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 ($\mathbf{z}$) equals a vector of total output, ($\mathbf{Bz}$) equals the sum of endogenous demands, and ($\mathbf{x}$) equals exogenous demands. The shares matrix ($\mathbf{B}$) 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:

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

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 ($\Delta\mathbf{z}$) summarizes *for all firms, factors, and households* in the economy the direct effects due to the shock itself ($\Delta\mathbf{x}$) 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)
Commodity:												
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
Married households with no children (by income class):												
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.