United States
Department of
Agriculture

Economic
Research
Service

Agricultural
Economic
Report
Number 791

Tracing the Costs and Benefits of Improvements in Food Safety

The Case of the Hazard Analysis and Critical Control Point Program for Meat and Poultry

Elise H. Golan, Stephen J. Vogel, Paul D. Frenzen,
and Katherine L. Ralston

It’s Easy To Order Another Copy!

Just dial 1-800-999-6779. Toll free in the United States and Canada.

Ask for ***Tracing the Costs and Benefits of Improvements in Food Safety: The Case of the Hazard Analysis and Critical Control Point Program for Meat and Poultry*** (AER-791).

For additional information about ERS publications, databases, and other products, both paper and electronic, visit the ERS website on the Internet at http://www.ers.usda.gov

National Agricultural Library Cataloging Record:

Tracing the costs and benefits of improvements in food safety: the case of the Hazard Analysis and Critical Control Point program for meat and poultry.
(Agricultural economic report; no. 791)
1. Meat industry and trade--Sanitation--United States--Cost effectiveness.
2. Poultry industry--Sanitation--United States--Cost effectiveness.
3. Foodborne diseases--United States--Costs. I. Golan, Elise H.
II. United States. Dept. of Agriculture. Economic Research Service.
III. Title.
TX556.M4

Tracing the Costs and Benefits of Improvements in Food Safety: The Case of the Hazard Analysis and Critical Control Point Program for Meat and Poultry. By Elise H. Golan, Stephen J. Vogel, Paul D. Frenzen, and Katherine L. Ralston. Food and Rural Economics Division, Economic Research Service, U.S. Department of Agriculture. Agricultural Economic Report No. 791.

Abstract

The level and distribution of the costs and benefits of the Hazard Analysis and Critical Control Point (HACCP) regulatory program for meat and poultry change dramatically once economywide effects are included in the analysis. Using a Social Accounting Matrix Model, we find that reduced premature deaths had a strong positive effect on household income, with economywide benefits almost double initial benefits. Contrary to expectations, reduced medical expenses resulted in a decrease in household income, while HACCP costs resulted in an increase. Net economywide benefits were slightly larger than initial net benefits, with poor households receiving a proportionally smaller share of the increased benefits than nonpoor because of their weak ties to the economy. Our SAM analysis provides policymakers useful information about who ultimately benefits from reduced foodborne illnesses and who ultimately pays the costs of food safety regulation. This analysis also sheds light on a number of issues central to cost-benefit analysis involving health, highlighting the danger of equating changes in income with changes in well-being.

Keywords: Food safety, foodborne illness, HACCP, Social Accounting Matrix.

Acknowledgments

We would like to thank Jean Buzby, Ron Meekoff, Laurian Unnevehr, and Gerald Schluter for helpful comments on the first draft of the report, J.B. McCraw for editing, and Curtia Taylor for graphic design.

1800 M Street, NW
Washington, DC 20036-5831

October 2000

Contents

Summary

The level and distribution of the costs and benefits of the Hazard Analysis and Critical Control Point (HACCP) regulatory program for meat and poultry changed dramatically once economywide effects were included in the analysis. We constructed a Social Accounting Matrix (SAM) model to extend the sector-specific cost-benefit analysis of the HACCP program to account for the economywide impact of the program on both producers and consumers. This type of analysis provides useful information for policymakers by indicating who ultimately benefits from improved health outcomes and who ultimately pays the costs of food safety regulation.

We used the SAM model to conduct two sets of simulations. One set examined the benefits of reducing foodborne illness and the other examined the cost of implementing HACCP. On the benefit side, the simulations examined the economywide benefits of reduced premature deaths and medical expenses. The SAM multiplier model indicated that every dollar of income saved by preventing premature deaths from foodborne illness resulted in an economywide income gain of $1.92. This result demonstrates that premature death imposes substantial costs on society as a whole. Fewer premature deaths led to an increase in household income nearly double the size of the initial increase.

For medical expenses, the SAM multiplier model showed that if households paid their medical expenses out of household income or savings, then every dollar saved through reduced foodborne illnesses resulted in an economywide income *loss* of $0.27. Likewise, if public or private insurance covered the cost of medical expenses, then every dollar saved because of fewer foodborne illnesses resulted in an economywide income *loss* of $0.32. These results indicate that the consumption of medical goods and services caused by foodborne illness triggers more economic activity than the consumption activities that households would have enjoyed if they had not needed to spend money on medical goods and services. One possible explanation for this result is that, in general, medical goods and services use a higher proportion of domestically produced inputs than do other goods and services. These results highlight the need for caution in interpreting income changes as changes in well-being and underline the need to refine methodology to account for changes in well-being that are not captured by income measures alone.

The final economywide distribution of the benefits of fewer illnesses and premature deaths differed from the initial distribution of benefits. Initially, the benefits of these reductions accrued to those who would have fallen sick or would have died prematurely. However, unlike the initial distribution of benefits, the final distribution did not mirror disease incidence, but depended instead on the relationship of households to the economy. As a result, higher income households, which have strong links to the economy, bore a larger share of the change in economic activity triggered by reduced premature deaths and medical expenses than lower income households, which have weak links to the economy.

Regarding costs, the simulations with the SAM multiplier model indicated that every dollar spent on HACCP implementation resulted in an economywide income loss of $0.35. This result occurred because, in this simulation, the increased costs of beef and poultry production due to HACCP implementation were passed on to

consumers so that households incurred a decrease in real income equivalent to the costs of HACCP implementation. When we held nominal income constant, economywide income actually rose by $0.65 for every dollar spent on HACCP. The spread between the real and nominal results serves as yet another reminder of the potential gap between a monetary accounting of economic activity and measures of well-being. The ultimate distribution of the reduction in real household income reflects the economic ties of the household groupings: both households below poverty and elderly households absorb relatively small percentages of the decrease in economywide income triggered by HACCP implementation.

The SAM analysis does not provide precise dollar estimates of the ultimate costs and benefits of HACCP. Instead, it provides information on the market mechanisms through which costs and benefits of the HACCP program affect the economy, thereby indicating the direction and magnitude of the economic flows resulting from regulation and reductions in foodborne illness. The SAM analysis also sheds light on a number of issues central to cost-benefit analysis involving health. It focuses attention on the different ways that health benefits are measured and reveals fundamental differences in the way different types of health benefits impact the economy. The SAM analysis demonstrates the usefulness of the cost-of-illness approach in deciphering economic distortions caused by health shocks to the economy and the danger of equating changes in income with changes in well-being.

Tracing the Costs and Benefits of Improvements in Food Safety

The Case of the Hazard Analysis and Critical Control Point Program for Meat and Poultry

Elise H. Golan, Stephen J. Vogel,
Paul D. Frenzen, and Katherine L. Ralston

Introduction

In 1997, the Federal Government introduced a new food safety regulation for meat and poultry slaughter and processing plants. Under the Pathogen Reduction and Hazard Analysis and Critical Control Point rule (commonly known as HACCP), slaughterhouses and processors must adopt new procedures to reduce the incidence of foodborne illness transmitted by raw meat and poultry products (see box, *The HACCP Program*). The costs and benefits of implementing HACCP are distributed throughout the economy. The costs of implementing HACCP are paid initially by the meat and poultry industry, while the benefits of controlling foodborne illness are distributed initially among consumers. However, the ultimate impact of these costs and benefits extends well beyond the initial payers and beneficiaries, with economic ramifications for many different segments of the economy.

To examine the full economic ramifications of HACCP implementation and answer the question as to how economic activity might be different if the HACCP system were implemented and foodborne illness were reduced, we developed a Social Accounting Matrix (SAM) multiplier model. The SAM multiplier model is a linear, general equilibrium model of the economy that traces the impact of exogenous change on every endogenous account in the economy. Our HACCP SAM model is based on the 1993 U.S. SAM derived from a Computable General Equilibrium (CGE) model of the United States developed by the Economic Research Service (ERS) of the U.S. Department of Agriculture (USDA) (Hanson et al., forthcoming).

In addition to building the HACCP SAM model, we needed to accomplish a number of other tasks in order to undertake the SAM analysis—tasks that required facing difficult problems in both the theory and empirical practice of health economics. The first task was to establish the initial benefits of HACCP. A wide variety of benefit estimates are available, and determining the one to use raises some fundamental theoretical questions in health economics, particularly, how to value life and health for economic analysis. The second task that had to be confronted in order to perform the SAM analysis was to establish the initial distribution of HACCP benefits. The initial recipients of HACCP benefits are households whose members would have fallen ill if HACCP had not been implemented. We had to determine the distribution of foodborne illness among different socioeconomic groups to establish the initial distribution of HACCP benefits. Because either private or public health insurers pay a large share of medical expenses, we had to account for the distribution of health insurance coverage among different socioeconomic groups. In addition to identifying the payers of foodborne illness costs, we also had to identify the receivers. Determining the distribution of medical expenses among hospitals, physicians, pharmaceuticals, and education services reveals the empirical difficulties in accurately measuring even one of the most straightforward of the economic measures of the cost of illness: medical expenses.

Using the HACCP SAM model and the information on the distribution of foodborne illness, we ran four basic simulations to illustrate the probable economic consequences of HACCP implementation. First, we traced

The HACCP Program

The Hazard Analysis and Critical Control Point (HACCP) program is administered by the Food Safety and Inspection Service (FSIS) of the U.S. Department of Agriculture, which is responsible for ensuring the safety of raw meat and poultry products. Prior to the introduction of the HACCP program, the FSIS inspection program for slaughter and processing plants was based on organoleptic (sight, smell, and touch) methods. These methods were adequate for removing noticeably diseased animals from the food supply but were not designed to detect potentially dangerous microbial pathogens that might be present in otherwise healthy animals.

The HACCP program was introduced in response to growing scientific consensus that food safety should be based on the systematic identification and reduction of risks involved in the production of each specific food. The program covers all Federal- and State-inspected meat and poultry slaughter and processing plants in the United States, as well as foreign plants that export meat or poultry products to the United States. The four major components of the HACCP program are: (1) implementation of a written HACCP plan by every slaughter and processing plant; (2) adoption of Sanitation Standard Operating Procedures (SSOPs) by every slaughter and processing plant; (3) *Salmonella* performance standards for slaughter and ground product plants; and (4) generic *E. coli* performance standards for slaughter plants.

The HACCP plan component of the HACCP program requires each slaughter and processing plant to analyze its own production processes and identify “Critical Control Points” (CCPs) where potential hazards affect food safety. Plants must then develop a written HACCP plan and maintain records to ensure that the production process remains within predetermined “critical limits” at each control point, based on parameters such as temperature or chlorine level. The largest plants, 500 or more employees, had to implement HACCP plans by January 1998. Smaller plants had until 1999 or 2000 to implement plans, depending on plant size.

The SSOP component of the HACCP program requires all slaughter and processing plants to prepare a written plan describing the daily procedures used to ensure sanitation during production. Plants must also detect, document, and correct any sanitation deficiencies. All plants were required to have SSOPs in place by January 1997.

The *Salmonella* and generic *E. coli* performance standards included in the HACCP program allow FSIS to monitor whether plants are adequately preventing pathogen contamination of raw meat and poultry products. *Salmonella* was selected for monitoring because it is one of the most common foodborne pathogens and is present in a wide variety of raw food products. Generic *E. coli* was selected because it is naturally found in animal feces and serves as an indicator of fecal contamination during production. FSIS sets maximum acceptable limits for both pathogens, based on baseline surveys of each class of animal and food product. The implementation dates for the *Salmonella* standard are the same as those for the HACCP plan. All slaughter plants were required to begin testing for generic *E. coli* in January 1997.

the economic impact of hypothetical reductions in the human capital costs of foodborne illness (benefits of HACCP). Second, we examined the economic impact of hypothetical reductions in medical expenses arising from foodborne illness (benefits of HACCP) when households paid these costs. Third, we examined the economic impact of hypothetical reductions in medical expenses when either private or public health insurers paid these costs. Fourth, we looked at the economic impact of hypothetical increases in meat and poultry plant operating expenses due to HACCP implementation. For each simulation, we investigated how the hypothetical change might affect the level and distribution of consumption, production, and income in the U.S. economy.

The first section of the paper presents the cost and benefit estimates that are used to initiate the simulations. The second section discusses the SAM framework and presents some details as to how the HACCP SAM was constructed. The third section explains how the SAM multiplier model works and outlines the simulations that we conducted with the HACCP SAM multiplier model. The fifth section begins by determining the incidence of foodborne illness and then traces the benefits of reductions in foodborne illness costs when either households or health insurers pay these costs. The sixth section traces the costs of HACCP implementation. The conclusion compiles all the simulation results to examine the net impact of HACCP implementation on the economy.

Which Costs and Benefits?

In any cost-benefit study, analysts must decide which costs and benefits to include in the analysis. For this study, we used estimates of the benefits of reductions in foodborne illness by ERS (Buzby et al., 1996) and estimates of the costs of HACCP implementation by USDA's Food Safety and Inspection Service (USDA, FSIS, 1996). These estimates were the basis for the official regulatory impact analysis of the HACCP program (USDA, FSIS, 1995 and 1996). Both estimates are examined in detail in Crutchfield et al. (1997). We could have used a number of other benefit and cost estimates. Our analysis provides insights into how the benefits of improved health and the costs of regulatory reform affect the economy. We did not intend and do not provide an all-encompassing assessment of HACCP costs and benefits.

Benefits of the HACCP Program

Estimates of the present value of 20 years of HACCP-program benefits reported in Crutchfield et al. (1997) range from $1.9-$171.8 billion in 1995 dollars (see table 1).[1] These benefits are the expected cost savings due to reduced foodborne illness resulting from the HACCP system. The estimates are conservative because they measure the benefits of reductions in illness caused by only four foodborne pathogens (*Salmonella, Escherichia coli* O157:H7, *Campylobacter jejuni* or *coli*, and *Listeria monocytogenes*), whereas over 40 different foodborne pathogens are known to cause illness (Council for Agricultural Science and Technology, 1994).

The ERS benefit estimates are quite imprecise, with the high-end estimate almost 100 times higher than the low-end estimate. Four primary reasons account for this wide range. First, the incidence of foodborne illness (and death) and the proportion of cases caused by contaminated meat and poultry are uncertain. Table 2 illustrates the wide variation in the estimated number of cases of foodborne illness. Second, the efficacy of the HACCP program in reducing foodborne illness is also uncertain. The highest benefit estimate reported in Crutchfield et al. (1997) incorporates an efficacy rate of 90 percent, while the lowest estimate uses a rate of 20 percent. Third, the benefit estimates vary because two different discount rates are used. Crutchfield's et al. lower estimates use a relatively high discount rate of 7 percent to reflect private valuations, while the higher estimates use a discount rate of 3 percent to reflect a societal viewpoint. The fourth, and most critical source of variation in the benefit estimates, is the use of two different methods to assign economic value to improvements in health and longevity resulting from reductions in foodborne illness. The higher benefit estimates reported in Crutchfield et al. use the willingness-to-pay methodology (derived from Viscusi, 1993), while the lower use a variant of the cost-of-illness methodology (derived from Landefeld and Seskin, 1982).

For this study, we used the mid-range benefit estimates of $4.7-$23.4 billion (see boldfaced type in table 1). These estimates are calculated with a HACCP efficacy rate of 50 percent, a discount rate of 7 percent, and the Landefeld and Seskin cost-of-illness approach.[2] We chose the moderate efficacy rate and the steeper interest rate simply to be conservative. We chose the cost-of-illness approach because it provides a measure of the distortions to the economy arising from illness and premature death (or in this case, a reduction in both). Cost-of-illness estimates measure two types of costs: direct medical expenses and human capital costs. The direct medical costs of illness are expenditures for medical goods and services such as doctor visits, hospitalization, residential care, and medications.[3] Human capital costs of illness are the present value of wages (and nonwage benefits) forgone as a result of an adverse health outcome. The cost-of-illness approach produces an accounting of the dollars that

[1] Benefits begin to accrue 5 years after the HACCP rule is enacted so the present-value calculations actually run over 25 years.

[2] In their cost-of-illness calculations, Landefeld and Seskin (1982) add an individualized element to their human capital calculations by including a risk-aversion factor, computing earnings net of taxes, including nonlabor income, and using an individual, rather than a social discount rate. Buzby et al. (1996) adjusted the Landefeld and Seskin measures of lifetime, after-tax income by averaging across gender, interpolating between age groups, and updating to 1993 dollars.

[3] Some studies include other types of expenses in their cost-of-illness estimates, and indeed, there are many other types of costs that could be included in a study of foodborne illness. Buzby et al. (1996) developed a list of potential foodborne illness costs that includes medical expenses, income or productivity losses, child-care costs, increased health insurance costs, lost leisure time, psychological costs, extra cleaning-time costs, and welfare costs due to unwelcome flavor changes in traditional recipes.

Table 1—HACCP benefits estimated for different scenarios

Scenario	Effectiveness of pathogen reduction	Discount rate	Valuation methods for premature death/disability	Benefits[1] Low	Benefits[1] High
	Percent	*Percent*		*1995 dollars (billions)*	
Preliminary FSIS proposal	90	7	Landefeld & Seskin[2]	8.4	42.1
Low-range benefits estimates	20	7	Landefeld & Seskin	1.9	9.3
Mid-range benefits estimates I	**50**	**7**	**Landefeld & Seskin[3]**	**4.7**	**23.4**
Mid-range benefits estimates II	50	3	VOSL[4] = 5 million	26.2	95.4
High-range benefits estimates	90	3	VOSL = 5 million	47.2	171.8

[1] Present value of 20 years of benefits (beginning 5 years after the HACCP rule is enacted).
[2] Landefeld and Seskin estimates averaged across gender.
[3] These values are used for the HACCP SAM analysis. For the analysis, they are converted to 1993 dollars.
[4] VOSL = Value of statistical life (calculated with willingness-to-pay methodology).

Source: U.S. Department of Agriculture, Economic Research Service, compiled in Crutchfield et al. (1997).

Table 2—Estimates of foodborne illness are imprecise

Pathogen	Annual cases	Annual deaths	Share foodborne	Share foodborne from meat and poultry	Annual cases from meat and poultry	Annual deaths from meat and poultry
			Percent	*Percent*		
Samonella	800,000-4,000,000	1,000-2,000	87-96	50-75	459,770-2,880,000	435-1,440
E. coli O157:H7	10,000-20,000	220-541	80	75	6,000-12,000	132-325
Campylobacter jejuni or *coli*	2,000,000-10,000,000	200-730	55-70	75	825,000-5,250,000	83-383
Listeria monocytogenes	1,118-1,903	270-510	85-95	50	464-884	115-242

Source: Buzby et al., 1996.

consumers and producers spend differently as a result of illness or premature death.

The human capital component of the cost-of-illness approach is based on the assertion that the cost to society of adverse health outcomes is the impact that such outcomes have on national income. Early proponents of the human capital approach argued that investments in health ultimately augment human capital and lead to increases in both the number and quality of people in the workforce, thereby increasing national income and social welfare (Mushkin, 1962). Robinson (1986) traced the philosophical underpinnings of the human capital approach to the economic doctrine dominant from the early 19th to the mid-20th century, which held that the best government policy is one that most effectively increases the "wealth of nations," as measured by national income. The human capital approach to valuing life is consistent with this notion. A life is valued in terms of its contribution to national income. The human capital approach is based on the tenet that social welfare is diminished by illness, disability, and premature death to the extent that these outcomes diminish national income.

Many economists have criticized the cost-of-illness method, primarily because it does not incorporate valuations for pain and suffering and other nonmarket commodities. Many prefer the willingness-to-pay approach, arguing that it provides a more accurate appraisal of the changes in welfare resulting from changes in health and longevity than the cost-of-illness method (for a review of valuation methodologies for health cost-benefit analysis, see Tolley et al., 1994, and Kuchler and Golan, 1999). However, willingness-to-pay amounts do not measure market distortions. Although the willingness-to-pay methodology may indicate how much a society would pay to avoid adverse health outcomes and premature death, it does not measure the economic impact of such outcomes. For example, the willingness-to-pay estimates used in the upper range of HACCP benefit estimates in

Crutchfield et al. (1997) were derived by observing the wage premium paid to workers for risky jobs. These wage premiums, and the attitudes toward risk and health that generated these premiums, do not shed light on the effect of illness or premature death on the level or distribution of economic activity.

The cost-of-illness approach tallies the primary economic flows associated with an adverse health outcome. It accounts for the drop in productivity resulting from illness, accident, or premature death, as well as the shift in consumer spending from general consumption and investment to medical goods and services. The cost-of-illness approach provides an accounting of the dollars spent on medical expenses and the earnings lost due to illness, accident, or premature death. Combined with a general equilibrium analysis, such as a SAM multiplier model, the cost-of-illness approach provides the first step in deciphering the full economic impact of illness and premature death. This information helps policymakers gauge the extent and distribution of the costs of foodborne illness caused by contaminated meat and poultry and the benefits of the HACCP program.

For the HACCP SAM analysis, we used the mean of the mid-range Crutchfield et al. 20-year present-value estimates converted to 1993 dollars (to conform to the 1993 SAM): $13.32 billion (table 3).

Table 3—Benefit and cost estimates used in the HACCP SAM simulations

Benefits[1]	Costs[2]
1993 dollars (billions)	
$13.3	$1.1

[1] Benefits are mean mid-range benefit estimates reported in Crutchfield et al. (1997) converted to 1993 dollars. These benefits are the present value of 20 years of benefits (beginning 5 years after the HACCP rule is enacted).

[2] Costs are mean cost estimates reported in Crutchfield et al. (1997 converted to 1993 dollars. These costs are the present value of 20 years of HACCP costs; they include both initial and yearly costs.

Costs of Implementing the HACCP Program

The HACCP program includes four essential elements: (1) implementation of a written HACCP plan by every slaughter and processing plant; (2) adoption of Sanitation Standard Operating Procedures (SSOPs) by every slaughter and processing plant; (3) *Salmonella* performance standards for slaughter and ground product plants; and (4) generic *E. coli* performance standards for slaughterhouses (see box, *The HACCP Program*). Throughout this report, references to HACCP and HACCP costs refer to all four components.

The cost estimates prepared for the Food Safety and Inspection Service (FSIS) cost-benefit analysis of HACCP include the additional costs for both FSIS and the meat and poultry industry to implement HACCP. The cost estimates depend on numerous assumptions, including assumptions about industry structure, wages, modification costs, costs of training, supply and demand conditions, and the timing of implementation. The 20-year present-value FSIS estimates of the costs of HACCP are $1.1-$1.3 billion (Crutchfield et al., 1997). Other studies have used different assumptions and have produced different estimates (for example, Knutson et al., 1995, Jensen et al., 1998). For this study we use the official FSIS estimates, though our methodology could be applied to any of the other cost estimates. The types of costs included in the estimates could cause the level and distribution of economic effects to differ substantially.

For the actual HACCP SAM analysis, we used the mean value of the FSIS HACCP 20-year present-value cost estimates converted to 1993 dollars (to conform to the 1993 SAM): $1.1 billion (table 3).

The Social Accounting Matrix Framework

A SAM is a snapshot view of the circular flow of accounts in an economy (fig. 1). Within a matrix of double-entry accounting, a SAM represents national income and product accounts and Input-Output (I-O) production accounts as debits (expenditures) and credits (receipts) in balance sheets of activities and institutions. The SAM generalizes the I-O framework by integrating the I-O tables in a disaggregated structure of institutional incomes and expenditures.

As illustrated in the simple schematic SAM (fig. 2), a SAM is comprised of a set of production activities (such as meat and poultry processors), commodity markets for goods and services (such as meat and poultry products), factors (labor and capital), households, a capital account, and other institutions (government and the rest of the world). The ij^{th} entry in the SAM represents the payment by account j to account i for services rendered or goods supplied (where "*i*" represents rows and "*j*" represents columns). For example, a firm's purchase of production inputs are registered in the second row, first column in the schematic SAM. Household purchases of goods or services are registered in the second row, fourth column in the schematic SAM. The ij^{th} entry can also represent an income transfer from account *j* to account *i*. For example, household tax payments to government are recorded in the sixth row, fourth column, while government welfare payments to households are registered in the fourth row, sixth column. The sum of the entries in the j^{th} column gives total expenditures made by account j to all accounts in the SAM. Similarly, the i^{th} row total represents all income payments to account *i* made by all other accounts. Double-entry accounting principles ensure that total gross income equals total gross expenditures across each account, meaning that all corresponding rows and column totals are equal.

The row and column entries of *production activities* and *commodities* in the SAM form the input-output table developed by the U.S. Department of Commerce, Bureau of Economic Analysis. In the first column of the schematic SAM, the total costs to firms are equal to the sum of intermediate input purchases; payments to factors in the form of wages, profits, and rents; and payments to the government in the form of indirect taxes. These total costs are equal to firms' total sales, which are composed of domestic sales plus exports (first row). Total absorption (second column) is equal to total domestic production, valued at market prices, plus imports and tariff payments. Total absorption is allocated between consumption of intermediate goods, household consumption, investment, and government purchases (second row).

The SAM framework also incorporates the reallocation of factor income from domestic and foreign sources

Figure 1
Linkages in a Social Accounting Matrix multiplier model

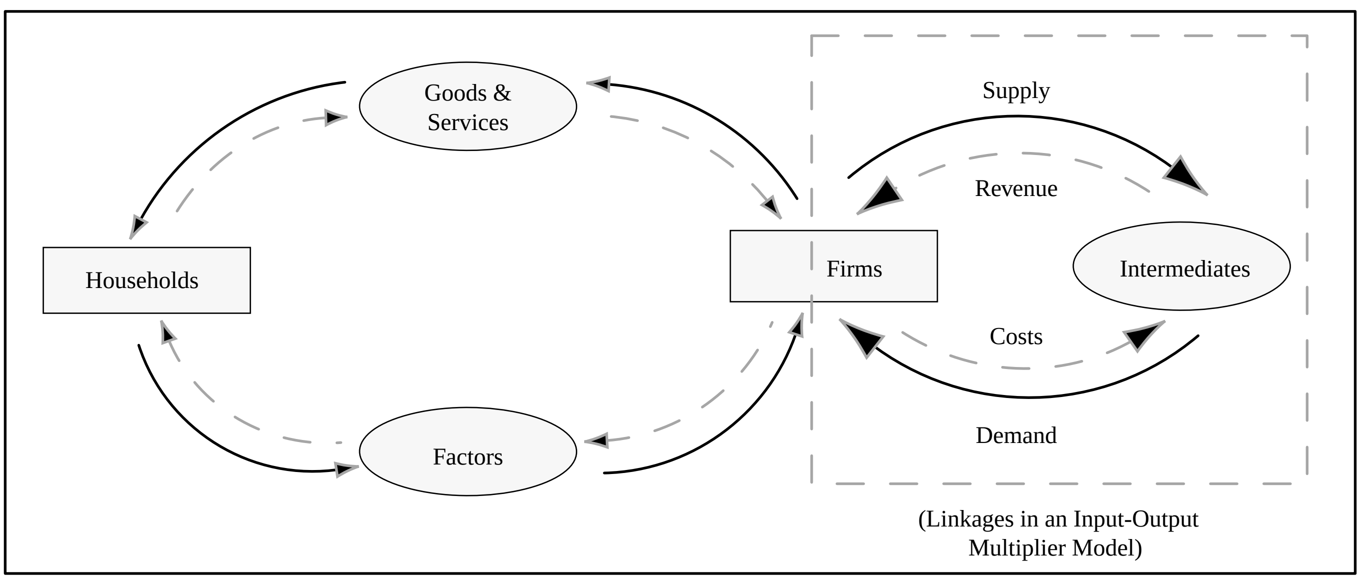


Figure 2
The double-entry accounting framework of the HACCP SAM

Accounts	Producer activities	Commodities	Factors	Households	Capital account	Other institutions	Total
Producer activities		Domestic sales				Exports	Sales
Commodities	Intermediate goods			Consumption	Investment	Govt. purchases	Components of domestic consumption
Factors (labor and capital)	Wages and capital income					Foreign factor income	Factor income
Households			Distribution of factor			Govt. transfers	Household income
Capital account			Corporate savings	Household savings		Govt. deficit, capital inflows	Savings
Other institutions (government and rest of world)	Indirect business taxes	Imports and commodity taxes	Factor taxes	Income taxes			Government income and imports
Total	Costs	Domestic consumption supply	Factor income	Household expenditures	Investment	Expenditures by government and rest of world	

(third row) to households, to the capital account in the form of corporate savings, and to the government in the form of factor taxes, such as social security taxes (third column). Households' total income, factor income plus government transfers (fourth row), equals their expenditures for consumer goods, savings, and income taxes (fourth column). The economy's macroeconomic equilibrium is found in the capital account in which savings from all sources (fifth row) equals investment (fifth column). Finally, the sixth row and column capture equilibrium for the two other institutions in the economy. For the government, tax revenue from all sources (indirect business, commodity, factor, and household taxes) equals its expenditures (government purchases, transfers to households and businesses, and government savings). For the rest of the world (ROW), imports equal exports plus remittances of foreign factor income—the definition of the trade balance.

Building the HACCP SAM

To construct a SAM, the first task is to identify the important activities and institutions in the economy with respect to the policy issues under consideration. Aggregating the industries, services, households, government agents, and ROW accounts of an economy into a smaller number of major accounts makes the model more manageable and focuses the investigation. The aggregation scheme determines the flows that the model can trace explicitly. If the aggregation is done correctly, the major flows in the economy, both positive and negative, are evident. Otherwise, the impact of policy will be blurred, with negative and positive flows occurring within a single account. In the HACCP SAM, the accounts focus the model on the primary activities and institutions affected by foodborne illness or by the HACCP program. We paid particular attention to the construction of the industrial and household accounts.

Industrial Accounts

For the industrial aggregation, all firms that make similar, but not necessarily identical products are grouped together into one account. The industrial aggregation in the HACCP SAM includes the major industrial and commercial sectors of the economy. In addition, the aggregation highlights the three major areas of the economy most directly impacted by HACCP and foodborne

Table 4—Population distribution by household type, 1993

	Households with children	Households without children	Elderly	Total
Number of households	35,823	49,424	21,189	106,436
Percent of all households	34	46	20	100
Number of persons	139,028	80,488	37,038	256,554
Percent of total population	54	32	14	100
Adults	71,573	79,054	7,186	157,813
Children	66,795	0	1,211	68,006
Percent of all children	98	0	2	100
Elderly	661	1,434	28,640	30,735
Percent of all elderly	3	4	93	100
Percent below poverty	18	13	17	16

Percents may not total to 100 due to rounding.
Note: Household and population numbers are in thousands.
Source: Hanson et al., forthcoming.

illness: the meat and poultry production and distribution sector, the health care sector, and the health insurance sector. The HACCP SAM does not explicitly isolate all of the flows generated by foodborne illness, but each set of flows is differentiated so that positive and negative flows do not occur in the same account (at least in the first round). The industrial aggregation in the HACCP SAM traces the flows generated by the production and sale of meat and poultry products (and regulatory costs) from the Livestock sector, to the Food Processing, Wholesale Trade, and Food Retail Trade sectors to consumers. Medical costs can also be traced from the account of payment (household and insurer) to the account of receipt (pharmaceuticals, medical services, etc.).

Household Accounts

The grouping of households for the HACCP SAM encompasses two primary considerations. First, the incidence of foodborne illness is most common among the very young and very old (Council for Agricultural Science and Technology, 1994). Households with young children and older adults are therefore expected to incur a disproportionately large share of the total expenses due to foodborne illness. Second, the expenditure and savings patterns of households depend on the income level and age composition of the household, particularly with regard to medical expenditures and participation in the Medicaid and Medicare programs. The three household categories for the HACCP SAM are: (1) households headed by persons age 65 or older, (2) households headed by persons under age 65 and one or more children under age 18, and (3) childless households headed by persons under age 65. Households with children account for the largest share of the population. Table 4 shows the population distribution among the household types.

Each household category is subdivided into households above and below the official poverty line to reflect the observation that income affects the ability and propensity to spend on health care as well as eligibility for Medicaid. The poverty rate is slightly higher for members of households with children than for other persons.[4]

The Data

The HACCP SAM is based on a 1993 SAM derived from a model of the U.S. economy developed at USDA's Economic Research Service (ERS) (Hanson et al., forthcoming). The underlying data are the 1987 benchmark I-O accounts prepared by the U.S. Department of Commerce, Bureau of Economic Analysis (1994). Information about the distribution of the U.S. population by household type and poverty level is based on estimates from the March 1994 Current Population Survey conducted by the U.S. Department of Commerce, Bureau of the Census.

[4] The income calculations for the poverty classification excluded all in-kind assistance, Earned Income Tax Credits (EITC), Supplemental Security Income (SSI), Aid to Families with Dependent Children (AFDC), and general assistance payments in order to focus on the household's ability to achieve an adequate income without government assistance.

The SAM Multiplier Model

The SAM quantifies the economywide interdependence of all agents operating in the economy (fig. 1). The I-O multiplier model captures only sales of intermediate goods and services, i.e., the market internal to firms. The SAM multiplier model captures not only the I-O flows, but also the flows of household expenditures on goods and services and firms' payments to households for factor services. Unlike the I-O multiplier model, the SAM multiplier model captures income and household consumption linkages, thereby permitting an appraisal of the full effects of specific changes to the economy.

In a SAM, total output equals total demand, as shown by

$$(1) \qquad \mathbf{z} = \mathbf{Bz} + \mathbf{x}$$

where (**z**) equals a vector of total output, (**Bz**) equals the sum of endogenous demands, and (**x**) equals exogenous demands. The shares matrix (**B**) represents the endogenous production, value-added, and household expenditures as shares of total expenditure. The exogenous accounts are government, the capital account, and domestic and foreign trade.

Equation 1 can be solved to determine the impact of a change (shock) in exogenous demand on total output, accounting for all changes in endogenous demand resulting from the exogenous change. Rewrite equation 1:

$$(2) \qquad \mathbf{z} = \mathbf{(I\text{-}B)}^{-1}\mathbf{x} = \mathbf{Mx}, \qquad \text{where } \mathbf{M} = \mathbf{(I\text{-}B)}^{-1}$$

so that

$$(3) \qquad \Delta\mathbf{z} = \mathbf{M}\Delta\mathbf{x}.$$

The matrix **M** captures the impact that an exogenous change in demand has on endogenous production, value-added, and household expenditures. **M** reflects the fact that an increase in demand for a particular sector's output creates additional demand for intermediate goods produced by other firms. In turn, these other firms pay their workers additional wages to produce these goods—and the workers, as consumers, spend their additional income on goods and services. Thus, in equilibrium, the vector (Δ**z**) summarizes *for all firms, factors, and households* in the economy the direct effects due to the shock itself (Δ**x**) plus the indirect effects in the form of new wage payments, household expenditures, and producer supply feedbacks (depicted in the circular flow diagram of fig. 1).

More formally, each sectoral multiplier (m_{ij}) represents the induced income flow to account *i* for services performed for account *j*, as a result of one unit of exogenous expenditure placed on sector *j*. If the change in exogenous demand (whether from investment demand, a government policy, or export demand) is for goods, the multiplier is a production multiplier. If the exogenous flow is directed to a household, the multiplier is an income transfer multiplier. Indirect household-expenditure production multipliers and interhousehold income transfer multipliers are associated with the income transfer multiplier.

Three assumptions underlying the SAM multiplier framework weaken its general applicability. First, income elasticities of demand are assumed to equal 1. The implication is that the SAM multiplier model understates the impact of an increase in household income on the demand for luxury goods and overstates the impact on demand for necessities. Second, fixed prices imply that only quantities adjust to clear markets. Third, the model is demand-driven, meaning that the supply response is perfectly elastic, which implies that downstream industries are able to maintain the required flow of intermediate goods and that there are always underutilized resources sufficient to meet increases in demand. This assumption also implies that the SAM model treats job gains and losses as permanent and instantaneous.

Although these assumptions may prove restrictive in some analyses, they are not particularly problematic for our HACCP analysis. Because the simulations conducted with the HACCP SAM multiplier model involve relatively small shocks, these assumptions are relatively harmless. At least in the long run, these simulated shocks are too small to have an important impact on prices. They do not result in supply shortages, and, given the small changes in consumption patterns triggered by the simulations, marginal consumption propensities will probably not vary greatly from average propensities.

Figure 3 shows the set of commodity market multipliers for the production activities associated with the

HACCP simulations: chemicals, miscellaneous durable manufacturing, transportation, financial services, health services, residential care services, and other services. For example, we report only expenditure multipliers for households of married couples with no children, disaggregated by income class. For space considerations, figure 3 presents the multiplier matrix a bit differently from traditional presentation. Figure 3 is organized so that each sectoral multiplier (m_{ij}) represents the induced income flow to account *j* for services performed for account *i*, as a result of one unit of exogenous expenditure placed on sector *i* (as opposed to traditional presentations in which each sectoral multiplier represents the induced income flow to account *i* for services performed for account *j*, as a result of one unit of exogenous expenditure placed on sector *j*).

Reading figure 3 left to right, we observe in row one that a $1 increase in demand for output from the chemicals sector generates $.14 in demand for farm and food output, $1.62 in nondurable manufacturing (including the original $1 in chemicals), $.33 for trade and transportation, $.10 for health, and $.88 for services. In total, $1 of new demand for chemicals generates an additional $3.32 in new demand for output from the other sectors. A $1 increase in chemicals

Figure 3

Selected HACCP SAM multipliers

Multipliers affecting:	Commodity markets								Factor income		Household income	
Sector	Farm	Food	Durable mfg.	Nondurable mfg.	Trade and transp.	Health	Services	Total commod. market	Labor	Capital	Poor (below poverty)	Nonpoor (above poverty)
<u>Commodity:</u>												
Chemicals	.043	.094	.255	1.619	.328	.098	.883	3.320	.858	.602	.028	.978
Misc. durable manufacturing	.041	.090	1.470	.403	.334	.099	.869	3.306	.919	.490	.033	.979
Transportation	.050	.111	.332	.408	1.498	.122	1.123	3.644	1.188	.503	.039	1.213
Financial services	.043	.098	.256	.255	.270	.106	2.191	3.219	.950	.620	.026	1.071
Health	.062	.132	.306	.413	.348	1.157	1.187	3.605	1.367	.499	.039	1.365
Residential care	.164	.331	.300	.393	.391	.136	2.274	3.989	1.345	.496	.045	1.342
Other services	.034	.078	.264	.264	.236	.082	1.788	2.746	.807	.321	.028	.810
<u>Married households with no children (by income class):</u>												
Below 50% of the poverty line	.085	.195	.374	.436	.483	.228	1.477	3.278	.986	.559	1.030	1.073
Between 50-100%	.083	.190	.364	.422	.468	.221	1.432	3.180	.959	.543	1.030	1.043
Between 100-130%	.083	.188	.358	.418	.463	.218	1.413	3.141	.946	.535	1.030	1.026
HH4*	.079	.181	.339	.394	.437	.206	1.336	2.972	.893	.506	.029	1.971
HH5	.074	.167	.318	.370	.410	.193	1.254	2.786	.839	.474	.026	1.911
HH6	.070	.160	.304	.354	.393	.185	1.202	2.668	.805	.455	.026	1.873
HH7	.067	.154	.289	.338	.374	.176	1.143	2.541	.766	.433	.024	1.832
HH8	.058	.133	.252	.293	.324	.153	.990	2.203	.663	.375	.020	1.719

Note: Commodity, factor-income, and household-income multipliers measure the impact of an exogenous shock on separate points in the circular flow of economic activity (see fig. 1). As such, they cannot be compared with each other.

*Households 4-8 are the nonpoor households. HH4 includes those married households with children with income above 130 percent of the poverty line and in the first quartile (the quarter of the households with the lowest income); HH5 includes households in the second quartile; HH6 includes households in the third quartile; HH7 includes households in the fourth quartile but with incomes lower than the 10 percent of households with the highest incomes; and HH8 includes households with incomes greater than 90 percent of households.

also generates $.86 in new wages and $.60 in capital income, while poor households, those with incomes below the poverty line, receive $.03, and nonpoor households, those with incomes above the poverty line, receive $.98 in additional income.

The multipliers affecting factor income provide information on the functional distribution of income, while the multipliers affecting household income provide information on the size distribution of income. These two groups of multipliers provide information about different points of the circular flow of economic activity. For example, a $1 increase in chemicals induces businesses to pay out $1.46 for labor and capital services, while households receive additional income of $1.01. These two groups of multipliers differ because each point in the circular flow is subject to different sets of taxes, savings, and government transfers. Depending on the structural relationship among industries, their use of factor services, and the distribution of income to households, the multipliers affecting factor income may produce effects greater than, less than, or equal to those affecting household income.

The commodity market multipliers reveal which sectors are more strongly woven into the fabric of producer relationships (transportation, health, and residential care); which sectors are relatively more capital intensive (chemicals and financial services) and which sectors are more labor intensive (transportation, health, residential care, and other services); which sectors generate higher wage income (transportation, health, and residential services); and which households are more strongly integrated into the production economy.

The household multipliers shed light on the relative impact of each household's expenditures on the circular flow of economic activity. In figure 3, these multipliers (the last eight rows) show that for married couples with no children, poor households' expenditures of an additional $1 of transfer income induce demand for additional output ranging from $3.14 to $3.28 (household consumption multipliers). By contrast, the wealthier households allocate proportionately more income to savings and taxes and, consequently, induce new output demand ranging from $2.54 to $2.97. Households in the top 10-percent income bracket contribute only an additional $2.20 in new output demand induced by a $1 transfer. For household multipliers impacting factor incomes, a similar pattern is repeated: expenditures by poorer households generate larger impacts on factor incomes. Likewise, expenditures by poor households generate larger indirect effects on household incomes, ranging from $1.06 to $1.10, compared with effects generated by wealthier households ranging from $.73-$1.01.[5] The fact that poor households receive an indirect impact of $.02 to $.03 for every $1 transfer of income to any household type tells us that their contribution to the production of goods and services in the economy is weak—despite their strong consumption multipliers.

The SAM provides a baseline description of the flows in the economy. These flows include medical expenses arising from foodborne illness, which are included in the flows from households to the medical sectors. These flows also reflect the impact of productivity losses: production and consumption levels included in the SAM are lower than they would have been in the absence of foodborne illness. We now ask the question: "How would economic activity differ if the HACCP system were implemented and foodborne illness were reduced?"

To answer this question requires unraveling a series of events. For example, a reduction in foodborne illness medical expenses may lead to reduced demand for pharmaceuticals. This in turn might lead to a reduction in pharmaceutical production, which may lead to a reduction in factor payments by the pharmaceutical industry, which may lead to a reduction in household income, which may lead to a reduction in household consumption and savings, which would lead to a reduction in demand for goods and services, which may trigger a reduction in general output, and so on. Simultaneously, the money saved through the reduction in pharmaceutical expenses due to reduction in foodborne illness would be saved or spent for other goods and services. Increased savings or consumption would lead to increased investment and production, which could lead to higher household incomes, which could in turn lead to higher savings and consumption, which would again trigger increased investment and production, and so on.

[5] These impacts were calculated by adding together the multiplier impacts on nonpoor and poor households and subtracting the direct impact of a $1 transfer (for example, (1.03 + 1.07) –1 = 1.10).

The costs and benefits of implementing HACCP will have ramifications beyond the individuals and industries affected most directly. HACCP implementation will directly affect health service industries, pharmaceutical and chemical industries, insurance companies, meat processors, government activities, and households. These direct impacts will then trigger shifts in economic activity that ripple across the economy. The net impact of all these effects is difficult to calculate without a general equilibrium framework. The SAM multiplier provides a way to calculate the general equilibrium consequences of HACCP implementation.

We used the multiplier model to simulate both the economic impact of the benefits of reductions in foodborne illness as well as the economic impact of the costs of HACCP implementation. Specifically, we traced the impact of $13.32 billion worth of benefits and $1.1 billion worth of costs (table 3). First, we ran three simulations to examine the probable impact of HACCP benefits. In the first simulation, we traced the economic impact of hypothetical reductions in the human capital costs of foodborne illness. In the second, we examined the economic impact of hypothetical reductions in medical expenses arising from foodborne illness when these costs are paid by households. Third, we examined the economic impact of hypothetical reductions in medical expenses arising from foodborne illness when these costs are paid by either private or public health insurance. In the fourth simulation, we examined the economic impact of hypothetical increases in government regulatory and processing plant operating expenses due to HACCP implementation. With the SAM model, we investigated the impact of all these hypothetical changes on the level and distribution of consumption, production, and income in the U.S. economy. The simulations provide insight into the way that the costs and benefits of HACCP percolate through the economy but do not provide precise dollar estimates of the wider costs and benefits of HACCP.

Tracing the Benefits of the HACCP Program

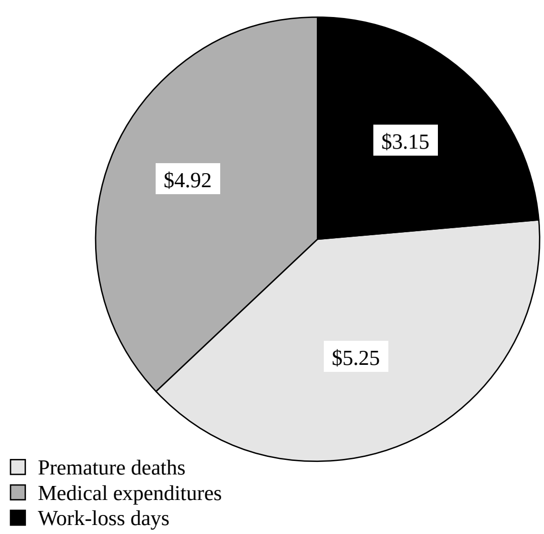
The economic impact of the benefits of reductions in foodborne illness depends on the nature of the benefits. In order to discover how economic activity would differ with less incidence of foodborne illness, we needed to know the economic transactions triggered by foodborne illness. Reductions in productivity costs due to death have a different economic impact than reductions in productivity costs due to illness; and any reduction in productivity has different economic impacts than reduced medical expenses. To trace the impact on the economy from reductions in foodborne illness, we first had to distinguish among the different types of benefits embedded in the HACCP benefit estimates. Extrapolating from information in Buzby et al. (1996), we estimate that the mean, mid-range benefit estimate of $13.32 billion is composed of $5.25 billion due to the reduction in premature deaths; $3.15 billion due to the reduction in work-loss days (productivity costs due to time lost from work because of nonfatal illness); and $4.92 billion due to reductions in the direct medical costs of illness, such as expenditures for physician visits, hospital and nursing home care, drugs, and medical tests and procedures (fig. 4).

The distribution of costs between medical and productivity loss depends on the death and disability rate of the illness. The greater the number of premature deaths and disabilities, the higher the productivity losses and the lower the share of medical expenditure in total cost. As a result, the comparative size of medical or productivity costs fluctuates with technological changes and medical advances, and the mix and level of foodborne illness costs may certainly change in the future. Mushkin (1979) argued that, over time, biomedical research, technological change and new diagnostics will result in proportionally higher medical costs, and she presented statistics indicating that, from 1900 to 1975, medical costs did rise as a proportion of total costs of illness. She found that, in 1900, medical costs of illness were 10 percent of total cost, while in 1975, they were 25 percent of the total.

Mushkin hypothesized that medical advances would lead to a reduction in human capital costs as a share of total costs of illness, and there are examples in which medical advances have almost eliminated human capital costs (for example, polio and smallpox). Where illness continues to result in high rates of premature mortality or disability, human capital costs still tend to outweigh medical costs, as is currently the case with most foodborne pathogens (see fig. 4). However, the relative size of the type of cost varies substantially by pathogen. For *Salmonella*, *Campylobacter jejuni*, and *Listeria monocytogenes*, medical expenditures account for 30-50 percent of total costs of illness, while for *Escherichia coli* O157:H7, medical expenses account for only 12 percent of total costs.

Figure 4
Costs of foodborne illness

1993 dollars (billions)



Initial Distribution of the Benefits of Reduced Foodborne Illness

For the HACCP SAM, the costs of foodborne illness estimates, as reported in figure 4, must be disaggregated further. The double-entry accounting system of the SAM framework requires that each flow be identified by sector of payment and sector of receipt. We must know who pays the costs of foodborne illness and who receives the payments. Those sectors or institutions that initially pay the costs of foodborne illness are the initial beneficiaries of reductions in foodborne illness. Those sectors or institutions that receive the payments initially suffer a drop in receipts if foodborne illness is reduced. The SAM simulation analysis traced the impact of these initial benefits as they trickled through the economy.

Sources of Data on Foodborne Illness

The Centers for Disease Control and Prevention (CDC) recently estimated that there are 76 million foodborne illnesses in the United States each year, resulting in 325,000 hospitalizations and 5,000 deaths (Mead et al., 1999). The CDC estimate is approximate because many foodborne illnesses are relatively mild and are not reported to public health agencies. Foodborne illnesses that require medical care are not always properly diagnosed. Public health agencies and health care providers consequently underestimate the actual incidence of foodborne illness, and also provide little or no information about the socioeconomic characteristics of persons who became ill.

The National Health Interview Survey (NHIS) provides alternative estimates of the incidence of foodborne illness, based on respondents' reports of health conditions, rather than on administrative records. The NHIS is a nationally representative annual survey of the U.S. civilian noninstitutional population conducted by the U.S. National Center for Health Statistics (NCHS) that inquires about health conditions in approximately 49,000 households (Benson and Marano, 1994.) Respondents are asked to report about the health of each household member for 2 weeks preceding the survey interview in order to minimize recall bias. NHIS also collects detailed information about family structure, income, employment, health insurance, and the impact of illness on work and other daily activities.

We pooled the 1992-1994 NHIS annual samples for this analysis to obtain more stable estimates of the incidence of foodborne illness by household category and income level. The pooled sample includes information on 354,000 persons, representing nearly 14,000 person-years of exposure to the risk of foodborne illness.

Foodborne illnesses were identified based on the standard ICD-9 codes assigned to each reported health condition by NCHS medical coders (Benson and Marano, 1994.) NHIS respondent reports tend to represent symptoms rather than medically diagnosed diseases, unless respondents had visited a physician who diagnosed their condition. Preliminary analysis of the NHIS data suggested that medical coders assigned most symptoms potentially due to foodborne pathogens to one of four general ICD-9 codes: food poisoning, unspecified (005.9); intestinal infections due to other organisms, not elsewhere classified (008.8); infectious colitis, enteritis, and gastroenteritis (009.0); or infectious diarrhea (009.2). Therefore, we defined foodborne illness as all acute conditions classified in one of these general codes, or in any one of 20 other specific codes corresponding to the six pathogens included in the ERS baseline estimates (003.0, 003.1, 003.2, 003.8, 003.9, 005.0, 005.2, 008.0, 008.41, 008.43, 27.0, and 130.0-130.9). Few acute conditions were classified under codes corresponding to other foodborne pathogens, so our definition of foodborne illness captured nearly all acute conditions due to foodborne pathogens.

To determine who initially pays the costs of foodborne illness, that is, who reaps the initial benefits of HACCP, we first determined the incidence and severity of illness in each household category. To measure the distribution of illness, we relied on respondents' reports of foodborne illness and acute health conditions resembling foodborne illness derived from the National Health Interview Survey (NHIS). The NHIS provides more information about the socioeconomic characteristics of persons who become ill than other sources of data on foodborne illness do (see box, *Sources of Data on Foodborne Illness*).[6]

The NHIS indicates approximately 13.5 million annual cases of foodborne illness and other acute conditions potentially caused by foodborne pathogens in the United States during 1992-94. In contrast, the Centers

[6] Perhaps a better source of such information is the FoodNet Population Survey, which identifies persons with diarrhea (a common symptom of foodborne illness).

for Disease Control and Prevention (CDC) recently estimated 76 million annual cases of foodborne illnesses in the United States (Mead et al., 1999). The NHIS estimate is not directly comparable with the CDC estimate because the NHIS counted only those cases severe enough to require at least half a day of restricted activity or a physician visit, whereas the CDC estimate includes all cases regardless of severity. The NHIS also excluded cases resulting in hospitalization or death because the survey did not cover hospitalized or deceased persons. Furthermore, the NHIS excluded cases among persons in nursing homes, prisons, and other institutions because the survey did not cover institutionalized populations. The NHIS estimate consequently includes only a subset of all foodborne illnesses in the United States.

Despite the shortcomings of the NHIS, it was the best available source of information on socioeconomic differences in the incidence of foodborne illness. For this study, we assumed that the distribution of foodborne illness among households revealed by the NHIS is similar to the distribution of foodborne illness due to the four pathogens included in the ERS HACCP benefit estimates (Buzby et al., 1996). In the absence of more comprehensive data with socioeconomic variations in foodborne illness, this assumption is not unreasonable.

The NHIS indicates that the incidence of foodborne illnesses and other acute conditions potentially due to foodborne pathogens varies by household type (table 5). The average annual number of cases per 1,000 persons during 1992-94 was highest in households with children (70). In contrast, the annual incidence rate was lowest in households with elderly heads of household (15.3). The reason for this low incidence rate is not entirely clear, although one factor may be because institutionalized persons are not included in the NHIS sample. Elderly persons in nursing homes may be in poorer health and therefore at greater risk of foodborne illness than the noninstitutionalized elderly, so the exclusion of the institutionalized elderly from the NHIS results in an underestimate of the incidence of foodborne illness among the elderly.

The NHIS also indicates that the average annual incidence of foodborne illness and other acute conditions potentially due to foodborne pathogens was slightly higher among the poor (60.1) than among the nonpoor (53). However, this difference was not statistically significant.

In contrast to the incidence of illness, there was little difference in the proportion of cases seen by physicians by either household type or income level. One

Table 5—Incidence of foodborne illness and other acute conditions potentially due to foodborne pathogens, 1992-94

Household characteristic	Average annual number of conditions per 1,000 persons		Conditions medically attended	
	Number		*Percent*	
Household type:				
With children	70.0	(3.7)	35.5	(3.6)
Without children	40.2	(3.7)	33.6	(6.2)
Elderly head	15.3	(3.3)	41.5	(16.5)
Income:				
Above poverty	53.0	(2.7)	35.1	(3.5)
Below poverty	60.1	(7.2)	36.4	(8.4)
Health insurance coverage:				
Public coverage	38.1	(4.2)	44.4	(8.7)
Private coverage	60.6	(3.7)	33.7	(4.1)
Uninsured	44.0	(7.7)	27.2	(10.4)
Total	52.9	(2.4)	35.3	(3.1)

Note: Standard errors shown in parentheses. Standard errors for individual years were calculated using the approximation method developed by NCHS (Benson and Marano, 1994). Standard errors for the 3-year pooled estimates assume that the correlation between annual estimates of acute conditions was equal to the mean correlation coefficient for the total population in 1982-84, the only period for which covariances between years have been reported (Bean and Hoffman, 1992). The standard errors are likely to be larger than the true standard errors because neither the NCHS approximation method nor the assumed correlation between annual estimates reflects the oversampling of Hispanics that began in 1992.

Source: 1992-1994 National Health Interview Survey.

explanation for this pattern may be that there is little difference in the degree of severity of illness. Alternatively, the propensity to visit a physician after becoming ill may vary within the population in a way that masks differences in the severity of illness.

The NHIS estimates provide a detailed picture of the distribution of foodborne illness and other acute conditions potentially due to foodborne pathogens severe enough to require physician care. The NHIS does not document which cases resulted in hospitalization or death, however. Since hospitalizations and deaths account for a substantial proportion of total costs of foodborne illness, assumptions about the distribution of hospitalizations and illness within the population may have a major impact on conclusions about the share of costs borne by different groups.

To determine the distribution of hospitalizations and deaths within the population, we assumed that the actual risks of hospitalization and death for persons who became sick enough to visit a physician were the same throughout the population. We also assumed that these risks were equal to the national-level risks implied by the estimates of physician-attended cases, hospitalizations, and deaths reported by the ERS baseline studies (Buzby et al., 1996). Using these assumptions, we allocated the total hospitalizations and deaths reported by Buzby et al. by household category. We distributed the initial benefits arising from reductions in the costs of illness according to this distribution.

The first two columns of table 6 present the distribution of human capital costs of foodborne illness. Because we used the human capital approach to measure the costs of foodborne illness, the costs of both work-loss days and premature death should be restricted to households with members in the labor force. Here we distributed these costs among households headed by a working-age adult to simplify the analysis. We recognize that some persons over age 64 still work, and that a small proportion of labor force participants age 18 to 64 are members of households headed by an elderly person (4 percent in 1992-94). Also, some households may have working-age adults but no labor-force participants. The third column of table 6 shows the distribution of medical expenses.

Having determined who initially pays the costs of illness (and reaps the initial benefits of reductions in foodborne illness), the next task was to determine who receives these payments (for example, who supplies the medical goods and services). The task of identifying a sector of receipt quickly reveals a fundamental difference between medical costs and productivity or human capital costs. Medical expenses are real flows, and both a payer and receiver can be identified. However, human capital costs are not flows. They are a pure drop in productivity and although a payer can usually be identified, a receiver cannot.

For medical costs, the sector of receipt was identified by extrapolation from Buzby et al. (1996). We esti-

Table 6—Initial distribution of the benefits of a reduction in foodborne illness, by household type

Household type	Benefits of reduction in premature deaths	Benefits of reduction in work-loss days	Benefits of reduction medical expenditures	Total benefits
	1993 dollars (billions)			
With children	3.99 (76%)	2.39 (76%)	3.54 (72%)	9.92 (74%)
Above poverty	3.26	1.95	2.87	8.08
Below poverty	.73	.44	.67	1.84
Without children	1.26 (24%)	.76 (24%)	1.13 (32%)	3.15 (24%)
Above poverty	1.12	.67	1.01	2.80
Below poverty	.14	.09	.12	.35
Elderly	0	0	.25 (5%)	.25 (2%)
Above poverty	0	0	.22	.22
Below poverty	0	0	.03	.03
Total	5.25 (100%)	3.15 (100%)	4.92 (100%)	13.32 (100%)
Above poverty	4.38	2.62	4.10	11.10
Below poverty	.87	.53	.82	2.22

Note: Percentages may not total to 100 due to rounding.

Table 7—Breakdown of medical expenses

Sector of receipt	1993 dollars (millions)
Medical services	4,000
Chemical	890
General manufacturing	1
Residential services	30
Total	4,921

mated that, of the $4.92 billion in total medical expenses, $4 billion was paid out to the Medical Services sector for medical care, $.89 billion to the Chemicals sector for pharmaceuticals, $1 million to the General Manufacturing sector for medical equipment, and $30 million to the Residential Services sector for rehabilitation and special education (table 7).

The Final Distribution of the Benefits of Reduced Foodborne Illness

The final distribution of benefits depends on households' economic reaction to the initial benefits and households' linkages with the rest of the economy. Direct medical costs and human capital costs have different kinds of impacts on the economy. Medical expenditures have direct and immediate impacts. These expenditures circulate throughout the economy, triggering economic activity and growth in some industries and reductions in others. Unlike direct medical costs, human capital costs do not entail economic flows that can be traced from one industry to another. Instead, these costs mark a pure drop in economic activity. In this section, we used the multiplier model to trace the impact of medical costs and human capital costs. For both types of costs, we attempted to identify the industries and households that ultimately benefit from reduced costs of foodborne illness.

Economic Impact of Reductions in Premature Death

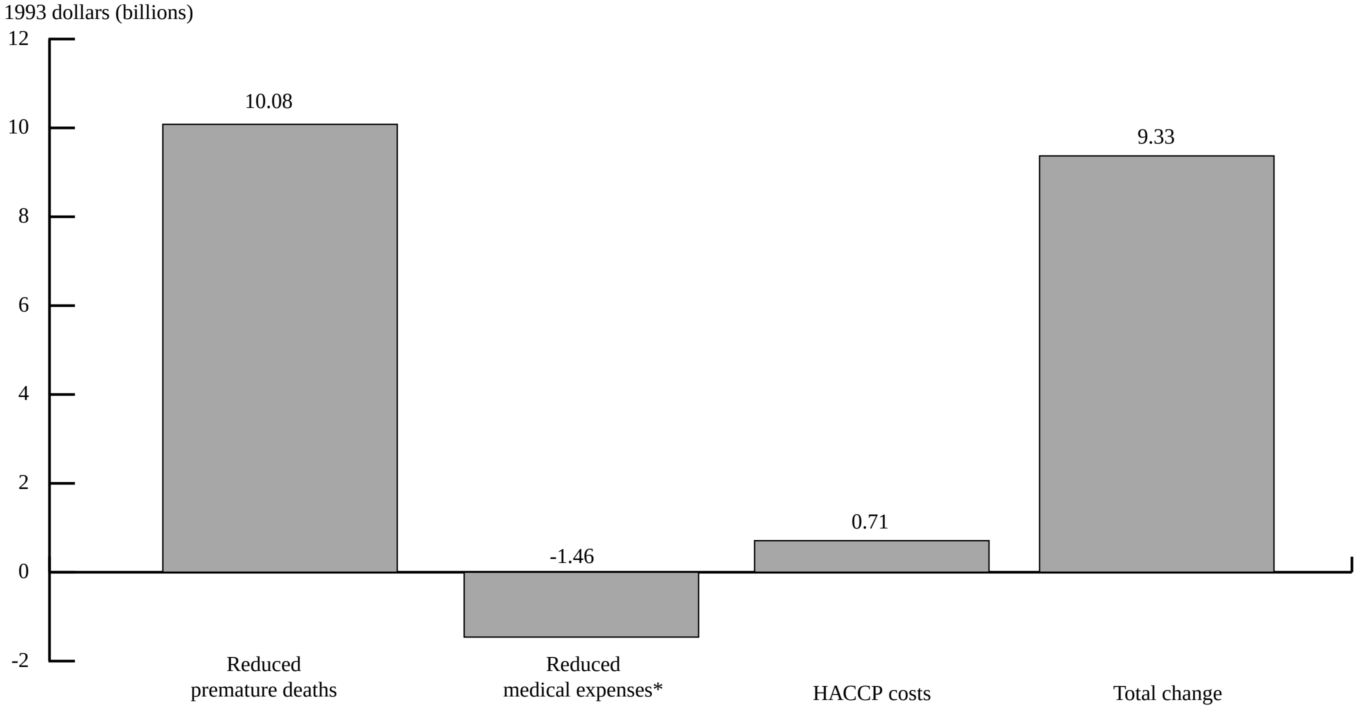
In the first simulation, we used the SAM model to trace the economic ramifications of the benefits of reductions in productivity losses due to premature deaths. In this simulation, the reduction in premature deaths initially resulted in increased household income. In other words, in keeping with the theoretical underpinnings of the human capital approach, the reduction in premature deaths resulting from HACCP translated into an increase in national income. This increase ($5.25 billion) was distributed among households according to the distribution described in the first column of table 6. This initial increase in national income did not represent the ultimate impact, because households responded to the initial increase in income by expanding consumption and savings. This expansion triggered further increases in economic activity extending far beyond the originally affected households.

The SAM multiplier model traced the impact of the initial increase in household income through its positive effects on consumer demand, industrial output, and factor payments. After the SAM model accounted for the general equilibrium impacts, the initial growth in household income due to the reduction in premature deaths resulted in a $14.31 billion increase in industrial output and a $10.08 billion increase in household income (fig. 5).[7] Thus, every dollar of income gained due to reduced premature deaths resulted in an economywide income gain of $1.92. These results demonstrate that premature death imposes substantial costs on society as a whole. In this simulation, the reduction in premature death led to an increase in household income nearly double the size of the initial increase.

The differences between the initial and final distribution of the benefits of reductions in premature deaths by household category are also noteworthy. Households with children gained a smaller percentage of benefits in the final benefits distribution than in the initial distribution, while childless households and elderly-headed households gained a higher percentage (table 8). In fact, although elderly-headed households were not allocated any initial benefits of reductions in premature deaths, they received 6 percent of the final benefits. These differences arose because, unlike the initial distribution of benefits, the final distribution did not mirror disease incidence, but depended instead on the linkages between households and the economy. A similar pattern appears when households above and below poverty are compared. Poor households realized 17 percent of the initial increase in income due to reductions in premature deaths, but only 9 percent of the final increase, reflecting the fact that lower income households have weaker factor-payment linkages to industrial production than other households. Conversely, upper income households with strong factor-payment linkages were more strongly affected by changes in the returns to labor and capital.

[7] The difference between output and income is accounted for by "leakages," such as taxes and government transfers.

Figure 5
Economic impact of HACCP on household income



*For this calculation, we averaged the results of the two simulation experiments involving reductions in medical expenditures.

Table 8—Final distribution of the impact of a reduction in foodborne illness, by household type

Household type	Benefits of reduction in premature deaths	Benefits of reduction in medical expenses paid by households	Benefits of reduction in medical expenses paid by insurance	Costs of HACCP	Total impact on household income[1]
	1993 dollars (billions)				
With children	5.75 (57%)	-.61 (46%)	-.74 (47%)	-.18 (47%)	4.90 (59%)
Above poverty	4.95	-.60	-.68	-.17	4.14
Below poverty	.80	-.01	-.06	-.01	.76
Without children	3.73 (37%)	-.70 (53%)	-.80 (51%)	-.19 (49%)	2.79 (34%)
Above poverty	3.58	-.69	-.72	-.19	2.68
Below poverty	.15	-.01	-.08	—	.11
Elderly	.60 (6%)	-.02 (1%)	-.03 (2%)	-.02 (4%)	.55 (7%)
Above poverty	.60	-.02	-.03	-.02	.55
Below poverty	—	0	—	—	—
Total	10.08 (100%)	-1.33 (100%)	-1.57 (100%)	-.39[2] (100%)	8.24 (100%)
Above poverty	9.13	-1.31	-1.43	-.38	7.38
Below poverty	.95	-.02	-.14	-.01	.86

Note: Percentages may not total to 100 due to rounding.
— = a quantity greater than zero, but less than $.01 billion.

[1] For the total calculations, the benefits of reduced medical expenses are calculated as the mid-point between columns 2 and 3.
[2] This amount represents the "real" decline in household income.

Economic Impact of Reductions in Work-Loss Days

As is the case with benefits arising from reductions in premature deaths, the impact of the initial distribution of the benefits of reduced work-loss days will likely be diffused and amplified once the general equilibrium effects of these productivity gains are calculated. The economic impact of time lost from work due to illness is more complex and difficult to interpret, however, than the impact of premature deaths. Column 2 of table 6 shows the initial distribution among households of benefits of reduced work-loss days based on incidence rates, but clearly, some, if not all, of the gain in productivity due to fewer work-loss days will be absorbed by industries.

Estimates of the incidence of foodborne illness and acute conditions resembling foodborne illness among workers are reported in table 9. Both the average annual number of cases per 1,000 persons and also the proportion of cases seen by physicians were lower among workers than among the general population, although neither difference was statistically significant. Workers reported losing about 6.6 million work days per year due to foodborne illness during 1992-94, or 56.1 work-loss days per 1,000 workers. The incidence of foodborne illness and work-loss days varied by industrial sector, although the differences between industries were not statistically significant due to the small size of the pooled NHIS sample. Food retail workers tended to have a higher rate of work-loss days than other workers, perhaps because they were at higher risk of foodborne illness (though many other explanations are possible, including stricter policies discouraging workers from reporting to work when ill). The high rate of work-loss days for public administration workers may reflect more generous sick-leave policies in the public sector than in the private.

Table 9—1992-94 National Health Interview Survey estimates of average, annual incidence of work-loss days, by industrial sector

Industrial sector	Work-loss days per 1,000 workers	
	Number	
Agriculture	20.6	(57.1)
Livestock	40.6	(71.4)
Fishing/hunting	0.0	(0.0)
Other primary	59.6	(94.5)
Construction	58.9	(33.8)
Food processing	53.8	(66.2)
Chemicals	71.9	(99.9)
Manufacturing	41.9	(18.0)
Transport/communications/utilities	19.6	(18.0)
Wholesale trade	31.5	(32.1)
Food retail	100.4	(40.4)
Other retail	33.7	(20.8)
Finance/insurance/real estate	66.3	(34.6)
Health services	69.5	(30.1)
Other services	45.9	(14.2)
Public administration	164.0	(61.6)
Total	56.1	(8.1)

Standard errors shown in parentheses, based on NHIS method for calculating approximate standard errors. Workers with industry unknown are excluded. Between-year correlations are assumed to equal zero for workers and .02 for work-loss days.

The economywide impact of productivity gains from reductions in time lost from work depends on the ultimate allocation of these benefits between industry and households. This allocation in turn depends on a number of industry-specific characteristics, notably sick-leave benefits. Modeling the relationship between industry and labor was beyond the scope of this report, and we did not simulate the impact of reduced work-loss days with our SAM model. However, whether these productivity gains are passed on to households through labor income, capital income, or lower prices, they will likely result in an increase in economic activity similar to the one modeled with reductions in premature deaths.

Economic Impact of Reductions in Direct Medical Expenses When These Expenses Are Paid By Households

We next used the SAM multiplier model to trace the economywide impact of reductions in medical expenditures due to foodborne illness when these expenses were paid directly by households. In the first step of this simulation, households reduced their demand for medical goods and services by $4.92 billion. To mirror this decrease in demand, we reduced output of $4 billion from the Medical Services sector for medical care, $.89 billion from the Chemicals sector for pharmaceuticals, and $30 million from the Educational Services sector for rehabilitation and special education. These savings were then redistributed back to households according to the original distribution of medical expense reductions reported in column 3 of table 6. In this expenditure-switching simulation, we allocated the additional consumption of other goods according to household consumption coefficients for each good. Households were assumed to spend or save these savings from reductions in medical expenses in the same way they spent other income.

After the SAM model accounted for the general equilibrium effects of the decrease in medical expenditures, there were net *decreases* of $1.6 billion in industry output and $1.33 billion in household income. Thus, every dollar of medical expenses saved as a result of HACCP led to an economywide income *loss* of $.27. The consumption of medical goods and services due to illness apparently triggered growth in the economy that outweighed the economic decrease due to reduced household spending on nonmedical goods and services. In other words, the medical expenditures precipitated by foodborne illness led to an increase in economic activity. Redirecting these expenditures to other goods and services resulted in a decrease in economic activity. The explanation for this result is that, in general, medical goods and services use a very high proportion of domestically produced inputs and have relatively stronger links to the domestic industrial structure.

Although economic activity may decrease with a reduction in foodborne illness, this decrease in income does not necessarily mean that households are worse off. Most people would undoubtedly prefer to avoid foodborne illness rather than to get sick and take the cure in order to generate economic activity. This result highlights the need to refine the methodology to account for changes in well-being not captured by income measures alone. The seemingly perverse positive effect of defensive expenditures (such as medical expenditures and pollution cleanup costs) on national accounts has been well documented by environmental economists (Lutz, 1992).

As shown by comparing tables 6 and 8, the ultimate decrease in household income triggered by the decrease in medical expenditures was distributed differently than the initial distribution of the reduction in medical expenses. Higher income households, which have stronger factor-payment links to the economy, bore a larger share of the decrease in economic activity than lower income households, which have weaker links to the economy. In fact, households with incomes below the poverty level bore only 1.5 percent of the decrease in household income triggered by increased medical expenditures, although their members comprised 16 percent of the population.

Economic Impact of Reductions In Direct Medical Expenses When These Expenses Are Paid By Health Insurance

In the above simulation, medical expenses were paid directly by households. However, in the United States, most households have health insurance provided by either private insurers or government insurance programs like Medicare and Medicaid. The economic ramifications of out-of-pocket versus third-party payments is quite different. To examine the economic impact of reducing medical expenses when they are covered by private or public medical insurance, we used additional information from the NHIS to classify households into one of three health insurance categories, based on the coverage of individual household members:[8]

(1) Households with public coverage: one or more household members had Medicaid, Medicare, or other public health coverage, regardless of whether any members had private coverage.

(2) Households with private coverage: at least one household member was covered by a private health plan, and all other members were uninsured.

(3) Households without coverage: no household member had either public or private coverage.

This classification distinguishes households whose health care costs were wholly or partially subsidized by public programs from households protected by private insurers and households lacking any kind of coverage. Public coverage took precedence in the classification in order to identify all households receiving public funds.

Medicare was considered public coverage because most Medicare beneficiaries elect optional Part B coverage, which is subsidized by the Federal Government. This approach differs from the classification developed by Paulin and Weber (1995), which treats Medicare as

[8]The focus on health insurance reduced the size of the NHIS sample available for analysis by approximately one-sixth, because the survey questions about health insurance coverage were not administered during the first half of 1993.

Table 10—Households, by health insurance type

Health insurance type	Households with children	Households without children	Elderly	All households
	Percent			
Public insurance	23	11	96	30
Private insurance	65	74	3	60
Uninsured	12	16	1	10
Total	100	100	100	100

Note: Health insurance type excludes households that could not be classified because of incomplete data.

private coverage. Military health coverage was treated as private coverage because military dependents and retirees included in the NHIS sample received coverage as an employment benefit. Single-purpose hospitalization plans covering only hospital charges were also counted as private coverage, following Bloom et al. (1997).

The majority of nonelderly households fell into the private insurance category (see table 10). Sixty-five percent of households with children and 74 percent of households without children had private coverage. In contrast, elderly households depended almost exclusively on public health insurance coverage, reflecting the role of Medicare in providing health care for the elderly.

Note that the three health insurance categories we used capture only some differences in sources of payment for health care. Many households with public coverage also had private coverage, notably so-called medigap policies for costs not covered by Medicare. Some households with private coverage paid less out-of-pocket for health care than others because they had more comprehensive policies, or because their employers paid a larger share of the premium. Finally, some uninsured households may have had better access than others to health care providers who reduce their fees for low-income patients and then shift the unreimbursed cost to public payers (through government subsidies or charitable deductions) or private payers (through higher charges). As a result, our conclusions about the effects of health insurance provide only a very general indication of the way that health insurance may affect economic activity.

We used the information from the NHIS on the distribution of illness by household insurance category (table 5) to distribute the $4.92 billion dollars in medical-expenditure savings. Households with private coverage accrued a much larger share of total savings ($3.19 billion) than households with public coverage ($1.39 billion) and households without coverage ($.34 billion). Thus, the availability of health insurance changes the linkages examined in the earlier simulation. Most important, the fact that nearly one-third of medical expenses were incurred by households with public or no coverage linked these savings to taxpayers.

We used the SAM multiplier model to trace the impact of reductions in direct medical costs when third-party payers (private insurers or the government) paid the bills. The initial drop in medical expenses for publicly insured and uninsured households was deducted from medical sectors and distributed back to households as "tax cuts." Specifically, the $1.73 billion reduction in the medical expenses of publicly insured and uninsured households was distributed back to households above poverty. These households increased their consumption and saving accordingly. The initial impact of the reduction in medical costs for privately insured households was represented by a $3.19 billion decrease in costs for the insurance sector. We modeled the decrease in costs for the insurance sector by diverting insurance sector expenditures from the purchase of medical goods and services to the purchase of other goods and services, as indicated by the expenditure coefficients in the SAM.

The final impact of the decrease in medical expenses paid by third parties was a decrease in economic activity. The decrease in output was similar, though slightly larger, when medical expenses were paid by third-party payers, $1.85 billion, than when they were paid out of household income, $1.6 billion. Similarly, the decrease in total household income was $1.57 billion when medical expenses were paid by third-party payers, and $1.33 billion when expenses were paid out of household income. Every dollar of medical expenses paid by third-party payers resulted in an economywide income loss of $.32, as opposed to a loss of $.27 when households paid expenses out of pocket.

The final distribution of the decrease in household income resulting from third-party payments of medical expenses differed from the initial distribution of foodborne illness for two reasons (table 8). First, medical expenses were paid by insurance companies and taxpayers rather than by households, thus diffusing *initial* cost reductions throughout the economy. Second, the decrease in economic activity resulting from lower medical expenditures was shared among household factor payments, thus diffusing the *final* decrease in income throughout the economy. When medical expenses were paid by third-party payers, the link between the initial distribution of illness and the distribution of the economic impacts was broken because both the initial and final impacts of foodborne illness were diffused throughout the economy. As a result of the greater diffusion, the final distribution of economic impacts differed from the distribution that prevailed when expenses were paid out of household income.

The final impact of a reduction in medical expenses on the economy probably falls between the two cases analyzed here because households and third-party payers share medical expenses. Regardless of the exact mix between household payments and insurance and government payments, the SAM multiplier simulations indicate that the ultimate impact of a reduction in medical expenses is a decrease in economic activity.

Tracing the Costs of HACCP

Tracing the costs of HACCP implementation is seemingly less complex than tracing the benefits of reductions in foodborne illness. Although there may be debate about which costs to include in the HACCP analysis, all possible types of costs entail straightforward flows from one sector of the economy to another. Calculating the ultimate impact of the costs of HACCP on the economy simply requires determining the types of costs triggered by HACCP and the sectors of payment and receipt. This scenario, however, is complicated by the problem of how ultimately to distribute the increase in production costs incurred by meat and poultry slaughterhouses due to HACCP implementation. Are these costs absorbed by industry, thereby decreasing profits and investment? Or, are these costs passed on to intermediate and final purchasers in the form of higher meat and poultry prices? In the long run, it is reasonable to assume that these costs are passed on to consumers as higher prices. Unfortunately, a SAM is a fixed-price model, so simulating the effects of price changes is not straightforward. In the following simulation, we worked around the limitations of the SAM model to illustrate the ultimate impact on the general economy of meat and poultry price increases triggered by HACCP implementation costs. Again, we caution the reader to interpret this simulation as a pedagogical exercise and not as a new estimate of HACCP costs and benefits.

Initial Distribution of HACCP Costs

The initial costs of HACCP accrue both to meat and poultry slaughterers and processors in the form of increased production costs and also to the Federal Government in the form of increased FSIS supervision costs. The mid-point estimates of the distribution of costs, as calculated by Crutchfield et al. (1997) are shown in table 11, second column.

Table 11—Breakdown of HACCP costs

Regulatory component	Cost estimates[1]	Expenditures (Percent of regulatory component)[2]	
	1993 dollars (millions)		*Percent*
Sanitation Standard Operating Procedures	175	Storage	1
		Labor	99
Microbial testing generic *E. coli* testing	175	Laboratory supplies	18
		Laboratory labor	37
		Other labor	45
Compliance with *Salmonella* standards	153	Chemicals	5
		Laboratory supplies	15
		Labor	80
HACCP plan			
Plan development	56	Labor	97
Annual plan review	9	Travel	2
Recordkeeping	449	Storage	1
Initial training	23		
Recurring training	22		
Additional overtime	18	Labor	100
FSIS costs	58	Labor	99
		Laboratory supplies	1
Total	1,138		

[1] Crutchfield et al. (1997) average cost estimates converted to 1993 dollars. These costs are the present value of 20 years of HACCP costs; they include both initial and yearly costs.

[2] Extrapolations from USDA, FSIS, 1995 and 1996.

The expenditures entailed with the regulatory activities listed in table 11 include a wide range of goods and services. For industries, the major expenditure is for increased labor. Additional expenditures include document storage, travel to classes, and specimen collection supplies. For FSIS, most of the increased expenditures are also for labor.[9] Columns 3 and 4 of table 11 outline our estimates of specific expenditures arising from HACCP implementation. These estimates were extrapolated from FSIS's regulatory impact analysis for HACCP (USDA, FSIS 1995, and 1996).

Final Distribution of HACCP Costs

Like medical expenditures, the costs of implementing HACCP had direct and immediate impacts on the economy. These expenditures circulated throughout the economy, triggering economic activity and growth in some industries and reductions in others. We simulated the initial impact of these costs on the economy in two steps. First, we traced the $1.1 billion increase in implementation costs for HACCP to the industries or factors supplying goods and services to meat and poultry slaughterers and processors and to FSIS. We estimated that of the $1.1 billion, $66 million went to paying Medical Services (laboratory labor), $8 million to Chemicals, $54 million to General Manufacturing (laboratory supplies), $4 million to Other Services, $9 million to Transportation and $997 million to Labor. Second, we assumed that all cost increases were paid by consumers of beef and poultry. Consumers paid $1.1 billion more for beef and poultry; however, this money did not trigger an increase in demand for inputs into beef and poultry slaughter but was used instead by industry to cover the costs of HACCP. We simulated this cost increase by increasing industry expenditure on Medical Services, Chemicals, General Manufacturing, Other Services, Transportation, and Labor, as outlined above.

To absorb the impact of higher beef and poultry prices, households reduced expenditures on other goods and services. We modeled the impact of the increase in meat and poultry prices by forcing households to reduce expenditures on other goods and services by an amount equal to their increased expenditures for beef and poultry. We calculated average meat and poultry expenditures by household group and apportioned the "income decrease" (the $1.1 billion increase in meat and poultry costs) according to these average shares.[10]

After the SAM model accounted for general equilibrium effects, the ultimate impact of these costs was a *decrease* in output of $.36 billion and a decrease in household income of $.39 billion. Every dollar spent on HACCP resulted in an economywide income *loss* of $.35. However, these changes do not tell the whole story. The simulation illuminated the impact that increased costs and increased meat and poultry prices have on the general economy, but in order to achieve these results with a fixed-price model, we shocked the model with a decrease in household income. In essence, we modeled the real income effects of price increases—the effect of the increase of beef and poultry prices on household purchasing power. To calculate the actual nominal impact on household income, i.e., to keep nominal household income constant, we added $1.1 billion back to household income, meaning that the final impact on household income was actually an increase of $.71 billion. The spread between real and nominal results serves as yet another reminder of the potential incongruence between a monetary accounting of economic activity and measures of well-being. In figure 5, we report the nominal results of this simulation (with the $1.1 billion added back into household income).

Table 8, column 4 traces the distribution of the decrease in real household income—the decrease that is indicated by the SAM multiplier model. The distribution of this decrease in household income reflects the labor market ties of the household groups. Households below poverty incurred only 3 percent of the decrease in economywide income, although that group comprised 16 percent of the population; and elderly households incurred only 4 percent of the decrease, although they were 20 percent of the population.

[9] Jensen, Unnevehr, and Gomez (1998) show a different breakdown of factors and inputs. They calculated that electricity and water were more important components of cost than labor. Their breakdown of costs would have a different impact on economic activity than the one we examined.

[10] A more theoretically consistent approach would have been to recalculate expenditures given the price change, create a new SAM with the recalculated expenditures, and then compare the multipliers of the new and old SAM models. Our approach illustrates an approximation of this procedure that is valid for small shocks, such as the one triggered by HACCP implementation.

Conclusion

The SAM multiplier analysis reveals that the ultimate economic impact of the benefits and costs of HACCP differs substantially from the initial impact. The initial costs and benefits triggered by HACCP circulate throughout the economy, expanding economic activity in some sectors and reducing activity in others. The simulations conducted here represent only one set of possible scenarios and were designed to provide information on the market mechanisms by which the benefits and costs of HACCP affect the economy. In particular, we highlighted the qualitative differences in the way different types of benefits and costs work through the economy.

On the benefit side, the SAM simulations indicated that every dollar of income saved by preventing a premature death from foodborne illness resulted in an economywide income *gain* of $1.92. Every dollar of household income saved by reducing medical expenses resulted in an economywide income *loss* of $.27 and every dollar of private and public insurance expenses saved by reducing medical expenses resulted in an economywide income *loss* of $.32.

On the cost side, the simulations indicated that every dollar spent on HACCP resulted in an economywide income loss of $.35. This stems from the increased costs of beef and poultry production due to HACCP being passed on to consumers in such a way that households incurred a decrease in real income equivalent to the costs of HACCP implementation. When we held nominal income constant, economywide income actually rose by $.65 for every dollar spent on HACCP. The spread between the real and nominal results serves as yet another reminder of the potential gap between a monetary accounting of economic activity and measures of well-being.

We summarized the simulation results in figure 5. The simulation results indicate that the net economic impact of the costs and benefits of HACCP on household income was an increase of $9.33 billion (1993 dollars). If we included the benefits of reduced work-loss days, these net benefits would be greater.

The SAM multiplier model extends the initial cost-benefit analysis to account for the full economic impact of HACCP on producers and consumers. Such an accounting indicates who ultimately benefits from improved health outcomes and who ultimately pays the costs of food safety regulation. Our SAM simulations found substantial differences between the initial and final distributions of the costs and benefits of HACCP. HACCP triggered economic activity in industries supplying HACCP inputs and an increase in the demand for labor at slaughterhouses and process plants. Conversely, reduced foodborne illnesses resulted in a decrease in economic activity for medical services and supply industries.

The ultimate increases in economic activity and economywide income were distributed back to households, particularly those with strong factor linkages with the economy. Economic feedback effects and private and public insurance diffused the benefits of reductions in foodborne illness throughout the economy. Households with children received 59 percent of the increase in income, households without children received 34 percent, and elderly households received 7 percent. Poor households received only 10 percent of the increase although their members composed 16 percent of the population.

The SAM accounting of the final impact of costs and benefits of HACCP provides useful information for policymakers by indicating the direction and magnitude of the economic flows resulting from regulation costs and subsequent reductions in foodborne illness. The SAM multiplier model also focuses attention on the difficulty of assessing the economic value of health. The SAM analysis demonstrates the usefulness of the cost-of-illness approach in deciphering the economic distortions caused by health shocks to the economy, and the danger of equating changes in income with changes in well-being.

References

Bean, J.A., and K.L. Hoffman. 1992. "Covariances for Estimated Totals When Comparing Between Years," *Vital and Health Statistics*. Centers for Disease Control and Prevention, National Center for Health Statistics. Series 2, No. 114.

Benson, V., and M.A. Marano. 1994. "Current Estimates from the National Health Interview Survey, 1993," *Vital and Health Statistics*. Centers for Disease Control and Prevention, National Center for Health Statistics, Series 10, No. 190.

Bloom, B., G. Simpson, R.A. Cohen,, and P.E Parsons. 1997. "Access to Health Care, Part 2: Working Age Adults," *Vital and Health Statistics*. Centers for Disease Control and Prevention, National Center for Health Statistics, Series 10, No. 197.

Buzby, J., T. Roberts, C.-T. J. Lin, and J. MacDonald. 1996. *Bacterial Foodborne Disease: Medical Costs and Productivity Losses*. Agricultural Economic Report No. 741, Economic Research Service, U.S. Department of Agriculture.

Centers for Disease Control and Prevention, National Center for Health Statistics. 1990. *Public Use Tape Documentation, Part III—Medical Coding Manual and Short Index*. Hyattsville, MD: National Center for Health Statistics.

Council for Agricultural Science and Technology. 1994. *Foodborne Pathogens: Risks and Consequences*. Task Force Report, No. 122: September.

Crutchfield, S., J. Buzby, T. Roberts, M. Ollinger, and C.-T. J. Lin. 1997. *An Economic Assessment of Food Safety Regulations: The New Approach to Meat and Poultry Inspection.* Agricultural Economic Report No. 755, U.S. Department of Agriculture, Economic Research Service.

Hanson, K., S. Vogel, E. Golan, and J. Olmsted. Forthcoming. *A Computable General Equilibrium Model for Analyzing Welfare Reform.* Agricultural Economic Report, U.S. Department of Agriculture, Economic Research Service, Food and Rural Economics Division.

Jensen, H., L. Unnevehr, and M. Gomez. 1998. "Costs of Improving Food Safety in the Meat Sector." Presented at the Southern Agricultural Economics Association meetings. Little Rock, AR. Jan. 31–Feb. 3.

Knutson, R., H. R. Cross, G. Acuff, L. Russell, J. Nichols, L. Ringer, J. Savell, A. Childers, Jr., and S. Wang. 1995. *Reforming Meat and Poultry Inspection: Impacts of Policy Options.* Institute for Food Science and Engineering, Agricultural and Food Policy Center, Center for Food Safety, Texas A&M University System.

Kuchler, F., and E. Golan. 1999. *Assigning Values to Life: Comparing Methods for Valuing Health Risks*. Agricultural Economic Report No. 784, U.S. Department of Agriculture, Economic Research Service.

Landefeld, J.S., and E.P. Seskin. 1982. "The Economic Value of Life: Linking Theory to Practice," *American Journal of Public Health* (6):555-566.

Lutz, E. (ed.). 1992. *Toward Improved Accounting for the Environment.* Washington, DC: World Bank.

Mead, P.S., L. Slutsker, V. Dietz, L.F. McCaig, J.S. Bresee, C. Shapiro, P.M. Griffin, and R.V. Tauxe. 1999. "Food-Related Illness and Death in the United States." *Emerging Infectious Diseases*, 5(5): 607-25.

Mushkin, S. J. 1979. *Biomedical Research: Costs and Benefits.* Cambridge, MA: Ballinger Publishing Company.

Mushkin, S. J. 1962. "Health as an Investment," *Journal of Political Economy*. (70):129-157.

Paulin , G.D., and W.D. Weber. 1995. "The Effects of Health Insurance on Consumer Spending," *Monthly Labor Review*. (118):34-54.

Pyatt, G., and J. I. Round. 1985. *Social Accounting Matrices: A Basis for Planning.* Washington, DC: International Bank for Reconstruction and Development

Robinson, J.C. 1986. "Philosophical Origins of the Economic Valuation of Life," *The Milbank Quarterly*. (64):133-155.

Tolley, G., D. Kenkel, and R. Fabian (eds.). 1994. *Valuing Health for Policy*. Chicago, IL: University of Chicago Press.

U.S. Department of Agriculture, Food Safety and Inspection Service. 1995. "Pathogen Reduction; Hazard Analysis, and Critical Control Points (HACCP) Systems: Proposed Rule." *Federal Register*, Part II, 60 (23): 6774-6889. Feb. 3.

U.S. Department of Agriculture, Food Safety and Inspection Service. 1996. "Pathogen Reduction; Hazard Analysis, and Critical Control Points (HACCP) Systems: Final Rule." Supplement-Final Regulatory Impact Assessment for Docket No. 93-016F. May 17.

U.S. Department of Commerce, Bureau of Economic Analysis. 1994. "Benchmark Input-Output Accounts for the U.S. Economy, 1987." *Survey of Current Business.* 74(4).

Viscusi, W.K. 1993. "The Value of Risks to Life and Health." *Journal of Economic Literature.* 31(4): 1912-1946.

United States Department of Agriculture

Economic Research Service
1800 M Street, NW
Washington, DC 20036-5831

http://www.ers.usda.gov