MEASURING THE ECONOMIC VALUE OF RESEARCH

The Case of Food Safety

The scientific advances that underpin economic growth and human health would not be possible without research investments. Yet demonstrating the impact of research programs is a challenge, especially in areas that span disciplines and industrial sectors and encompass both public and private sector activity. All areas of research are under pressure to demonstrate benefits from federal funding of research. This exciting and innovative study demonstrates new methods and tools to trace the impact of federal research funding on the structure of research and the subsequent economic activities of funded researchers. The case study is food safety research, which is critical to avoiding outbreaks of disease. The authors make use of an extraordinary new data infrastructure and apply new techniques in text analysis. Focusing on the impact of US federal food safety research, this book develops vital data-intensive methodologies that have a real-world application to many other scientific fields.

Kaye Husbands Fealing is Chair of the School of Public Policy at the Georgia Institute of Technology in Atlanta, GA. She was inaugural director of the National Science Foundation's Science of Science and Innovation Policy program and study director at the National Academy of Sciences. She serves on the executive board of the American Association for the Advancement of Science and is an elected distinguished AAAS Fellow.

Julia I. Lane is a professor at the New York University Wagner Graduate School of Public Service and at the NYU Center for Urban Science and Progress, and a Provostial Fellow for Innovation Analytics. She has published more than 70 articles in leading economics journals, and authored or edited 10 books. She is an elected fellow of the American Statistical Association, the International Statistical Institute, and the American Association for the Advancement of Science.

John L. King is an economist and researcher in innovation and science policy. During a 15-year career at the US Department of Agriculture Economic Research Service and Office of the Chief Scientist, his research has examined intellectual property, industry structure, and research impacts, in both the food and agriculture sector and more broadly. He is currently Director of Analysis and Policy (Graduate Studies) at the University of California, Davis.

Stanley R. Johnson is Distinguished Professor of Economics–Emeritus at Iowa State University, Ames, IA, and Assistant to the Dean for Special Projects in the College of Agriculture, Biotechnology, and Natural Resources at the University of Nevada, Reno. He also serves as Chair of the Board of Directors of the National Center for Food and Agricultural Policy, Washington, DC.

Measuring the Economic Value of Research

The Case of Food Safety

Edited by

KAYE HUSBANDS FEALING
Georgia Institute of Technology

JULIA I. LANE
New York University

JOHN L. KING
University of California, Davis

STANLEY R. JOHNSON
University of Nevada, Reno

CAMBRIDGE UNIVERSITY PRESS

CAMBRIDGE
UNIVERSITY PRESS

University Printing House, Cambridge CB2 8BS, United Kingdom

One Liberty Plaza, 20th Floor, New York, NY 10006, USA

477 Williamstown Road, Port Melbourne, VIC 3207, Australia

314–321, 3rd Floor, Plot 3, Splendor Forum, Jasola District Centre, New Delhi – 110025, India

79 Anson Road, #06–04/06, Singapore 079906

Cambridge University Press is part of the University of Cambridge.

It furthers the University's mission by disseminating knowledge in the pursuit of education, learning, and research at the highest international levels of excellence.

www.cambridge.org
Information on this title: www.cambridge.org/9781107159693
DOI: 10.1017/9781316671788.

First published 2018

Printed in the United States of America by Sheridan Books, Inc.

A catalogue record for this publication is available from the British Library.

ISBN 978-1-107-15969-3 Hardback
ISBN 978-1-316-61241-5 Paperback

To John H. Marburger III

Contents

Figures

Tables

Contributors

Nathan Goldschlag is a senior economist at the Center for Economic Studies at the Census Bureau. He received his PhD from George Mason University. His research focuses on innovation, technological change, and business dynamism. He oversees a number of efforts to build new data resources by creating novel linkages between administrative and survey data.

Kaye Husbands Fealing is Chair of the School of Public Policy at the Georgia Institute of Technology, Atlanta, GA. She has served as inaugural director of the National Science Foundation's (NSF) Science of Science and Innovation Policy program; study director at the National Academy of Sciences; executive board member of the American Association for the Advancement of Science (AAAS); and committee member for American Economic Association, Council of Canadian Academies, National Academies, National Advisory General Medical Science Council, and NSF. She was elected AAAS Distinguished Fellow and has earned distinctions for outstanding teaching. She holds a PhD in economics from Harvard University.

Akina Ikudo is a doctoral student in economics at the University of California, Los Angeles (UCLA). She is a microeconomic theorist with research interests in mechanism design, game theory, and decision theory. Prior to joining UCLA, she was a modeling analyst at American Electric Power in Columbus, OH. She holds an MA in economics from UCLA and a BS in mathematics, an MAS in applied statistics, and an MS in industrial engineering from Ohio State University.

Lee-Ann Jaykus is an expert in microbiological food safety, with emphasis on food virology and microbial risk assessment. Her professional activities include the National Advisory Committee on Microbiological Criteria for Foods, various National Academy of Sciences panels, and the executive board (president, 2010–2011) of the International Association for Food Protection (IAFP). She is recipient of the North Carolina State University Alexander Quarles Holladay Medal for Excellence, IAFP Maurice Weber Laboratorian Award, and NSF Food Safety Leadership Award. Dr. Jaykus has taught food microbiology/safety for over 20 years, mentored 60 graduate students and postdocs, and authored more than 170 publications.

Stanley R. Johnson is Distinguished Professor of Economics–Emeritus at Iowa State University, Ames, IA, where he served as director of the Center for Agricultural and Rural Development (CARD) and Vice Provost for Extension. He has published widely in econometrics, food, and agricultural and environmental policy and advised hundreds of PhD students. He is a Fellow of the American Agricultural Economics Association (AAEA) and has earned numerous appointments to academies of science around the world, outstanding article awards, and Doctor Honoris Causa appointments. He chairs the Board of Directors of the National Center for Food and Agricultural Policy (NCFAP) in Washington, DC.

Yeong Jae Kim is a senior research associate at the Tyndall Center for Climate Change Research, Norwich, UK, whose research focuses on energy economics and innovation. He joined the Tyndall Center after completing his PhD at the School of Public Policy at Georgia Tech in 2017. As a graduate research assistant at Georgia Tech, he applied some of the quantitative methods he learned on how to use patent data in his dissertation. He is also a member of the Climate and Energy Policy Laboratory. He has an MS in agricultural economics from Texas A&M University and a BA from Hanyang University.

John L. King researches science policy and innovation. As an economist at the US Department of Agriculture (USDA) Economic Research Service and senior advisor/acting director in the Office of the Chief Scientist, he examined intellectual property, industry structure, and research impacts in food and agriculture. He participated in several Office of Science and Technology Policy initiatives to quantify impacts and enhance science

policy, including STAR METRICS, the Science of Science Policy, and federal policy on open access to publications and data. Currently he is Graduate Studies Director of Analysis and Policy at the University of California, Davis. He received his PhD from Vanderbilt University.

Evgeny Klochikhin is senior data scientist and researcher with the American Institutes for Research, Washington, DC. He provides expertise to projects in several countries, with responsibilities including data collection, database development, and visualization. He contributes to the development of innovative methods of evidence-based policy and evaluation using advanced data science, computational techniques, text mining, and Big Data analysis. He co-leads the PatentsView project funded by the US Patent and Trademark Office. Dr. Klochikhin holds a PhD in public policy and management from the University of Manchester, UK, and has published in *Research Policy, Review of Policy Research*, and elsewhere.

Julia I. Lane is a professor at the New York University Wagner Graduate School of Public Service and at the NYU Center for Urban Science and Progress, and a Provostial Fellow for Innovation Analytics. She co-founded the UMETRICS and STAR METRICS programs at the National Science Foundation, and led the creation and permanent establishment of the Longitudinal Employer-Household Dynamics Program at the US Census Bureau. She has published more than 70 articles and authored or edited 10 books. She is an elected Fellow of the American Association for the Advancement of Science, Fellow of the American Statistical Association, and recipient of the Julius Shiskin and Roger Herriot awards.

Jason Owen-Smith is a sociologist who examines how science, commerce, and the law cohere and conflict in contemporary societies and economies. He works on projects that examine the dynamics of high-technology industries, the public value of the research university, and the network organization of surgical care. He is the Barger Leadership Institute Professor of Organizational Studies, Professor of sociology, Research Professor in the Institute for Social Research (ISR) Survey Research Center (CRC) at the University of Michigan, Ann Arbor, MI, and Executive Director of the Institute for Research on Innovation and Science (IRIS). He has received numerous awards for research and scholarship.

Matthew B. Ross is a postdoctoral scholar in the economics department at Ohio State University, Columbus, OH. His research uses tools from applied microeconomics and machine learning to investigate policy relevant questions from the fields of labor and public economics as well as the economics of innovation. He received his PhD in economics from the University of Connecticut.

Reza Sattari is a postdoctoral researcher in the department of economics at Ohio State University, Columbus, OH. He completed his PhD in economics at Simon Fraser University in Canada. His doctoral research evaluated the impact of various early childhood education policies on the development of cognitive and non-cognitive skills among young students. Reza is also affiliated with the Center for Education Research and Policy (CERP). He is generally interested in applying modern econometric methods and techniques to evaluate the effects of policy interventions in a variety of contexts that have direct implications for society.

Laurian Unnevehr is Professor Emerita in the Department of Agricultural and Consumer Economics at the University of Illinois. She has also held positions at the USDA's Economic Research Service, the International Food Policy Research Institute, and the International Rice Research Institute. She is a Fellow of the Agricultural and Applied Economics Association (AAEA), recognized for original contributions in the economics of food policy and demand. She received her PhD from the Food Research Institute, Stanford University, and her B.A. in economics from the University of California at Davis.

Bruce A. Weinberg is Professor of Economics and Public Administration at Ohio State University, Columbus, OH. His research spans the economics of creativity and innovation, determinants of youth outcomes and behavior, and technological change. He is an Institute for Labor (IZA) Research Fellow, National Bureau of Economic Research Research Associate, and associate editor of *Regional Science and Urban Economics* and the *New Palgrave Dictionary of Economics*. He has received support from the Federal Reserve Bank of Cleveland, the National Institutes of Health, the National Science Foundation, and the Kauffman, Sloan, and Templeton Foundations. He received his PhD from the University of Chicago.

Chia-Hsuan Yang is a research scientist at the New York University Center of Urban Science and Progress. She is an accomplished data scientist with expertise in research design, problem identification, econometrics, data analysis, record linkage, and machine learning. She has a PhD and MSc in engineering and public policy from Carnegie Mellon University and an MSc and BSc in computer science from National Tsing Hua University. Her research interests include economics of innovation, science and technology policy, and national innovation systems. Dr. Chia-Hsuan Yang has published articles on dormant IP licensing opportunities and impacts of offshoring on technology trajectories of global firms.

Nikolas Zolas is an economist with the Center for Economic Studies at the US Census Bureau. Nikolas started at the Census Bureau in 2012 after completing his PhD in economics from the University of California at Davis. Prior to receiving his PhD, he worked for UBS Investment Bank and started a non-profit corporation. Nikolas received his bachelor's degree from Rice University in 2003. Zolas's research interests are in innovation, technology transfer, intellectual property, and international trade. He has published papers in *Science*, *Research Policy*, and *World Economy*.

Foreword

The safety of food marketed to the public and promoting science for the public good have been concerns of local, state, and the federal government in the United States for a very long time. Safe food is essential to good health, as are clean air and water. The public cannot by sight, smell, or taste determine if food is safe, and unsafe food can spread disease and lead to debilitating illness and sometimes death. Hence, government has a role in assuring that food producers, processors, and retailers do what they can to deliver a safe product to consumers.

Creating the conditions conducive to science and economic growth was seen by the Founding Fathers as a role for the federal government. Its importance is underscored by its prominent placement in the US Constitution. Article 1 stipulates that Congress has the authority "to promote the Progress of Science and useful Arts, by securing for limited Times to Authors and Inventors the exclusive Right to their respective Writings and Discoveries." A century later as the United States was entering the Civil War, Congress enacted a series of laws to promote science. In 1862, Congress created the Department of Agriculture and assigned in the preamble of the Act "the general designs and duties of which shall be to acquire and to diffuse among the people of the United States useful information on subjects connected with agriculture in the most general and comprehensive sense of that word, and to procure, propagate, and distribute among the people new and valuable seeds and plants." That same year, Congress passed the Morrill Act, which established a Land Grant University in each state dedicated to "teach such branches of learning as are related to agriculture and the mechanic arts, in such manner as the legislatures of the States may respectively prescribe, in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions in life." The following year, the National Academy

of Sciences was created through an act of Congress to "whenever called upon by any department of the Government, investigate, examine, experiment, and report upon any subject of science or art." In its early years, the federal government repeatedly asked the new National Academy of Sciences to provide advice on food-related questions, especially ones related to weights and measures and how to determine the sugar composition of foods.

Fast forward to today, and both these topics – food safety and government's role in sponsoring scientific research – are still current concerns. There is a resurgent public interest in food safety. A foodborne outbreak of the past might have affected the attendees at the local church social, but today, due to the volume of production and rapid national and international distribution of food, a foodborne outbreak can affect hundreds or even thousands of people in multiple locations. Unlike measles, mumps, and other infectious diseases of childhood, there is no vaccine to protect a child from the common foodborne pathogenic bacteria and viruses. And the public is increasingly weighing in on concerns about other aspects of modern agriculture and the science of genetic engineering of food.

Public attention to accountability in government extends to the agencies that conduct and sponsor scientific research. Congress has stepped up its oversight of the science agencies through hearings and additional reporting requirements. Since passage of the Government Performance and Results Act of 1993 (GPRA), science agencies (along with all federal agencies) must set goals, measure results, and report annually on their progress. This scrutiny along with GPRA's legal requirements has led the federal science agencies to seek new ways to measure and evaluate the impact of their research programs on the economy, on health, and on other issues of public importance.

From the beginning, the science agencies struggled to find meaningful short-term and medium-term metrics for the impacts of their research investments that could be reported to Congress. The ways in which the scientific community evaluated research productivity – through numbers of publications, citation indexes, patents, awards, and other recognitions – met with little understanding in Congress and the public. Stories that related how research by multiple performers contributed to some public good were better received; for example, more milk is produced in the United States today with fewer cows than 40 years ago due to improved genetics, better nutrition, and advances in veterinary medicine, which can be attributed to a combination of specific breakthroughs from publicly and privately funded research.

In 2005, Dr. John Marburger III (who was then Science Advisor to President Bush) sought to bring research to bear on this problem and challenged the federal science agencies to develop a science of science policy. One result of his challenge was the establishment of a database of federally funded research grants called STAR METRICS (Science and Technology for America's Reinvestment: Measuring the Effect of Research on Innovation, Competitiveness and Science). When I joined the USDA as Chief Scientist in 2010, we were not yet contributors to this effort, but soon did join with NSF, NIH, and other federal science agencies.

Which leads us to this book. It explores the intersection of these two topics – food safety and accountability in science – and uses newly available data and new analytical techniques to provide insights into how the federal government's investment in food safety research is paying off. The research reported here would not have been possible without the work over the past decade on the science of science policy conducted by the science agencies and academic researchers, and I'm pleased to see that USDA's data coupled to NSF and NIH data provides the basis for this analysis of food safety research. The authors explore a variety of topics from the demographics of the food safety research workforce, to early career outcomes, patenting activity, and bibliometrics. The analytical approach illustrated here bodes well for the scientific community's future ability to communicate to the public the value of the research investment in food safety and other areas of science.

Catherine E. Woteki, PhD
Former Chief Scientist and Under Secretary
for Research, Education and Economics
US Department of Agriculture

Acknowledgments

This book both begins and ends with quotes from the late Jack Marburger, the father of the field of science of science policy. He provided the impetus for the establishment of the Science of Science and Innovation Policy (SciSIP) program at the National Science Foundation – Kaye Husbands Fealing was the inaugural program officer, and Julia I. Lane was the second. He also established the Interagency Working Group on Science of Science Policy on which Kaye Husbands Fealing, John L. King, and Julia I. Lane served. His vision, elucidated in many writings as well as the *Science of Science Policy Handbook* that was co-edited with Husbands Fealing and Lane, was that scientific empirical evidence, rather than advocacy, should be the basis for research investments.

The data infrastructure upon which much of this book is based is the result of much hard work by many people. The initial impetus was to respond to Office of Management and Budget and congressional imperatives to report the economic impact of the 2009 stimulus funding. The Federal Demonstration Partnership, under the leadership of Susan Sedwick, Cindy Hope, and Dick Seligman, supported both the development of the proof of concept pilot and the resulting program, STAR METRICS (Science and Technology for America's Reinvestment: Measuring the Effects of Research on Innovation, Competitiveness and Science). The federal support was provided by participants in the Interagency Working Group White House (Office of Science and Technology Policy), the National Science Foundation, the National Institutes of Health, the US Department of Agriculture, and the Environmental Protection Administration. The 2012 transfer of the program to a university-led activity was initiated by Roy Weiss at the University of Chicago and Barbara McFadden Allen at the Committee on Institutional Cooperation. The successful launch of UMETRICS (Universities Measuring the Effects of Research on

Innovation, Competitiveness and Science) was led by Jason Owen-Smith at the University of Michigan, Bruce Weinberg at Ohio State University, and Julia I. Lane at New York University, with the active help and support of Toby Smith from the American Association of Universities, Carol Whitacre of Ohio State University, and Jay Walsh at Northwestern University. The links to Census Bureau data were made possible by the vision of Ron Jarmin and Nancy Potok, to US Patent and Trademark Office data by Stuart Graham and Alan Marco. The links to dissertation data were generously provided by a license agreement with Proquest. Several program officers – notably Danny Goroff of the Alfred P. Sloan Foundation, Earnestine Psalmonds and Nimmi Kannakutty of the National Science Foundation, Robbin Shoemaker of the US Department of Agriculture, and E. J. Reedy of the Ewing Marion Kauffman Foundation – were critical to providing the initial grants that made the program possible.

We owe a great debt of gratitude to Sandra Hoffman, whose deep knowledge of food safety research provided invaluable guidance. She also greatly contributed to the organization of the expert workshop that brought together individuals with many different perspectives on the field. We also received excellent comments from three reviewers: Helen Jensen, Francesca Nelson, and Per Pinstrup Anderson. John Cuffe, of the US Census Bureau, also provided very thoughtful suggestions and input, as did participants at seminars at the American Association for Agricultural Economics and the Center for Economic Studies at the US Census Bureau. We thank Cameron Conrad, Ahmad Emad, Christina Jones, Andrew Hanus, and Wei Cheng for research assistance; Greg Carr, Marietta Harrison, David Mayo, Mark Sweet, Jeff Van Horn, and Stephanie Willis for help with data issues; and Jay Walsh, Roy Weiss, and Carol Whitacre for their continuing support. Natsuko Nicholls at the Institute for Research on Innovation and Science, Nathan Ramsey at the US Census Bureau, and Craig Radford Schott at New York University provided amazing institutional help, and our very thoughtful editor, Teresa Barensfeld, was key to getting the document finalized.

Any opinions and conclusions expressed herein are those of the authors and do not necessarily represent the views of the US Census Bureau. All results have been reviewed to ensure that no confidential information is disclosed. This research was supported by USDA AFRI grant number 1005677; NSF SciSIP Awards 1064220 and 1262447; NSF Education and Human Resources DGE Awards 1348691, 1547507, 1348701, 1535399, 1535370; NSF NCSES award 1423706; NIHP01AG039347; and the Ewing Marion Kaufman and Alfred P. Sloan Foundations.