A Procedure For Determining Food and Fiber Output, Employment, and Value-added by Agricultural Sector

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"Supply creates its own demand"

Say's Law, the much maligned building block of Classical Economics continues to be quoted not because it is universally applicable, but because it describes a phenomenon commonly observed. From the movie, "Field of Dreams" 's "Build it and they will come." to new products like cellular telephones, we see the belief that if a product or service is supplied, consumers of the product or service will appear and use it. Economic statistics can be subject to the same phenomenon. When the Economic Research Service (ERS) began estimating the income and employment generated in the Food and Fiber System [Lee, et. al., 1987] the series was quickly accepted as part of the Federal data system. It was published in the Statistical Abstract of the United States from 1987 to 1994 and in various ERS publications since. This new source of information generated demand for similar estimates related to particular commodities (e.g., Otto and Lawrence for hogs, a mid-1980's Wharton study of the tobacco industry, some private groups' assessment of the U.S. beef industry reported in the popular press, etc). A concern with these studies is their additivity to an economically supportable whole. In this paper we outline the conceptual and measurement issues involved in making these estimates. We further propose and estimate a procedure for disaggregating ERS's Food and Fiber

System estimates by agricultural sector.

The US Food and Fiber System

The conceptual basis for measuring the size of the Food and Fiber System (FFS) relies heavily upon the fact that most farm production goes directly into domestic personal consumption of food, clothing, and tobacco or the export market. Also included in the system but at much smaller relative values are net inventory change, consumption of flowers, seeds, and potted plants, government purchases of farm commodities, farmers' capital expenditures and imported food and fiber products. By tracing the nation's final demand for domestic and foreign agricultural commodities, estimates of national income and employment which originate in the farm sector are measurable.

The first step in building a FFS estimation model is to define the products and final demands of the system. ERS defines the final demands of the system as (1) domestic consumers' expenditures for food, (2) domestic consumers' expenditures for clothing, shoes, tobacco products, flowers, seeds, and potted plants, (3) net agricultural and textile exports, and (4) the value of farm inventory change and the value of changes in off-farm private and government stocks of farm commodities (Table 1).

Estimating supporting activity

Once ERS identifies the final demands of the Food and Fiber System, they follow the tradition of Davis and Goldberg and use this information as exogenous demands for an input-output model. Professors John Davis and Raymond Goldberg of the Harvard Business School in 1957 first used input-output analysis to measure the total contribution of the farm sector to the economy. The professors coined the term "agribusiness," to convey a sense of all the businesses that support the delivery of food, clothing and shoes, tobacco, flowers and agricultural exports to their final consumers. Since that time ERS economists have adopted this generic definition. Under our use the measurement has evolved, expanded, and been refined to better capture farm related activity. Some of the changes are: measuring the effects of imported food and fiber products, including farm capital expenditures, and incorporating exports of apparel - the values of which were negligible during the time of the original Davis and Goldberg study. ERS researchers renamed this expanded measurement the Food and Fiber System. ERS includes activities that support farm capital expenditures as part of the business activity that supports the FFS because maintaining the capacity to produce farm products requires periodic replacement of and additions to the farm

TABLE 1. COMPONENTS OF FINAL DEMAND, 1996

[BILLIONS OF 1992 DOLLARS]

			TOTAL
PERSONAL	1.	OFF PREMISE CONSUMPTION (food)	379.2
CONSUMPTION	2.	OFF PREMISE CONSUMPTION (alcohol)	55.5
EXPENDITURES	3.	PURCHASED MEALS AND BEVERAGES	246.6
(FOOD)	4.	FOOD FURNISHED TO EMPLOYEES	8.0
	5.	FOOD PRODUCED & CONSUMED ON FARMS	.4
		SUBTOTAL	689.7
OTHER	6.	TOBACCO	46.8
PERSONAL	7.	SHOES	37.6
CONSUMPTION	8.	CLOTHING	229.9
EXPENDITURES	9.	FLOWERS	14.4
		SUBTOTAL	328.7
NET EXPORTS	10.	RAW AGRICULTURAL EXPORTS	19.4
	11.	PROCESSED AGRICULTURAL EXPORTS	32.3
	12.	RAW AGRICULTURAL IMPORTS	-5.6
	13.	PROCESSED AGRICULTURAL IMPORTS	-22.4
	14.	APPAREL EXPORTS	8.5
	15.	APPAREL IMPORTS	-55.0
		SUBTOTAL	-22.8
OTHER	16.	LIVESTOCK INVENTORY CHANGE	-1.5
FOOD & FIBER	17.	CROP INVENTORY CHANGE	3.0
DEMANDS	18.	OTHER FINAL DEMANDS	-0.8
	19.	FARM CAPITAL EXPENDITURES	12.3
		SUBTOTAL	13.0
TOTAL	1-19		1008.6

capital stock of machinery, equipment, and structures.

Using the identified sales of the various industries that contribute to the final output of the Food and Fiber System, ERS employs input-output analysis to estimate the level of supporting economic activity required from each sector of the economy to produce this final output of the Food and Fiber System. Specifically, following the United Nations System of National Accounts conventions, ERS calculates:

$$X = (I-BW)^{-1}Y, \quad (1)$$

where X is an $n * m$ matrix of outputs generated by a corresponding level of final demands; $(I-BW)^{-1}$ is an n * n commodity by commodity total requirements matrix; Y is an $n * m$ matrix of final demands of the food and fiber system disaggregated and bridged to the sector of origin; m is the number final demand categories, 19 for this analysis; and n is the number of economic sectors, 491 for this analysis.

Ideally when estimating Food and Fiber income and employment, one wants only the income associated with personal consumption expenditures (PCE) and exports of clothing and shoes from natural materials. Man-made and natural fibers often get blended in textile and clothing manufacturing, leather and man-made materials often get blended in footwear manufacturing, and

even the unblended products often get grouped together in consumption statistics. With this fuzzing of the distinction between the use of man-made and natural materials there is not likely to be a simple cost-effective way of making the desired adjustment. We have devised such an adjustment procedure.[1]

It is at this point, where ERS has an X matrix as adjusted by the man-made fibers procedure, that we begin our sharing out of total output generated by food and fiber final demands to the seventeen agricultural input-output sectors.

Sharing FFS output or "How do you handle Campbell's Vegetable Beef Soup?"

The analysis and discussion to this point have been rather standard input-output-based analysis. Input-output is a demand-driven economic model. We defined a set of Food and Fiber System demands and defined a Food and Fiber System using a modified I/O analysis of the output required to meet these demands. To go to a lower level of identification, e.g., defining output related to a particular commodity or agricultural sector, using this procedure, one encounters intractable classification and data problems. One would need to classify the set of Food and Fiber System demands by commodity or agricultural sector. "Oh," you might say, "That's easy. PCE for milk is Farm Dairy Products,

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PCE for fresh vegetables is Vegetables, PCE for vegetable beef soup is ... Oh, I see the problem." The challenge is to choose a proxy which captures the demand basis essence of these unobservable agricultural sector demand allocations. The proxy we chose to use was the relative distribution of the sixteen agricultural sectors (excluding Farm Forest Products) in a given column of the total requirements matrix. We chose this proxy because these coefficients are the agricultural sector output generated per dollar of final demand. Accepting that a sector that provides supporting output for a final demand indicates a linkage between that sector and that final demand (we also would be more comfortable with a direct demand linkage than an indirect indication of demand linkage), this procedure provides a mechanism to allocate the generated food and fiber system output to the individual agricultural sectors.

If the 491 by 19 ($n * m$) matrix X of equation (1) can be thought of as a loaf of bread, our allocation procedure - equation (2) below, is an attempt to slice it into seventeen pieces. Each piece is also 491 by 19 but of a "thickness" which is in proportion to the actual importance or value of economic activity that is generated by that input-output sector.

To accomplish this, we start with the inverse or total requirements, $(I-BW)^{-1}$, matrix of equation (1), a 491 by 491 square matrix. Using only the first 17 rows of this matrix, each of the nth columns are summed and then divided by its total

making a new 17 by 491 matrix of proportions, all of which sum to one.[2] There were fourteen columns in this matrix which consisted of zeros. In these cases proportions were used which best reflected the makeup of that sector. For example, there were zeroes in the knit outerwear mills sector, input-output code 180201, the proportions from the apparel made from purchased materials and dressed furs sector (180400) were substituted.

These proportions are applied to each cell in the nth row of X. In the case of the mth column of the nth row of X, the first cell of the resulting 17 by 1 column vector is assigned to row n, column m of X^1, the matrix of outputs for the first I/O sector 010100 (dairy). The second cell is assigned to row n, column m of X^2, I/O sector 010200 (poultry) etc. After calculating all seventeen partitioned output matrices, they are each modified as in equations (3) and (4) to generate estimates of employment and value-added.

Specifically we calculate:

$$X^k_{nm} = \frac{c_{ik}}{\sum_{i=1}^{17} c_{ik}} X_{nm} \qquad (2)$$

where c_{ik} is a total requirement coefficient from $(I\text{-}BW)^{-1}$.

To estimate FFS employment in a year other than that in

[2] Farm Forest Products, I/O sector 020701 produces no primary output, i.e. its output is products primary to the forest sector not the farm sector. To eliminate noise from this secondary production, we zeroed the total requirements coefficients for this sector for all nonfarm columns prior to this calculation of shares.

which a benchmark I/O table has been published and to accommodate for the unavailability of all pertinent information, equation (1) can be modified:

$$E = pL(I-BW)^{-1} Se \qquad (3)$$

where E is an $n * m$ vector of sector employment needs for meeting the outputs of the food and fiber system; p is an n element diagonal matrix of current year sector labor productivity relative to the base year; L is an n element diagonal matrix of employment needs per dollar of sector output; $(I-BW)^{-1}$ is as previously defined; S is an $n * m$ matrix of sectoral shares of food and fiber system demand category j; $j = 1,...,m$; $E^{n}_{i=1}\ s_{ij}=1$; s_{ij} is an element of matrix S; e is an $m * 1$ vector of real expenditures of m categories of FFS demands.

If during the period between the base year and the current year the underlying assumptions of I/O analysis (constant relative prices, fixed input coefficients, etc.) are violated sufficiently to bias our estimate, a gross adjustment for nonfarm sectors employment should be made. To adjust for these changes, we compute:

$$GDP = v(I-BW)^{-1} C\ gdp \qquad (4)$$

where GDP is an *n* * 1 vector of estimated gross domestic product originating by sector; *v* is an *n* element diagonal matrix of sector gross domestic product per dollar of output in the base year; $(I-BW)^{-1}$ is as defined before; C is an *n* * *k* share matrix like S but inclusive of all categories of the national income and product accounts, not just FFS; *k* is the number of categories, 23 for this analysis; and *gdp* is a *k* * 1 vector of constant dollar expenditures by national income and product account categories.

We use the 491-sector U.S. input-output table to make our estimates of total Food and Fiber output. For the ease of presentation in summarizing the results of this analysis, these 491 sectors are aggregated into eight main categories of food and fiber output and employment (Table 2). The categories consist of one category of direct farm production of raw agricultural commodities (farming); two categories of farm product manufacturing (food processing and textiles); trade; transportation; a category of direct distribution of processed products to consumers (eating places); a category of supporting manufacturing inputs (such as food packing materials); and an eighth category that includes service industries and all others not included in the previous seven.

These eight categories encompass the entire domestic economy. Individual jobs within these categories include a range of activities from grain elevator operators or barge captains in

a small town to waiting on tables and supermarket checkers in a big city. Most job categories, either directly or indirectly support the food and fiber system. It is the output from these job categories and economic activities that satisfies food and fiber final demand. This analysis does not include Government workers and household workers (maids, butlers, etc)

Table 2 presents estimates of employment and value-added generated in the FFS for the 17 originating sectors and eight categories of economic activity in 1996. Of the 24.3 million FFS workers, 2,396,000 support the Dairy sector. Within that sector 199,000 of these are farm workers, 147,000 food processing workers, and 1,061,000 were workers in eating and drinking places.

Either in terms of employment or income the Meat Animal, Feed Crop, and Greenhouse and Nursery sectors are the largest sectors in the Food and Fiber System. Because the first two sectors include major agricultural commodities and the latter high value nursery products, this may not surprise.

Summary and Conclusions

We presented a preliminary procedure for allocating the Food and Fiber System output, income, and employment to component agricultural sectors. Our procedure maintains additivity for component sectors. Our procedure maintains secondary linkage relationships, e.g. feed crops which provide feed for meat

animals (wool and mohair) was the forth most important agricultural sector providing support to textile output. Our procedure is preliminary, we welcome comments on our allocation procedure or suggestions for alternative procedures.

TABLE 2. EMPLOYMENT AND VALUE-ADDED WITHIN EIGHT SECTOR CATEGORIES OF THE FOOD AND FIBER SYSTEM AND SEVENTEEN ORIGINATING SECTORS, 1996

EMPLOYMENT		(1,000 WORKERS)							
I/O CODE	SECTOR	FOOD : FARMING	OTHER PROCESSING	TEXTILES	SERVICES & MANUFACTURING	OTHER	EATING TRADE	TRANSPORTATION	PLACES TOTAL
010100	DAIRY	199	147	5	65	247	612	62	1061
2396									
010200	POULTRY	129	151	7	75	229	614	41	512
1759									
010301	MEAT ANIMALS	342	207	107	206	677	1765	138	2156
5598									
010302	MISC. LIVESTOCK	14	30	103	48	113	158	17	118
599									
020100	COTTON	12	8	755	132	178	294	32	20
1431									
020201	FOOD GRAINS	105	135	5	62	78	151	18	164
717									
020202	FEED CROPS	374	299	60	351	680	1397	116	1238
4514									
020203	GRASS SEEDS	2	1	0	5	35	44	4	6
98									
020300	TOBACCO	117	0	0	46	4	10	0	0
178									
020401	FRUITS	97	97	1	20	84	183	24	315
821									
020402	NUTS	16	20	0	3	13	20	2	25
98									
020501	VEGETABLES	81	77	2	29	121	272	30	510
1123									
020502	SUGAR CROPS	14	64	1	7	33	130	7	111
367									
020503	MISC. CROPS	7	28	5	28	45	72	9	26
219									
020600	OILS CROPS	104	136	13	102	178	434	34	241
1242									
020701	FOREST PRODUCTS	1	0	0	0	0	0	0	0
1									
020702	GRNHSE / NRSRY	46	15	13	191	828	1887	71	53
3103									

	TOTAL	1660	1415	1077	1370	3543	8043	605	6556
24264									

VALUE-ADDED	:	($MILLIONS)							
I/O CODE	SECTOR	: FARMING	FOOD PROCESSING	TEXTILES	OTHER MANUFACTURING	SERVICES & OTHER	TRADE	TRANSPORTATION	EATING PLACES
TOTAL									
010100	DAIRY	2184	12644	125	4178	15789	22545	3497	24268
85230									
010200	POULTRY	2319	6827	203	4628	11934	25430	2309	11717
65367									
010301	MEAT ANIMALS	6178	10744	2882	12196	44756	58870	7785	49335
192746									
010302	MISC. LIVESTOCK	176	1494	2945	3029	6066	6075	942	2693
23420									
020100	COTTON	1625	731	22052	8527	9822	12036	1832	447
57072									
020201	FOOD GRAINS	5153	13759	146	4563	4753	5743	987	3752
38857									
020202	FEED CROPS	19247	31134	1668	24066	42814	51728	6700	28334
205691									
020203	GRASS SEEDS	220	155	13	314	2687	1453	237	147
5227									
020300	TOBACCO	1446	7	2	22667	271	376	25	4
24797									
020401	FRUITS	3486	9717	34	1266	5274	6894	1301	7205
35176									
020402	NUTS	935	1815	6	203	791	738	115	563
5166									
020501	VEGETABLES	6745	6194	55	1881	7631	9953	1706	11675
45840									
020502	SUGAR CROPS	1277	5556	18	460	2036	4424	384	2550
16707									
020503	MISC. CROPS	228	4063	140	1945	4045	2580	521	604
14127									
020600	OILS CROPS	7346	12072	379	6945	10688	17585	1898	5520
62435									
020701	FOREST PRODUCTS	315	0	0	0	0	0	0	0
315									
020702	GRNHSE / NRSRY	5262	1459	369	12951	62539	67079	4029	1216
154904									

TOTAL	64142	118371	31037	109819	231896	293509	34268	150030	1033077

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