



AgEcon SEARCH
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search
<http://ageconsearch.umn.edu>
aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

Staff Paper No. 128

Revised: August 1987

Forward and Backward Linkages:
Implications for Ag-Related Employment

D. K. Klinko*

J. L. Findeis*

Staff Papers are circulated without formal review
by the Agricultural Economics and Rural Sociology
Department. Content is the sole responsibility
of the authors.

Agricultural Economics and Rural Sociology
College of Agriculture
The Pennsylvania State University
University Park, PA 16802

Paper presented at the 1987 Annual Meeting of the American Agricultural
Economics Association, East Lansing, Michigan, August 2-5, 1987.

*The authors are, respectively, Graduate Research Assistant and Assistant
Professor of Agricultural Economics, Department of Agricultural Economics and
Rural Sociology, The Pennsylvania State University, University Park, PA.

Forward and Backward Linkages:
Implications for Ag-Related Employment

Abstract

Forward and backward linkages in the U.S. food production and distribution system in 1972 and 1977 are measured utilizing a technique that sequentially assesses forward linkages without double-counting of backward linkages. The employment implications of changing export and domestic consumption final demand on forward and backward linkages are examined.

Forward and Backward Linkages: Implications for Ag-Related Employment

Introduction

While the number of farms in the U.S. has declined steadily over time leading to fewer farm families and fewer individuals self-employed in agricultural production, employment throughout the U.S. food and fiber system is significant and continues to increase overall (Rosenberg). In 1983 the agricultural production sector alone employed 2.6 million individuals as hired farmworkers (Pollack, p. 2), in addition to the on-farm labor provided by farm family members. The primary agricultural production sectors also stimulate direct and indirect output through backward linkages to input suppliers. Employment is thus stimulated in other industries by agricultural production.

In addition, the agricultural production sectors like many resource-based industries such as mining and forestry have strong forward linkages. Industries with strong backward linkages to the food production sectors depend integrally on the supply of raw agricultural products. These industries generate additional ag-related employment from direct and indirect output effects through backward and forward linkages to other interdependent sectors. These impacts are in addition to the backward linkages attributable to agricultural production. In the U.S., the food processing and manufacturing industry represents a strong first linkage from the food production sectors. The food retailing industry represents a second strong forward linkage. The extent to which labor resources are employed will depend in part on the employment potential at each link.

The output and employment effects in the food production and distribution system depend on output final demand. Export and domestic consumption final demands determine the value of output sold by each linked sector in this

system. Changes in export final demand and domestic consumption of raw farm products, processed farm products, and food retailing services affect the employment actually created. The overall impact on employment reflects the levels of export and domestic consumption final demand for output produced by each linked industry, the extent of backward linkages, and the employment/output technical coefficients of all industries producing output to satisfy final demand.

In this study, the employment directly and indirectly attributable to the alternative levels of the U.S. food production and distribution system are examined for 1972 and 1977 based on the 1972 and 1977 U.S. Input-Output Accounts (U.S. Department of Commerce; Ritz et al.). The output and employment impacts resulting from the loss of export markets for raw and processed agricultural output during the 1980's are then examined to determine the extent to which these events affected employment induced through the U.S. food system.

Approach

In the literature there has been considerable discussion over the measurement of forward linkages as well as over multipliers that account for "total effects" where forward linkage effects are explicitly considered (Bulmer-Thomas; Jones; Boucher; Lee; Augustinovics). In an input-output framework, the direct and indirect effects associated with the backward linkages from a particular sector can be easily measured. However, the accounting of effects associated with the forward linkages is less straight forward and can potentially lead to double-counting of effects. Double-counting can be avoided by utilizing techniques that sequentially "switch off" particular sectors while accounting for the effects of other linked sectors. The approach used here is based on a technique developed by Hartoorne that

accurately measures the direct and indirect effects of forward and backward linkages attributable to each of n levels of closely linked industries. These sectors could be the farm production sectors, the food processing and manufacturing sectors, and the food retailing sectors of the U.S. economy.

The approach considers each of n levels of linked sectors sequentially, with the direct and indirect output effects attributable to each linkage measured by "switching off" backward linkage effects attributable to industries already accounted for. Thus, the total effects of the farm production sectors are considered first. These sectors are then switched off and the effects of the food processing and manufacturing sectors are considered next. Lastly, the effects attributable to the food retailing industry are considered, with the agricultural production and processing sectors switched off to avoid double-counting. The linked sectors can be sequentially switched on and off by the use of selection vectors (s_i) and rest vectors (r_i), defined for each of the n levels of linked industries (i.e., $i = 1, 2, \dots, n$).

This technique is conceptually similar to the use of output restrictions (or exogenously determined output levels) discussed in Johnson and Kulshreshtha, Milana, and Findeis and Whittlesey. The concept was extended to the measurement of forward and backward linkages by Henry and Schluter in a model partitioning the farm production sectors from the nonfarm sectors in the U.S. food and fiber system. The approach used here further disaggregates the linkage-induced effects and allows for the straightforward assessment of the output, value-added and employment impacts associated with each of a series of forward linkages.

Methodology

If the farm production sectors are considered as the first link ($n = 0$) in the agricultural product production chain, the total output required from all industries to support the "core" industry (i.e., food production) can be represented as:

$$Z_0 = [s_0(I-A)^{-1} + (I-r_0Ar_0)^{-1} r_0As_0(I-A)^{-1}] Y \quad (1)$$

where:

s_0 = selection vector in diagonal matrix form for the farm production sectors;

A = matrix of technical coefficients;

r_0 = rest vector in diagonal matrix form for the farm production sectors;

Y = final demand vector;

Z_0 = vector of total output effects (direct and indirect) attributable to core industry activity.

The selection vector, s_0 , is a diagonal matrix with elements equalling 1 for the farm production sectors and 0 elsewhere on the diagonal. The rest vector, r_0 , is the complement of s_0 .

Equation (1) can be interpreted most readily if the two components, $s_0(I-A)^{-1}$ and $(I-r_0Ar_0)^{-1}r_0As_0(I-A)^{-1}$, are separately considered. The expression

$$s_0(I-A)^{-1} \quad (2)$$

can be used to find the total output (direct and indirect) required from the farm production sectors. The expression

$$(I-r_0Ar_0)^{-1}r_0As_0(I-A)^{-1} \quad (3)$$

then represents the total backward linkage effects from the core. Together, the sum of (2) and (3) represent a transformed interdependence coefficients

matrix that translates final demand (or components of final demand) into output requirements by the core industry.

When linkages from the core industry, such as the first forward linkage from the farm production sectors to the food manufacturing and processing sectors, are considered, the economic activity induced by backward linkages from the farm production sectors is excluded. To accomplish this, selection and rest vectors are again utilized. To assess the output and employment effects attributable to the first forward linkage (solely), the effects directly induced by the first forward linkage are summed with the backward linkage effects exclusively attributable to the first forward linkage. The backward linkage effects from the farm production sectors are excluded, even though agricultural output is a key direct input. Similar procedures can be utilized to examine the second ($n = 2$), third ($n = 3$), and n^{th} levels of forward linkages. For each level, the direct and indirect effects at each forward linkage can be represented by:

$$s_n(I - r_{n-1}A r_{n-1})^{-1} \quad (4)$$

where r_{n-1} is the complement of s_{n-1} plus all previous selection vectors. Equation (4) is similar in interpretation to (2), except that the direct and indirect effects attributable to the $n-1$ previous linkages have been excluded.

The backward linkages directly and indirectly attributable to the n^{th} forward linkage can be found by using

$$(I - r_n A r_n)^{-1} r_n A s_n (I - r_{n-1} A r_{n-1})^{-1} \quad (5)$$

Summing (4) and (5) will yield the total effects attributable to the n^{th} linkage. Therefore, the output (direct and indirect, all sectors excluding previous linkages) can be found as follows (Hartoorne):

$$Z_n = [s_n(I - r_{n-1}Ar_{n-1})^{-1} + (I - r_nAr_n)^{-1}r_nAs_n(I - r_{n-1}Ar_{n-1})^{-1}]Y \quad (6)$$

In this study the first forward linkage ($n = 1$) from the farm production sectors (livestock and livestock products; other agricultural products) include the food processing and tobacco manufacturing sectors (food and kindred products and tobacco manufactures). A second forward linkage ($n = 2$) from the core industry is also considered, the linkage through the food processing industry to the food retailing industry. Alternative export scenarios are then assessed to determine the sectoral impacts on output and employment induced by linkages in the U.S. food production and distribution system.

Ag-Related Output and Employment

The direct and indirect employment induced by the linkages in the U.S. food production and processing sectors is shown in Tables 1 and 2 for 1972 and 1977, respectively. Each table compares the employment effects from exports to the effects from domestic consumption. The direct and indirect effects at each link are indicated as well as the employment effects of backward linkages attributable to each link.

Employment due to export final demand for agricultural output from the three levels of ag-related linkages equalled 393,170 jobs in 1972 and 700,040 jobs in 1977. Of the 393,170 jobs stimulated by export final demand in 1972, 204,460 jobs were due to direct and indirect effects in the linked sectors comprising the food production and distribution system. An additional 188,710 jobs were in the backward linked industries dependent on the food production and distribution system. In 1977, 349,640 jobs stemmed from the direct and indirect effects of export final demand and 350,400 jobs were required in the backward linked industries.

Table 1. 1972 Employment Effects Attributable to Forward and Backward Linkages in the U.S. Food Production and Distribution System.

	Attributable To Exports (000 jobs)	Attributable To Domestic Consumption (000 jobs)
I. Food Production: Direct and Indirect Effects		
Unprocessed	66.80	108.36
Incorporated by Food Processing	30.40	733.71
Incorporated by Food Retailing	0	128.85
Incorporated by Other Industries	5.11	80.77
Food Production: Backward Linkage Effects		
Unprocessed	90.06	123.53
Incorporated by Food Processing	28.54	669.65
Incorporated by Food Retailing	0	118.62
Incorporated by Other Industries	5.18	83.76
II. Food Processing: Direct and Indirect Effects		
Processed	51.77	1,306.06
Incorporated by Food Retailing	0	211.03
Incorporated by Other Industries	6.23	84.18
Food Processing: Backward Linkage Effects		
Processed	52.06	1,184.40
Incorporated by Food Retailing	0	182.96
Incorporated by Other Industries	5.47	733.65
III. Food Retailing: Direct and Indirect Effects		
Retailing	0	2,662.18
Incorporated by Other Industries	44.16	544.18
Food Retailing: Backward Linkage Effects		
Retailing	0	446.34
Incorporated by Other Industries	7.40	91.24

Table 2. 1977 Employment Effects Attributable to Forward and Backward Linkages in the U.S. Food Production and Distribution System.

	Attributable To Exports (000 jobs)	Attributable To Domestic Consumption (000 jobs)
I. Food Production: Direct and Indirect Effects		
Unprocessed	193.75	162.67
Incorporated by Food Processing	47.05	666.55
Incorporated by Food Retailing	0	122.30
Incorporated by Other Industries	7.95	96.69
Food Production: Backward Linkage Effects		
Unprocessed	170.18	159.36
Incorporated by Food Processing	52.63	761.90
Incorporated by Food Retailing	0	139.61
Incorporated by Other Industries	8.36	100.73
II. Food Processing: Direct and Indirect Effects		
Processed	84.70	1,200.77
Incorporated by Food Retailing	0	193.59
Incorporated by Other Industries	7.74	85.89
Food Processing: Backward Linkage Effects		
Processed	97.28	1,390.29
Incorporated by Food Retailing	0	225.14
Incorporated by Other Industries	9.00	99.89
III. Food Retailing: Direct and Indirect Effects		
Retailing	0	3,703.29
Incorporated by Other Industries	8.45	756.44
Food Retailing: Backward Linkage Effects		
Retailing	0	561.13
Incorporated by Other Industries	12.95	114.62

In comparison to exports, final demand for domestic food consumption has a greater impact on employment in the U.S. In 1972, almost one million jobs were attributable to production activity in the food production sectors from backward linkages alone. In 1977, 5.41 million jobs were supported by food production and processing, with an additional 5.14 million jobs induced by the food retailing sector. More jobs are required to support domestic consumption final demand in the U.S. relative to foreign exports due to the larger amount of output sold domestically and the fact that more domestically consumed food products are processed. Processing creates additional jobs.

Export-Induced Employment

Although in both 1972 and 1977 export final demand created less employment in the U.S. than domestic consumption of food products and services, a significant number of jobs in the U.S. are dependent on food exports, raw and processed. A majority of these jobs are in the food production sector. Between 1977 and 1981, the deflated value of agricultural exports increased by approximately 24 percent, stimulating additional employment as a result. However, this situation was short-lived. Between 1981 and 1986, exports of U.S. agricultural products decreased by approximately 50 percent. At the same time agricultural imports to the U.S. have increased.

The impacts of declining exports on ag-related employment attributable to forward and backward linkages can be readily measured using the methodology to measure the sequential effects of forward linkages. The net impacts on the U.S. food production and distribution system of increasing exports (1977-81) and decreasing exports (1981-86) are shown in Table 3. The changes are based on the 1977 U.S. I-O Accounts.

Table 3. Employment Impacts from Decline in Deflated Value of U.S. Farm Exports, 1977-86.

	<u>Employment and Change in Employment</u>	
	<u>Attributable To</u> 1977 Exports and Domestic Consumption (000 jobs)	<u>Change</u> Due to Declining Exports (1977-86) (000 jobs)
I. Food Production: Direct and Indirect Effects		
Unprocessed	356.42	-50.4
Incorporated by Food Processing	713.60	-12.2
Incorporated by Food Retailing	122.30	- 0.0
Incorporated by Other Industries	104.64	- 0.0
Food Production: Backward Linkage Effects		
Unprocessed	329.54	-44.2
Incorporated by Food Processing	814.53	-13.7
Incorporated by Food Retailing	139.61	- 0.0
Incorporated by Other Industries	109.09	- 0.0
II. Food Processing: Direct and Indirect Effects		
Processed	1,285.47	-22.0
Incorporated by Food Retailing	193.59	- 0.0
Incorporated by Other Industries	93.63	- 0.0
Food Processing: Backward Linkage Effects		
Processed	1,487.56	-25.3
Incorporated by Food Retailing	225.14	- 0.0
Incorporated by Other Industries	108.89	- 0.0
III. Food Retailing: Direct and Indirect Effects		
Retailing	3,703.29	- 0.0
Incorporated by Other Industries	764.89	- 0.0
Food Retailing: Backward Linkage Effects		
Retailing	561.13	- 0.0
Incorporated by Other Industries	127.57	- 0.0

As shown in Table 3, declines in the value of U.S. agricultural exports in the range of the decreases witnessed over the 1977-86 period generally have small direct and indirect impacts on industry employment except in the food production sector, and to a lesser extent in the food processing sector. As a result of declining exports, employment in the food production sectors declined by 50,000 jobs. Due to the reduction in export final demand, employment in those industries with forward linkages to the food production sectors also decreased significantly. These industries supply inputs to the farm production sector.

Summary and Conclusions

Forward and backward linkages in the U.S. food production and distribution system in 1972 and 1977 are measured utilizing a technique that sequentially assesses forward linkages without double-counting of backward linkages. The methodology allows for the disaggregation of linkages within a production chain, such as the food production and distribution system.

The employment generated in the food production and distribution system and in those industries with linkages to this system is large. A significant proportion of the employment created by the food production, food processing and manufacturing, and food retailing sectors is due to production and processing of food commodities for domestic consumption. The employment created by export demand is significantly smaller. This results because approximately 63 percent of the value of exports from the food production and processing sectors is sold as raw output. The additional jobs (and value-added) created through processing are not realized.

These observations mean that when the value of exports decline, employment losses principally affect the agricultural production sectors as well as the suppliers of farm inputs to the food production sectors. As shown in Table 3, the employment impacts on these sectors are significant.

References

- Augustinovics, M. "Methods of International and Intertemporal Comparison of Structure" in A. P. Carter and A. Brody (eds.), Contributions of Input-Output Analysis. Amsterdam: North Holland. 1970.
- Boucher, M. "Some Further Results on the Linkage Hypothesis." Quarterly Journal of Economics. 90(1976):313-18.
- Bulmer-Thomas, V. Input-Output Analysis in Developing Countries. Chichester: John Wiley & Sons. 1982.
- Crane, J. F. "Employment and Employee Compensation in the 1972 Input-Output Study," BEA Staff Paper No. 38. 1982.
- Findeis, J. L. and N. K. Whittlesey. Competition Between Irrigation and Hydropower Water Use in Washington State. State of Washington Water Research Center Report 44, Washington State University and the University of Washington. 1982.
- Harthoorn, R. "Backward and Forward Linkages With an Application to the Dutch Agro-Industrial Complex." Paper presented at the Eighth International Conference on Input-Output Techniques, Sapporo, Japan. July/August 1986. (UNIDO Reprint)
- Henry, M. and G. Schluter. "Measuring Backward and Forward Linkages in the U.S. Food and Fiber System." Agricultural Economics Research. 37,4(1985):33-39.
- Johnson T. and S. K. Kulshreshtha. "Exogenizing Agriculture in an Input-Output Model to Estimate Impacts of Alternative Farm Types." Western Journal of Agricultural Economics. 7(1982):187-98.
- Jones, L. P. "The Measurement of Hirschmanian Linkages." Quarterly Journal of Economics. 90(1976):323-33.
- Lee, K. C. "Input-Output Multipliers With Backward, Forward and Total Linkages." Paper presented at the Eighth International Conference on Input-Output Techniques, Sapporo, Japan, July/August 1986. (UNIDO Reprint)
- Milana, C. "Direct and Indirect Requirements for Gross Output in Input-Output Analysis." Metroeconomica. XXXVII,3(1985):283-292.
- Pollack, S. L. The Hired Farm Working Force of 1984: A Statistical Profile. Agricultural Economic Report No. 554. USDA/ERS. 1986.
- Ritz, P. M., E. P. Roberts, and P. C. Young. U.S. Department of Commerce, Bureau of Economic Analysis. "Dollar-Value Tables for the 1972 Input-Output Study." Survey of Current Business. 59,4(1979):51-74.

Rosenberg, H. R. "Getting Work Done: Labor Issues in the Food and Fiber System." The Farm and Food System in Transition: Emerging Policy Issues. Cooperative Extension System, Michigan State University. 1987.

U.S. Department of Commerce, Bureau of Economic Analysis "Employment and Employee Compensation in the 1977 Input-Output Accounts." Survey of Current Business. 65,11(1985):11-25.

_____. "The Input-Output Structure of the U.S. Economy, 1977." Survey of Current Business. 64, 5(1984):42-84.