions?*
    - *4.2 Externalities: Unintended side effects of market activity*
5. **Market power**: Imperfect competition and strategic behavior
    - *5.1 Monopoly and monopsony: When one seller or buyer sets total quantity*
    - *5.2 Strategic behavior: Game theory for two-person interactions*
6. **Collective action**: Government policies and programs
    - *6.1 Public goods and social choice: Property rights, taxes and subsidies*
    - *6.2 Cost-effectiveness and nonmarket goals in food and agriculture*
7. **Poverty and risk**: Variation among people and over time
    - *7.1 Inequality, inequity and disparities in agriculture and nutrition*
    - *7.2 Vulnerability, resilience, and safety nets in the food system*
8. **Food and health**: Behavioral economics and response to intervention
    - *8.1 Behavioral economics of food choices for future health*
    - *8.2 Interventions for behavior change*
9. **Food in the macroeconomy**: The whole is more than the sum of its parts
    - *9.1 National income and the circular flow of goods and services*
    - *9.2 Recessions and unemployment, with links to food jobs and the social safety net*
10. **International development**: Systemic change over time
    - *10.1 Agricultural transformation: Demography, urbanization and farm size*
    - *10.2 Food systems and dietary transition: From inadequacy to excess and health*
11. **International trade and value chains**: From local to global
    - *11.1 How trade and policies link local markets to global food systems*
    - *11.2 Value chains, social accounting and institutions in the food system*
12. **The future of food**: Meeting human needs with systemic change
    - *12.1 Agribusiness and agroecology: The environment, climate, and resources*
    - *12.2 Nutrition and health: Food environments, retail markets, and diet quality*

Source: Masters, W.A. and A.B. Finaret (2024), *Food Economics: Agriculture, Nutrition, and Health*. Cham: Palgrave Macmillan. Open access, at https://bit.ly/FoodEconBook

The structure of *Food Economics* as shown in Table 1 is designed so the casual reader can skip around to find topics of interest to them. At each place in the book readers can see how that topic is presented and explained using economic principles, real-life examples and food system data, with references back to building blocks presented earlier in the text. Readers can also begin from a standing start on page 1, and skim the book lightly or read more slowly, depending on how much time and attention they can devote to the subject. Our courses cover the entire book in sequence, but an entire semester could be devoted to economic principles in the first half (chapters 1-6), followed by an entire semester on food system data using the second half (chapters 7-12).

The book and associated teaching materials could also be used for more topical courses. For example, a class on agricultural production and agribusiness could teach chapters 1-3, then chapter 5, and chapters 10-12, thereby skipping material on social welfare, poverty and risk, food and health, and macroeconomics so as to concentrate on natural resource management, productivity and induced innovation**.** Courses that focus on food and health could teach chapters 1-3, then 5, then 7-8, 10 and 12, thereby skipping material on social welfare, collective action, macroeconomics and international trade, so as to concentrate on drivers of food choice and diet quality, including income, prices and preferences. In each case, there would be some use of the analytical diagrams and economic principles from chapters 1-6, and some use of the food system data and written descriptions from chapters 7-12.

Teaching about agricultural technologies and the private sector in food economics

A distinctive feature of the Food Economics book is teaching about the interaction between agroecosystems, agricultural technologies, and induced innovation over time. We begin by observing that human food systems are no longer primarily a flow of produce directly from farmers to consumers. Instead, we see agribusinesses whose supply of inputs to farmers is designed to yield specific varieties with valuable attributes, and businesses that buy farm outputs for onward sale as packaged and processed items or prepared meals and food service. Our book and teaching materials aim to help students make sense of these food value chains, in terms of geographic specialization and sourcing from farms in producing regions, transport through terminal markets, and onward distribution to geographically dispersed consumers. Students then gain familiarity with the technologies and marketing arrangements that led to these value chains, including the role of financial markets in transmitting price forecasts for almost all traded agricultural commodities.

A value chain approach differentiates the functions performed at various stages of food production and by several different types of enterprises, providing insight into the logistics and value addition process from origin to destination. One distinctive feature of our approach is to show that each value chain is part of an interconnected web where goods and services flow from upstream sources to downstream destinations, with value added through transportation, storage, handling, processing, and packaging. When an existing value chain is disrupted, for example by bilateral tariffs that limit trade between the U.S. and China, goods are rerouted to other destinations and brought from different sources, so that the ultimate cost difference is somewhat more expensive transportation and transaction costs. Many other aspects of the institutions, regulatory frameworks and organizational structures as well as informal norms and practices are important and can help students work in or with the private sector in the food system.

The Food Economics textbook shows how each food value chain is linked to its larger context, through transport and storage as well as processing and marketing. The book shows how

international trade can help stabilize local markets by diversifying food sources, while leading each location to experience the synchronized price spikes experienced in global commodity markets. The governmental responses to trade pressures should also be included in any module about international trade, examining how agricultural trade policies are balanced with domestic concerns to manage their impacts on both producers and consumers.

In this and other texts, international trade is taught in the context of economic growth, structural transformation and development. Growth and change is taught through the interconnected dynamics of demography, urbanization, agriculture, nutrition, and health, emphasizing recent evidence on the gradual and multidimensional nature of development over time (Gollin and Kaboski 2023). These chapters of the textbook focus on shifts between sectors and transformation within agriculture associated with capital accumulation, involving investment in physical and human resources such as infrastructure, education, and technological innovation. We use long-term historical data from the U.S. and other countries as well as cross-country evidence to illustrate different trajectories of development, emphasizing how history, policy decisions, and external factors have shaped development paths. While development patterns can be generalized, each country's path is unique, shaped by its specific historical, cultural, and environmental contexts. Understanding these patterns and the underlying factors driving them is crucial for formulating effective development policies for sustainable and inclusive growth.

Teaching about nutrition and health in food economics

The Food Economics book's subtitle explicitly links agriculture to nutrition and health. This reflects the way that food supplies have changed over time, from basic staples and farm produce to more diverse and different diets whose nutritional value is often unknown and sometimes harmful for a person's future health. Changes in relative costs and consumer demand have driven a dietary transition among food groups towards more animal source products and vegetable oils, and a shift towards more processed and packaged foods as well as meals prepared away from home. That change in food choices is associated with a nutrition transition towards fewer deficiencies of essential micronutrients, and more excesses that cause diet-related illnesses such as hypertension, diabetes, and kidney disease, as well as unintended weight gain and obesity. Those changes in nutritional status are in turn embedded in a larger epidemiological transition in disease patterns, as medical success in combatting acute events and infectious disease leaves a greater role for chronic conditions and noncommunicable diseases in which diets play an important role.

Our focus on nutrition is helpful to understand how changes in agriculture and food systems affect human health and wellbeing, and the same analysis works in reverse to help explain consumer demand and market conditions facing farmers and agribusinesses. For both purposes the textbook builds on a recent *Handbook of Agricultural Economics* chapter that draws on hundreds of citations to summarize the latest available evidence on economic aspects of human nutrition (Masters, Finaret and Block 2022). That literature review shows how recent improvements in data collection and analysis, as well as changes in the food system itself, have revealed facts about food demand systems that were previously hidden from view.

One key fact about food choice discovered in recent years concerns demand for total calories consumed per person per day. Early studies of food demand found higher total quantities of food produced and sold at places and times with higher incomes and lower food prices, leading to

demand system estimates with relatively large and significant income and price elasticities of demand for total dietary energy. With more accurate measurement of dietary intake relative to other factors, we now know that income and price elasticities of total calories consumed are primarily due to variation in body size driven by experiences early in life, and by variation in the share of food that is discarded. Direct measurement of food loss and waste is extremely difficult, as shown by Boiteau and Pingali (2023), but indirect estimates suggest a high income elasticity of willingness to discard food as shown by Barrera and Hertel (2021).

Total dietary energy consumed each month is little affected by contemporaneous changes in price and income. Total calorie intake is instead guided by autonomous physiological mechanisms that align energy intake with energy needs, with each person's level of energy balance dictated by their person's height, weight and physical activity as well as pregnancy and breastfeeding status. Total energy intake is therefore determined by past events, with contemporaneous prices and incomes primarily affecting future heights and weights. Attained heights are affected primarily by conditions in utero and the first two years of infancy that trigger changes in bone length, and hence the degree to which a person attains their genetic potential for height. Body weight is also influenced by genetics as well as variation in diet composition that can trigger episodes of weight gain at any age, after which the person's new level of weight is maintained by hormonal signals and other autonomous mechanisms.

In the new understanding of energy metabolism reflected in our textbook, contemporaneous income and price elasticities of demand for total calorie intake per day are almost precisely zero, with almost all response occurring through changes in diet composition and spending on other goods and services. People adjust the mix of foods they eat and the other things they consume to maintain a body weight that was determined by past events, including impacts of long-ago prices and incomes that affected their growth trajectory earlier in life. Some of the most dramatic evidence for how autonomous processes dictate total intake of dietary energy comes from recent experience with GLP-1 medications such as Wegovy or Ozempic.

The use of GLP-1 medications has demonstrated clearly how human physiology determines a person's desire and willingness to eat, as these hormone agonists trigger involuntary responses that then lead to eating less and losing weight to a new, lower level of energy balance each day. Other drugs and medical conditions can have the opposite effect, increasing appetite and causing weight gain, further demonstrating how autonomous mechanisms regulate total energy intake and body weight. Meanwhile, even very large changes in prices or income are known to have almost no effect on energy balance. For example, when students move on to a fixed-price cafeteria meal the marginal cost of calories goes to zero, but for most students there is no change in total intake and body weight when they go on or off the meal plan, and in cases where intake does change it is often attributable to stress or other factors.

Having established the importance of each person's fixed calorie intake set by their height, weight and physical activity, the book and teaching materials address variation in diet composition and how those calories are supplied. We observe those patterns using a variety of data visualization techniques such as Preston curves, showing changes using scatter plots or line graphs with income or time on the horizontal axis. These charts show each kind of transition over time, and help explain changes in diet, nutritional status and disease prevalence alongside the rise and fall in population growth rates, size, and age structures, as well as sectoral composition of the economy from agriculture to services and industry.

Teaching about government regulation and the political economy of food

An important emphasis of the book is how the private and public sectors of the food economy are deeply intertwined. Governments establish the legal frameworks that allow private enterprises to operate, influencing market dynamics through policies and regulations. Governments define property rights, which significantly influences consumer and producer welfare and total economic surplus, as well as the overall distribution of incomes and wealth. Private enterprises, including commercial and nonprofit organizations, operate within these frameworks. Public policies are crafted through a political process that involves coalition-building, negotiation, and balancing diverse interests, and effective policies require understanding the costs and benefits to individuals and groups, as well as which groups are more likely to engage in collective action. These debates occur in a media landscape that amplifies messages tailored to specific audiences, adding to the complexity of modern political economy as shown for example by Ramaswami et al. (2022).

Students in food economics should become familiar with how governments use direct regulations, taxes, and subsidies to address market failures and achieve economic outcomes. When introducing the types of government intervention in the food system, we start with the standard two-by-two matrix defining four types of goods and services in the economy (private goods, public goods, common resources, and club goods), and use a variety of food system examples to describe the public sector's role in providing non-excludable goods, regulating markets, and ensuring equitable resource distribution to complement the private sector's role in market provision and innovation.

Understanding the economics of government regulation in the food system is crucial for those working in the private food sector because government regulations directly impact operational costs, market access, and competition. Regulations can dictate production standards, safety protocols, labelling requirements, and trade restrictions, all of which influence a private company's supply chain, pricing strategies, and product development. By grasping the economic rationale and implications of various food system policies, students and early career graduates can better navigate compliance, optimize their processes, innovate within regulatory frameworks, and plan for potential changes in policy. This knowledge not only ensures adherence to legal standards but also enhances the ability to anticipate and adapt to regulatory shifts, thereby maintaining market viability and competitive advantage.

For current and future food service professionals, understanding food economics can help with developing menus and menu pricing, cost control, and overall profitability. Knowledge of food economics helps food service professionals make informed decisions about sourcing ingredients, managing inventory, and setting prices that reflect both market conditions and consumer demand. Knowledge about food economics also aids in budgeting and financial planning, ensuring that operations remain sustainable and competitive. Additionally, understanding economic trends can guide menu design in the long-term as well as promotional strategies, allowing food service businesses to adapt to changing economic environments and consumer preferences.

Teaching about induced innovation, including towards climate resilience and sustainability

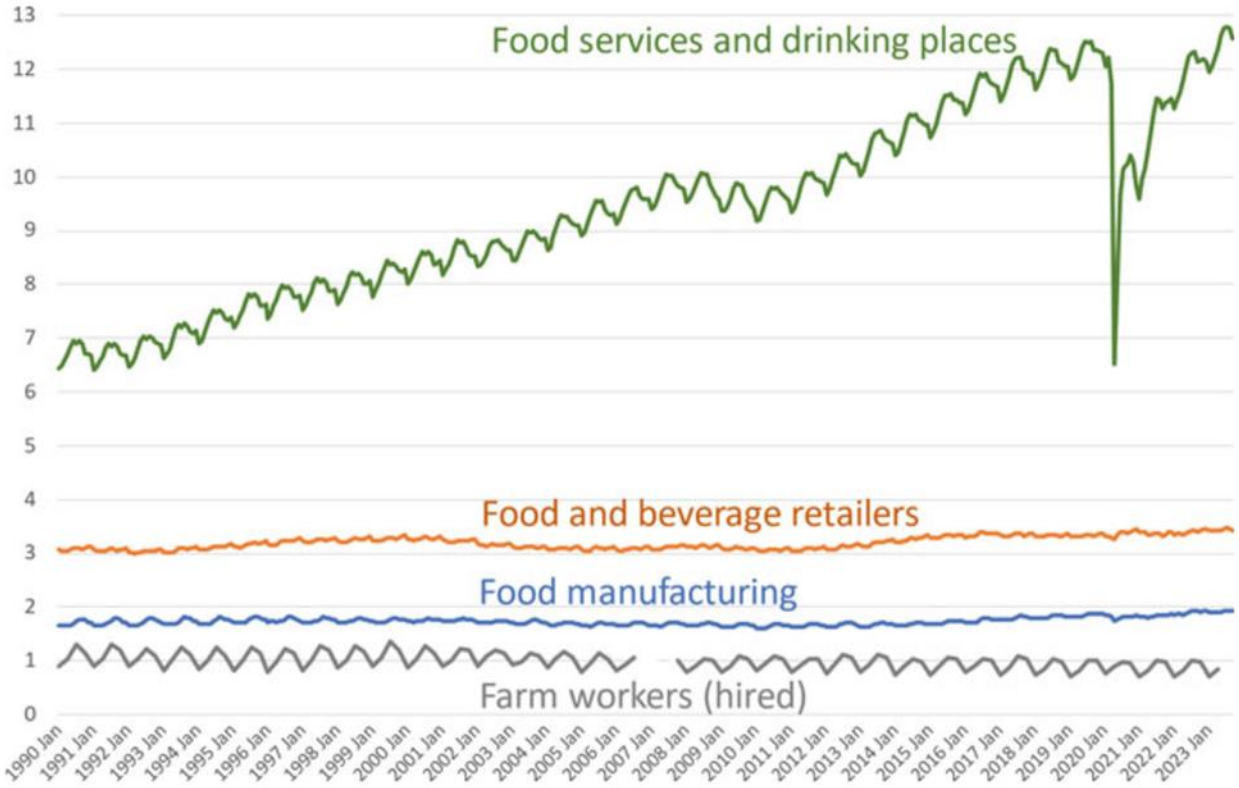
The direction of change for new production methods and food system technologies is explained in the book using the principle of induced innovation, by which incentives to invent and adopt new practices are driven by changes in the relative scarcity of their inputs and outputs. With no change in relative scarcity, people would invest in innovation at similar rates over all kinds of inputs and outputs, but changing relative prices creates an incentivize for people to use less and produce more of what is increasingly scarce. The main worldwide shift affecting agriculture and other sectors was towards increasing use of fossil fuels and other contributors to climate change throughout the 20th century, followed by a reversal towards decarbonization and climate resilience in recent years. Somewhat similar swings in the direction of innovation within specific regions include changes in the relative scarcity of land, labor and capital, as well as changes in demand for different food attributes. Induced innovation could also lead farmers to shift production towards attributes sought by different end users such as supermarket chains in India (Nuthalapati et al. 2020) and could also lead farmers to improve the nutritional value of crops to the extent that quality assurance allows those unseen traits to be rewarded in the marketplace (Huang et al. 2002).

Induced innovation sets the direction of change, but the speed with which new technologies are deployed depends on other factors including public investments and regulations. The Food Economics textbook uses a variety of examples and data visualizations to describe the speed and kind of innovations affecting agriculture and nutrition. These include developing new crop varieties and livestock breeds, agronomic techniques to manage soil nutrients and moisture such as precision farming, mechanization to change the area of land that one farmer can manage, and the many applications of digital agriculture (Birner et al. 2021). Focusing on induced innovation helps explain and predict the kind of new technologies that are most likely to be successful and provide insights into the distributional and environmental effects of those innovations, thereby helping students respond to the rapid changes they are likely to face throughout their careers.

Changing employment trends faced by students

An important aspect of the book is to help students learn the knowledge and skills needed for professional success in careers related to agriculture, food and nutrition. Technological change including generative AI ensures that job descriptions will change dramatically over time, with a smaller role for some tasks and the introduction of entirely new activities and positions. The knowledge and skills taught in the book focus on fundamentals that are unlikely to change, and the book also includes useful descriptions of the food sector's employment trends as shown in the book's Figure 9.11 in the book, reproduced as Figure 1 here:

Figure 1. Farm and food system employment in the U.S., January 1990–September2023



Source: Authors' chart of USDA and BLS data, shown as millions of workers by month for food sector employment and seasonally in January, April, July and October for hired farm workers. Food employment is from U.S. Bureau of Labor Statistics, Current Employment Statistics survey, not seasonally adjusted. Updated data are at https://www.bls.gov/ces/data/employment-situation-table-download.htm. Farm data are from USDA National Agricultural Statistics Service, Farm Labor Survey and includes only hired workers [not self-employed or unpaid]. Data for July 2007 are missing. Updated values are at https://www.nass.usda.gov/Surveys/Guide_to_NASS_Surveys/Farm_Labor

The central idea of Figure 1 is that employment trends within the food sector mirror trends in the macroeconomy, as rising productivity when making things drives a rising fraction of employment and earnings into service provision. Figure 1 also has the feature of showing persistent seasonality in food service and hired farm workers, but a declining degree of seasonality in food manufacturing, and fluctuations in food services associated with income growth and recessions. Beyond the crude numbers in Figure 1, the book includes more granular details about wages and job types, for example regarding the agribusiness services likely to provide farmers with techniques relating to data-intensive precision agriculture, sustainable intensification and climate resilience. Similarly in food manufacturing, employment is expected to include new roles involving computational biology, artificial intelligence, and robotics, addressing the growing emphasis on nutritional attributes, food safety, quality control, and traceability.

For food service professionals, the landscape will change as consumer preferences and dining habits evolve, influenced by factors such as convenience and demand for attributes associated with health and sustainability. Skills in related to digital technology, customer service, and culinary innovation will become increasingly valuable. Additionally, there will be a heightened focus on food

safety and hygiene standards, further shaping the roles and responsibilities within this sector. In all aspects of food there is likely to remain many jobs requiring intense and repetitive physical labor under harsh conditions, making equity among workers an important concern.

Conclusion: Food economics as an open-access resource for dialogue among diverse groups

We conclude this chapter by noting how the topic of food economics provides an unusual opportunity to discuss common ground between people, addressing the interplay between food producers and consumers, rural and urban places, private and public sectors, households and corporations among other interactions in the food system. Using economic principles to describe these interactions in terms of supply and demand provides some of the most vivid demonstrations of how differences among people lead to gains from trade. This topic allows students to discuss how all kinds of people contribute to the task of feeding each other, and to identify how they can help improve outcomes based on their specific situation. The topic of Food Economics also provides many opportunities for the pursuit of equity and justice, as described for example in a recent presidential address for the Agricultural and Applied Economics Association (Wilson 2023).

Access to our Food Economics book has been greatly aided by publishing it on an open-access basis, thanks to project funding from the Bill & Melinda Gates Foundation through the UK-based Agriculture, Nutrition and Health Academy (ANH Academy 2024). Choosing open-access publication means foregoing royalties, in addition to having the Gates Foundation pay the publisher about $20,000 for publication services, in exchange for which we can reach a much larger audience especially in Africa and Asia.

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Our hope is that open-access publication will facilitate adoption for class use, and help the casual reader find and browse the book. The text and figures are intended to provide a gentle introduction to many different aspects of food economics, leading quickly to in-depth analysis of a type that can promote understanding and dialogue about agriculture, nutrition and health around the world.

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