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Errata

	Present	Correct
Page 5, Table 2 and Page 6, Table 3: Last column heading:	Total Farms 1978	Total Farms 1974
Page 5, Table 2: Row label, last row:	Total, 1974	Total, 1978

In This Issue

An economist is an expert who will know tomorrow why the the things he predicted yesterday didn't happen today. — *Laurence J. Peter*

This tongue-in-check definition of an economist by the originator of the Peter Principle pokes good-natured fun at the imprecision of the economics profession. Denied the luxury of controlled laboratory experiments to develop and verify their theories, economists must rely on their observations of the real world to develop, verify, or refute economic hypotheses proffered to explain the economic forces operating in the real world. And, if the economic forces operating in the real world weren't subject to change, the economics profession wouldn't continually need to anticipate and explain the changes. Therefore, Peter should not be surprised if economists are occasionally found explaining how what had previously seemed a logical prediction was actually well off the mark. Explaining these misses is not the useless exercise of rationalizing with perfect hindsight implied by Peter, but rather part of the continuing development of human, intellectual, and professional capital in a profession whose theories can be no more static than the human capabilities and potentials upon which they are based.

In the lead article, Edwards, Smith, and Peterson introduce formerly unavailable data from the *Census of Agriculture* which suggest a reevaluation of previously held beliefs about the size structure of U.S. farms. After decades of falling farm numbers and farms' growing by absorbing neighboring farms, many observers perceived this pattern was the norm. Structural issues were prominent in public policy debates in the mid- to late seventies. A popular view was that this movement toward fewer and larger farms would continue unchecked, barring public intervention to stem the tide. According to the recently available data used by Edwards, Smith, and Peterson, the size structure of the U.S. farm sector had already stabilized even as this public policy debate raged over future farm structure. The authors use this new evidence of a more stable structure in a Markov analysis to examine implications for future farm size structure if the 1974-78 stability persists rather than our seeing a return to previous trends.

In the following article, which concerns the effect on public intervention in the market process, Folwell, Mittelhammer, Hoff, and Hennessy examine the effect of the Federal marketing order on hops. They find evidence that the order stabilized acreage, production, and nominal prices, but not enough statistical evidence is available to conclude that either real or nominal sales or real prices were more stable in the Federal order period.

Shifting themes from incorporating surprising new data and the effect of public intervention in the market process, Henry and Schluter attempt to develop meaningful summary statistics of the myriad transactions involved in the production, assembly, processing, and distribution of raw food and fiber in the U.S. economy. Summary statistics are the indicators economists use to alert them to changing economic forces. And, changing economic forces can make formerly useful summary statistics obsolete and induce a search for more meaningful replacements.

In the final article, Boxley returns to the issues of farm structure. His topic, farmland ownership and the distribution of land earnings, reminds us there are more actors in farmland utilization decisions than just farm operators, and he reviews some characteristics of tenant-operated farms and farm landlords. From his perspective, Boxley broadens the number of factor owners affected by farm policy choices and illustrates the complications in assessing the impacts of public intervention in the market process.

The science of economics and economic inquiry is not precise. Changing economic and social conditions and direct interventions by governments can alter the economic environment, undermine current analysis, and make predictions risky.

In this issue our profession is ably represented in refuting Peter's image of economists.

Gerald Schluter

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The Changing Distribution of Farms by Size: A Markov Analysis

By Clark Edwards, Matthew G. Smith, and R. Neal Peterson*

Abstract

Farm numbers and average farm size in the United States have held about constant since the 1974 Census, but the proportion of mid-sized farms has decreased. This pattern follows four decades of a strong trend toward fewer and larger farms. Markov analysis is a standard procedure for projecting changes in the number and distribution of firms in an industry based on observations of recent changes. Previous applications to the U.S. farm sector have met with difficulty because of a lack of appropriate data. This article applies Markov analysis to a recently available longitudinal data set for 1974-78 from the Census of Agriculture. The model predicts reasonably well the actual changes during 1978-82 and indicates that the future distribution of farms by acres per farm will be more like the present than the present is like the past.

Keywords

Markov, agriculture, distribution, projection, size of farm, structure

The number of farms in the United States reached a peak in the thirties and then declined. The 1935 Census of Agriculture reported 6.81 million farms; by 1974 the number had dropped to 2.31 million, an average annual decrease of 2.73 percent. If the 1935-74 trend is projected to 2000, the number of farms decreases substantially to about 1.13 million. Total land in farms changed little, so the average farm size increased rapidly during 1935-74, and the distribution of farms by acres per farm shifted steadily toward the larger size classes. The number of farms between 50 and 259 acres declined from 1935 on; the number of farms between 260 and 499 acres continued to increase until the midfifties and then began to decline; and the number of farms between 500 and 999 acres peaked in the 1969 Census of Agriculture. The trend during 1935-74 characterized an agricultural industry whose firms were steadily becoming fewer in number and larger in size.

During the seventies this pattern changed. The last three Censuses of Agriculture, 1974, 1978, and 1982, show little change in farm numbers with no appreciable change in average farm size between 1974 and 1982. In 1982, there were 2.24 million farms, an average annual rate of decrease of only 0.4 percent since 1974. If the 1974-82 trend is projected to 2000, the number of farms moderately decreases to about 2.08 million.

The distribution of farms by size continued to evolve, however. The number of farms of 1,000-1,999 acres peaked in 1978 and then declined in 1982, but the number of farms of 2,000 acres or more continued to increase. Farms of fewer than 50 acres began increasing in number in 1974, reversing the longstanding decline.[1] The experience of the seven-

*The authors are economists with the National Economics Division, ERS. They received helpful comments from Dave Freshwater, Charlie Hallahan, Bill Lin, Lester Myers, Agapi Somwaru, Lloyd Teigen, and Mike Weiss. John Blackledge and staff at the Agriculture Division, Bureau of the Census, helped in data acquisition and processing.

[1]All U.S. summary data for 1978 used in this analysis were adjusted by the Census of Agriculture from totals published in the 1978 Census of Agriculture to account for the effects of the direct enumeration of sample areas conducted in 1978. The adjustments make the data from the 1978 Census more nearly comparable to those from prior and subsequent Censuses. Without the adjustments, the number of farms in 1978 was slightly larger, and farms with fewer than 50 acres declined between 1978 and 1982. All 1978 summary data used in this analysis were drawn from the adjusted totals published in the 1982 Census volumes.

ties thus suggested a somewhat different future for U.S. agriculture: a relatively stable number of farms moving toward a bimodal structure with a large and increasing proportion of small farms, a small but increasing proportion of large farms, and a decreasing proportion of midsized farms.

This article analyzes changes in size among individual U.S. farms during 1974-78 to explore the process of structural change in U.S. agriculture. How strong a trend toward bimodality is reflected by recent data? What sort of future structure do the changes imply?

Markov Analysis of Structural Change

A variety of methods may be used to project the structure of an industry on the basis of historical data. Among these are simple trend extrapolation (linear or nonlinear), age cohort analysis, dynamic systems simulation, and Markov analysis. Each of these procedures offers advantages and disadvantages depending on the context of inquiry, the nature of the system under study, and the data available (*10*).[2] Markov analysis is well suited to examining shifts among classes of farm size. However, the data requirement is stringent, and most Markov analyses of U.S. agriculture have employed imputed data. This study applies Markov analysis to unique, recently available data from the Census of Agriculture covering 1974-78.

A finite Markov chain is one in which a population at time t has the distribution S^t over the discrete states, $S_1, S_2, \ldots S_n$, and in which the probability P_{ij} of moving from state S_i at one point in time to state S_j at a later time is dependent only on the initial state S_i and not on any prior state. The transition probabilities P_{ij} form the transition probability matrix P, where $\sum_j P_{ij} = 1$ and $P_{ij} \geq 0$ for all i and j. Together with an initial distribution of states S^t, these properties completely define a finite Markov chain (*8*).[3]

One can obtain the distribution of states after one time interval S^{t+1} by multiplying the initial distribution vector S^t by the transition probability matrix P. Let S^t be a row vector; then $S^{t+1} = S^tP$. One can obtain the distribution of states after k intervals S^{t+k} by multiplying the initial distribution vector S^t by the matrix P^k, that is, P raised to the k^{th} power; $S^{t+k} = S^tP^k$. The appendix shows how to evaluate S^{t+k} when k is any rational fraction. The system converges toward an equilibrium distribution as k approaches infinity. In a Markov process the equilibrium distribution depends only on the transition probability matrix and is independent of the initial distribution.

In economic analysis, use of the Markov chain carries several important assumptions. First, a continuous variable such as farm size may reasonably be classified into discrete states, and the choice of states does not appreciably affect the results. Second, the specified transition probabilities remain constant over time. Third, a process that is continuous may be modeled as occurring at discrete points in time, and the choice of time intervals does not appreciably affect the results. Markovian projections represent the implications of behavior observed during a given period persisting into the future. This representation implies that the exogenous conditions affecting the observed behavior—for example, shocks from a food or energy crisis, or relative rates of unemployment and wages affecting entry and exit—would also persist.

Markov analysis has been used frequently in agricultural economics research. Farris and Padberg projected the structure of the Florida citrus packing industry, based on actual longitudinal data (*6*).

Several researchers have employed Markov analysis to investigate the implications of structural change in the U.S. farm sector. Krenz projected the distribution of farms in North Dakota by size in acres to the year 2000 (*9*). Daly, Dempsey, and Cobb projected U.S. farms by sales class to the year 2000 (*3*). Lin, Coffman, and Penn projected U.S. farms by both acreage and sales class, also to the year 2000 (*10*). Those three farm structure studies were not based on longitudinal data. Transition probabilities were imputed from published Census data. The assumptions made in imputing transition probabilities have a substantial impact on the behavior of the resulting Markov system. In each study the transition matrices were assumed to be upper triangular; that is, farms were assumed to grow or

[2]Italicized numbers in parentheses refer to the items cited in the References at the end of this article.

[3]Some Markov analyses use the transpose of matrix P, in which case the columns, not the rows, sum to unity.

to exit the industry, but never to contract in size (*3, 9, 10*). Although these assumptions appeared reasonable on the basis of aggregate trends and the limited available data on individual farm behavior, they led to modeling structural change as a Markov process in which the largest size class and the exit from agriculture are absorbing states. This necessarily implies a longrun equilibrium distribution with all surviving farms in the largest size class. This implication is consistent with the popular characterization of the 1935-74 trend that U.S. agriculture will eventually become one (or a few) very large farm(s).

The Data

The data set used in this analysis consists of longitudinal records from the 1974 and 1978 Censuses of Agriculture (*12*). The Agriculture Division, Bureau of the Census, created the data set from the control file of the 1978 Census of Agriculture. The control file, a normal part of recent censuses, aids in data collecting and processing. It contains only a limited number of economic variables thought to be helpful in identifying farms and avoiding duplication. Individual farm records were matched by the use of Census File Number (CFN) codes attached to each address label on the Census questionnaire. CFN codes for 1978 were based largely on responses to the 1974 Census; farm records were included in the longitudinal set when a match was found between the two censuses. All primary data processing was performed on Census Bureau computers under the supervision of Census Bureau employees so that the confidentiality of individual data was maintained.

The longitudinal data may include some farms that underwent significant ownership, organizational, or management changes between 1974 and 1978. Changes could be missed if a new operator returned the 1978 questionnaire, addressed to the previous operator, with the mailing label uncorrected. Similarly, the data set may exclude farms that continued in operation from 1974 to 1978, but for which a different CFN was assigned. For example, a sole proprietorship becoming a partnership, a partnership incorporating, a different partner responding to the second census, a mailing address changing, duplicate questionnaires being received in 1978, or the mailing label provided not being used, all could have been cause for assigning a different CFN in 1978 than in 1974. Thus, the 1974-78 longitudinal data used in this analysis are neither a complete enumeration of all U.S. farms continuing in operation during the period nor a random sample of them.

Nevertheless, a large number of farms were matched between the two censuses. The total number of farms reported in 1974 was 2,314,013 (table 1). The 1,200,252 farms which were matched to the 1978 Census represent 52 percent of all farms enumerated in 1974. This leaves 1,113,761 of the 1974 farms for which the 1978 status is not known. These farms are listed as nonlongitudinal in table 1. If exit rates in U.S. agriculture during this period were comparable to those in Canada, where 36 percent of all 1971 operators had exited by 1976 and 30 percent of 1976 operators had exited by 1981 (*5*), approximately one-quarter of all U.S. farm operators counted in the 1974 Census probably left agriculture by 1978. This conjecture suggests that the longitudinal data set may capture approximately two-thirds of all "true" longitudinal farms. That is, about half the farms in the 1974 nonlongitudinal row of table 1 may actually have left agriculture. This sample represents the first comprehensive longitudinal data base ever available for U.S. farms.

The proportion of 1974 farms represented in the 1974-78 longitudinal set varies by farm size, with medium- and large-sized farms more highly represented than smaller farms. Among the 507,797 farms of fewer than 50 acres in 1974, 41 percent were included in the 1974-78 longitudinal set, while 60 percent of farms of 260 acres or more were included. Similarly, the longitudinal set includes 43 percent of all farms with 1974 sales of less than $2,500 and 65 percent of farms with 1974 sales of $100,000 or more. Varying rates of inclusion by farm size may approximately reflect the farm sector. In Canada, small farms have much higher entry and exit rates than do large farms (*5*).

Four economic variables were collected in the longitudinal set: farm size by acres per farm, by value of sales, by tenure, and by standard industrial classification. The measure of farm size in acres avoids problems posed by inflation when constructing intertemporal farm size classes based on sales, and it allows U.S. farm structure to be thought of

Table 1—Longitudinal and nonlongitudinal farms, 1974 and 1978, and allocation of nonlongitudinal farms between continuing and entering/exiting states

Item	Unit	Acres per farm								Total farms
		1-49 acres	50-99 acres	100-179 acres	180-259 acres	260-499 acres	500-999 acres	1,000-1,999 acres	2,000 plus acres	
1974:										
All farms	Number	507,797	384,762	443,122	253,232	362,866	207,297	92,712	62,225	2,314,013
Longitudinal	do.	209,987	180,175	230,473	143,539	217,189	126,881	55,718	36,290	1,200,252
Nonlongitudinal	do.	297,810	204,587	212,649	109,693	145,677	80,416	36,994	25,935	1,113,761
MAX OUT	do.	297,810	204,587	212,649	109,693	145,677	80,416	36,994	25,935	1,113,761
Nonlong/long	Ratio	1.4182	1.1355	0.9227	0.7642	0.6707	0.6338	0.6640	0.7147	0.9279
Continuing farms	Number	131,074	112,466	143,862	89,597	135,570	79,199	34,779	22,652	749,200
MIN OUT	do.	166,736	92,121	68,787	20,096	10,107	1,217	2,215	3,283	364,561
1978:										
All farms	do.	542,787	355,755	403,292	233,854	347,777	213,209	97,800	63,301	2,257,775
Longitudinal	do.	212,452	181,951	225,922	138,202	212,536	131,270	59,326	38,593	1,200,252
Nonlongitudinal	do.	330,335	173,804	177,370	95,652	135,241	81,939	38,474	24,708	1,057,523
MAX IN	do.	330,335	173,804	177,370	95,652	135,241	81,939	38,474	24,708	1,057,523
Nonlong/long	Ratio	1.5549	0.9552	0.7851	0.6921	0.6363	0.6242	0.6485	0.6402	0.8811
Continuing farms	Number	132,613	113,574	141,021	86,266	132,665	81,939	37,031	24,090	749,200
MIN IN	do.	197,722	60,230	36,349	9,386	2,576	0	1,443	618	308,323
Net change, MAX	do.	32,525	– 30,783	– 35,279	– 14,041	– 10,436	1,523	1,480	– 1,227	– 56,238
Net change, MIN	do.	30,986	– 31,891	– 32,438	– 10,701	– 7,531	– 1,217	– 772	– 2,665	– 56,238

as a constantly changing number and mix of farms on a nearly fixed land base. Total U.S. land in farms decreased by only 0.2 percent from 1974 to 1978 and by only 8 percent from 1940 to 1982.

Results

Markov analysis was applied first to the 1.2 million longitudinal farms. However, the longitudinal set alone fails to account for changes in the total number of farms during the period and does not reflect the size distributions in 1974 and 1978 of farms not included in the set, shown as nonlongitudinal farms in table 1. A subsequent reformulation of the problem accounts for the presence of continuing farms excluded from the longitudinal sample and for entry and exit.

Longitudinal Farms Only

The Markov transition matrix for the longitudinal set appears in table 2. The table shows for each size class in 1974 how many farms moved into the various size classes by 1978. These are the only unpublished data used in this article. Several points stand out in the transition matrix. The matrix has near symmetry around the main diagonal. Numbers on the diagonal are relatively large; 68 percent of the longitudinal farms were in the same class at the end of the period as at the beginning. Numbers of farms off the diagonal approximately balance, symmetrically, cell by cell, thus indicating that growth in some farms is about offset by decline in others. The upper right and lower left triangles are not empty, indicating that small farms can become very large from one census to the next and also that large farms can become very small. For example, 432 farms went from under 50 acres to over 2,000, while 395 others went from over 2,000 acres to under 50. The central tendencies of the system are thus quite stable.

The transition probability matrix in table 3 differs significantly from the transition matrices imputed in the studies reviewed earlier, which were assumed to be upper triangular. The flows indicated in the table are greater than one would expect from the low rates of farm real estate sales, implying that most of the large fluctuations, both up and down, were accomplished via land rental rather

Table 2—Transition matrix, farm size in acres per farm, 1974-78

1974 acres per farm	1978 acres per farm								Total farms 1978
	1-49 acres	50-99 acres	100-179 acres	180-259 acres	260-499 acres	500-999 acres	1,000-1,999 acres	2,000 plus acres	
	Number of farms								
1-49	163,914	22,985	12,040	4,385	4,066	1,592	573	432	209,987
50-99	24,385	122,100	21,819	5,922	4,237	1,324	277	111	180,175
100-179	12,664	25,134	154,083	20,960	13,477	3,237	683	235	230,473
180-259	4,494	6,185	21,563	82,386	24,092	3,997	639	183	143,539
260-499	4,322	4,126	13,097	20,850	144,220	27,080	2,860	634	217,189
500-999	1,705	1,040	2,527	3,028	20,004	83,550	13,456	1,571	126,881
1,000-1,999	573	267	556	478	1,933	9,277	36,724	5,910	55,718
2,000 plus	395	114	237	193	507	1,213	4,114	29,517	36,290
Total, 1974	212,452	181,951	225,922	138,202	212,536	131,270	59,326	38,593	1,200,252

Source: Special longitudinal tabulation, 1974 and 1978 Censuses of Agriculture, Bureau of the Census, U.S. Department of Commerce.

than purchase. This conclusion is consistent with the observations that 41 percent of U.S. farmland was operated by someone other than the owner in 1982 and that there are more farmland owners than operators.

If the 1.2 million farms in the longitudinal sample were to have moved again during 1978-82 as they did during 1974-78 and then were to move again and again in subsequent 4-year intervals according to the probabilities in table 3, a steady state would eventually be reached in which additional moves will each bring the system back to the same distribution it had before the additional move. Table 4 compares the steady-state, longrun equilibrium distribution of farms implied by the 1974-78 transition probability matrix with the actual distributions of farms in the longitudinal set in 1974 and 1978.

These distributions for the longitudinal sample suggest that the tendency among the longitudinal farms was toward a moderately lower proportion of farms under 500 acres and a higher proportion of farms with more than 500 acres. And, the longitudinal data reflect a slight trend toward a shrinking of the middle-sized classes of farms. However, these tendencies observed for 1974-78 are not dramatic; they imply a longrun equilibrium distribution not very different from the original 1974 distribution.

Allowance for Entry, Exit, and Continuing Farms Excluded from the Sample

"Neither economic theory nor applied economic studies in agriculture adequately consider the subject of exit and entry of firms," according to Conneman and Harrington (*2*, p. 40). They emphasize the importance of reliable data on exit and entry for Markov analysis. The longitudinal data set includes only about half the farms in U.S. agriculture in 1974-78. The other half is composed of: (1) farms present in 1974, but not present in 1978 (exiting farms); (2) farms not present in 1974, but present in 1978 (entering farms); and (3) farms present in both years, but not picked up in the longitudinal sample (continuing/excluded farms). Dealing with entry and exit raises two issues: how to allocate the nonlongitudinal farms between the continuing/excluded and entry/exit states, and how to model the population of potential and former farmers.

In earlier studies, Farris and Padberg (*6*) had complete information on entry and exit, so there were no imputational problems. The following studies imputed transition matrices from aggregate data, and they assumed that there were no entrants so there was no need to model the population of potential farmers. Krenz (*9*), Daly, Dempsey, and Cobb (*3*), and Lin, Coffman, and Penn (*10*) assumed farms either remained in the initial state, moved up one or two size classes, or exited. Dean, Johnson, and

Table 3—Transition probability matrix, farm size in acres per farm, 1974-78

1974 acres per farm	1978 acres per farm								Total farms 1978
	1-49 acres	50-99 acres	100-179 acres	180-259 acres	260-499 acres	500-999 acres	1,000-1,999 acres	2,000 plus acres	
	Probability								
1-49	0.7806	0.1095	0.0573	0.0209	0.0194	0.0076	0.0027	0.0021	1.0000
50-99	.1353	.6777	.1211	.0329	.0235	.0073	.0015	.0006	1.0000
100-179	.0549	.1091	.6686	.0909	.0585	.0140	.0030	.0010	1.0000
180-259	.0313	.0431	.1502	.5740	.1678	.0278	.0045	.0013	1.0000
260-499	.0199	.0190	.0603	.0960	.6640	.1247	.0132	.0029	1.0000
500-999	.0134	.0082	.0199	.0239	.1577	.6585	.1061	.0124	1.0000
1,000-1,999	.0103	.0048	.0100	.0086	.0347	.1665	.6591	.1061	1.0000
2,000 plus	.0109	.0031	.0065	.0053	.0140	.0334	.1134	.8134	1.0000

Table 4—Relative distributions of longitudinal farms, by size of farm, 1974, 1978, and projected equilibrium

Year	Acres per farm								Total farms
	1-49 acres	50-99 acres	100-179 acres	180-259 acres	260-499 acres	500-999 acres	1,000-1,999 acres	2,000 plus acres	
	Percent								
1974	17.5	15.0	19.2	12.0	18.1	10.6	4.6	3.0	100.0
1978	17.7	15.2	18.8	11.5	17.7	10.9	4.9	3.2	100.0
Equilibrium	17.5	14.5	17.1	10.3	16.7	12.1	6.6	5.2	100.0

Carter (*4*) used similiar assumptions, but showed, in addition, some moves to the next smaller size class.

The entry, exit, and nonfarm population constraints can be treated by the addition of a row and a column to the matrices in tables 2 and 3. One can compute the gross flows of nonlongitudinal farms by farm size from published Census data by subtracting longitudinal farms from all farms in each size class. We used two sets of assumptions about the nonlongitudinal farms. First, the longitudinal farms are a complete count of all continuing farms so that the nonlongitudinal farms represent solely entry and exit (tables 5 and 6). This assumption overestimates turnover; it indicates the maximum that could have entered or exited each farm class during 1974-78. Second, the number of continuing/excluded farms is maximized (and the number of entries and exits minimized) for each farm size subject to the restriction that the distribution of continuing/excluded farms among the farm size classes is identical to the distribution of longitudinal farms (tables 7 and 8). The calculations pertaining to the second assumption are explained below. In this case, entry and exit by size class are at a minimum subject to the proportionality assumption. This assumption probably underestimates actual turnover.

Table 1 presents the maximum and minimum flows of entry and exit computed under the above assumptions. In the first case, when the number of continuing/excluded farms is assumed to be zero, entries and exits are labeled MAX OUT and MAX IN and are equal to the number of nonlongitudinal farms in 1974 and 1978, respectively. In the second case, imputed entries and exits are labeled MIN OUT and MIN IN, and the implied continuing/excluded farms for each year are also identified. We derived these values as follows. The smallest ratio of nonlongitudinal to longitudinal farms (labeled Nonlong/long in the table) was for the 500-999 acre class in 1978; the ratio was 0.6242. For each class, the estimated number of continuing/excluded farms in 1978 is 62.42 percent of the number of longitudinal farms, and the MIN IN row is the residual. This calculation yields zero entrants for the 500-999-acre class and positive levels of entry for each of the other classes. To distribute the 749,200 continuing farms among size classes in 1974, we made parallel computations. For each class, the estimated number of continuing/excluded farms is 62.42 percent of the 1974 distribution of longitudinal farms, and the MIN OUT row is the residual. This calculation yields positive levels of exit for each size class. The last two rows of table 1 show the net changes in each size class under the two sets of assumptions. These net changes are similar despite differences in the gross flows from which they were derived. Both show most of the net entries under 50 acres. For farms of 500-1,999 acres, the maximum case shows net entries, whereas the minimum case shows net exits.

Table 5 shows an expanded transition probability matrix reflecting the assumption of maximum flows in and out of agriculture. The matrix in table 5 is derived from a transition matrix which has the MAX IN row from table 1 as a new top row and the MAX OUT row as a new first column. Similarly, table 7 shows an expanded transition probability matrix reflecting the minimum flow assumptions. The matrix in table 7 is derived from a transition matrix which has the MIN IN and MIN OUT rows of table 1 as an extra row and column. However, in this case we increased the 8-by-8 portion of the new transition matrix by 749,200 farms, to reflect the farms assumed to be continuing/excluded, by raising each entry in table 2 by the ratio of all continuing farms to longitudinal sample farms—that is, by multiplying by 1.6242. This procedure treated about two-thirds of the nonlongitudinal farms as continuing and the other one-third as entry and exit. This set of calculations associated with our second assumption implies more stability than suggested by the Canadian experience cited above, whereas the MAX IN and MAX OUT assumption clearly implies too much turnover.

One further problem remains in accounting for farms outside the longitudinal data set. The logic of Markov analysis requires information about the total size of the nonfarm population of potential farm oprators from which entrants come and to which exiters go. This problem did not arise in earlier studies using imputed transition probabilities and with entries to agriculture assumed to be zero; in such cases the number of potential entrants is irrelevant. Farris and Padberg (*6*) arbitrarily assumed a population of potential entrants over three times larger than the actual number of firms in the industry. From the logical viewpoint, the population of potential entrants can be any finite, nonnegative number; for example, it can be zero. Or, for a study of this type, one might suppose it equal to the number of nonfarm households in the United States or to the number of households in rural areas of the United States. This arbitrary choice has no effect on the longrun equilibrium

Table 5—Transition probability matrix assuming maximum flows of entry and exit, 1974-78

1974 acres per farm	Nonfarm population	1978 acres per farm							
		1-49 acres	50-99 acres	100-179 acres	180-259 acres	260-499 acres	500-999 acres	1,000-1,999 acres	2,000 plus acres
	Probability								
Nonfarm	0.7885	0.0661	0.0348	0.0355	0.0191	0.0270	0.0164	0.0077	0.0049
1-49	.5865	.3228	.0453	.0237	.0086	.0080	.0031	.0011	.0009
50-99	.5317	.0634	.3173	.0567	.0154	.0110	.0034	.0007	.0003
100-179	.4799	.0286	.0567	.3477	.0473	.0304	.0073	.0015	.0005
180-259	.4332	.0177	.0244	.0852	.3253	.0951	.0158	.0025	.0007
260-499	.4015	.0119	.0114	.0361	.0575	.3974	.0746	.0079	.0017
500-999	.3879	.0082	.0050	.0122	.0146	.0965	.4030	.0649	.0076
1,000-1,999	.3990	.0062	.0029	.0060	.0052	.0208	.1001	.3961	.0637
2,000 plus	.4168	.0063	.0018	.0038	.0031	.0081	.0195	.0661	.4744

percentage distribution (*1*, pp. 899, 901). However, the shortrun time path of distributions is sensitive to the choice, as is the total number of farms in equilibrium. Stanton and Kettunen show algebraically that the equilibrium number of farms is a function of the number of potential entrants; a larger nonfarm population results in a larger equilibrium farm population (*11*). However, as Stanton and Kettunen explain, as the number of potential entrants is increased, the net effect on the resulting projections decreases at a decreasing rate. They add that a larger choice may suit a competitive market situation, but that a smaller choice may better represent oligopoly. By experiment, we found that the shortrun time path was particularly sensitive to smaller numbers, such as zero, or 1 million, but that choices above 5 million made little difference after the first few transitions. Consequently, we chose to complete the modification of table 2 by assuming an initial nonfarm population of 5 million potential operators in 1974. Appending the new first row and column reflecting the gross flow assumptions to table 2 and assuming a 1974 nonfarm population of 5 million produce the transition probability matrix in table 5.

The number of farms that entered agriculture during 1974-78 failed to offset the number that left, so the augmented probability matrix suggests a moderately decreasing number of farms. However, the projected decrease is slow, tending toward a longrun equilibrium only slightly below the initial level. The number of farms entering at the smaller and larger sizes exceeded the number leaving, whereas the number leaving at the middle sizes exceeded the number entering. This situation indicates a stronger tendency toward bimodality than appeared in projections using farms from the longitudinal sample alone, with more farms under 50 acres and over 500 acres and with fewer in between. The tendency is not great, however, and the overall stability implied by the longitudinal data alone continues to hold (table 6).

The above analysis assumes that all continuing farms were captured in the longitudinal sample. In the alternative formulation, the maximum number of continuing farms, consistent with the distribution of the longitudinal set, was assumed to have been excluded from the longitudinal set. Minimum entrants are appended as a new first row to table 2, and minimum exiters are appended as a new first column. The continuing/excluded farms were incorporated into the remaining eight rows and columns of the transition matrix in the same proportion as the farms in the longitudinal sample. The result is the new transition probability matrix shown in table 7.

The first row of table 7 shows no farms entering the 500-999-acre class and very few in any size class over 260 acres. The first column of the table shows that the proportion of farms exiting is highest at sizes below 180 acres and that it rises slightly for farms above 1,000 acres. Table 8 shows the past and projected distributions.

Compared with the earlier analysis, this one suggests a longrun equilibrium with somewhat fewer farms, about 15 percent below the present number.

Table 6—Projected number of farms, by size for 1982, 1990, 2000, and equilibrium when maximum flows of entry and exit are assumed

Year	Nonfarm population	Acres per farm								Total farms
		1-49 acres	50-99 acres	100-179 acres	180-259 acres	260-499 acres	500-999 acres	1,000-1,999 acres	2,000 plus acres	
	People	*Number of farms*								
1974	5,000,000	507,797	384,762	443,122	253,232	362,866	207,297	92,712	62,225	2,314,013
1978	5,056,238	542,787	355,755	403,292	233,854	347,777	213,209	97,800	63,301	2,257,775
1982	5,076,885	554,384	347,231	388,534	225,846	340,892	215,331	100,492	64,418	2,237,128
1990	5,087,286	559,732	343,893	380,797	221,212	336,368	216,328	102,494	65,721	2,226,726
2000	5,088,762	560,437	343,537	379,811	220,368	335,383	216,443	102,999	66,226	2,225,203
Equilibrium	5,088,921	560,496	343,504	379,681	220,260	335,236	216,454	103,097	66,366	2,225,094

Table 7—Transition probability matrix assuming minimum flows of entry and exit, 1974-78

1974 acres per farm	Nonfarm popu-lation	1978 acres per farm							
		1-49 acres	50-99 acres	100-179 acres	180-259 acres	260-499 acres	500-999 acres	1,000-1,999 acres	2,000 plus acres
	Probability								
Nonfarm	0.9383	0.0396	0.0121	0.0073	0.0019	0.0005	0	0.0003	0.0001
1-49	.3284	.5243	.0735	.0385	.0140	.0130	.0051	.0018	.0014
50-99	.2395	.1029	.5154	.0921	.0250	.0179	.0056	.0012	.0005
100-179	.1554	.0464	.0921	.5647	.0768	.0494	.0119	.0025	.0009
180-259	.0794	.0288	.0397	.1383	.5284	.1545	.0256	.0041	.0012
260-499	.0279	.0193	.0185	.0586	.0933	.6455	.1212	.0128	.0028
500-999	.0060	.0134	.0081	.0198	.0237	.1567	.6545	.1054	.0123
1,000-1,999	.0242	.0100	.0047	.0097	.0084	.0339	.1625	.6432	.1035
2,000 plus	.0533	.0103	.0030	.0062	.0050	.0132	.0316	.1073	.7700

In the intermediate run, from 1978 to 2000, the reduction in farm numbers is projected at an average annual rate of 0.4 percent, which, by coincidence, is the same average annual rate observed from Census data during 1974-82. The implied equilibrium distribution shows a greater tendency toward bimodality than the other projections, with a much larger proportion of farms under 100 acres and a slight increase in farms over 1,000 acres. The projected rate of concentration by farm size is not great even in the long run, however, and implies relatively little change from the initial distribution.[4]

Projections to 1982 Based on 1974-78 Transition Probabilities

Both the augmented Markov transition matrices produced reasonable estimates of 1982 from the 1974 distribution by using 1974-78 probabilities. Table 9 compares the projections with the actual 1982 distribution. The minimum flow matrix came a bit closer to the actual 1982 distribution than the maximum flow matrix did. In both projections to 1982, the number of farms under 50 acres was underestimated and the number of farms in each of the other size classes was slightly overestimated.[5] More farms were estimated toward the center of the distribution than were actually there, indicating that the trend toward bimodality was somewhat more pronounced in 1978-82 than in 1974-78.

Table 10 shows the relative distributions associated with the data in table 9. It also shows a distribution quotient measuring how close one relative distribution is to another. The distribution quotient is the sum of the positive first differences between the the elements of a pair of relative distributions (7, pp. 252-53). The quotients are calculated with actual 1982 data as the base distribution, so each quotient compares a distribution with the actual 1982 distribution. Distribution quotients computed in this way range from zero to unity. A zero value indicates two relative distribu-

[4]Under both sets of assumptions, projected distributions of farms by size in acres to the year 2000 imply a total acreage in farms within recent historical levels, assuming 1982 average farm sizes in each class.

[5]One factor almost certainly contributing to the wide fluctuations observed in the number of farms in the smallest size class from census to census is the practice of defining as farms all places meeting the minimum sales threshold ($1,000 in 1974, 1978, and 1982) on the basis of potential as well as actual sales of agricultural products. Using a point system derived by the Agricultural Research Service, the Census imputes potential sales values to each place on the basis of features such as cropland not harvested, pasture, and number of animals. Because of fluctuating product values, the number of points assigned to each item also varies from census to census. As a result, even with no change in the characteristics of a given place, changing point allocations may classify it as a farm in one census and as a nonfarm place in another. In addition, the inclusion in the point system of some common animals, such as horses, for the first time in 1982 raises further difficulties for year-to-year comparisons. In 1982, for example, farms with actual sales of less than $1,000 increased by about 95,000 from 1978, the only sales class below $80,000 to show an increase in numbers. Although the Census does not publish data on the acreage distribution of farms classified under the point system, a significant portion of the increase in farms of fewer than 50 acres reported in 1982 was probably due to the point system.

Table 8—Projected number of farms, by size for 1982, 1990, 2000, and equilibrium when minimum flows of entry and exit are assumed

Year	Nonfarm population	Acres per farm								Total farms
		1-49 acres	50-99 acres	100-179 acres	180-259 acres	260-499 acres	500-999 acres	1,000-1,999 acres	2,000 plus acres	
	People	*Number of farms*								
1974	5,000,000	507,797	384,762	443,122	253,232	362,866	207,297	92,712	62,225	2,314,013
1978	5,056,238	542,787	355,755	403,292	233,854	347,777	213,209	97,800	63,301	2,257,775
1982	5,105,636	557,846	339,406	376,525	219,268	334,161	215,111	101,488	64,571	2,208,377
1990	5,182,459	566,707	322,901	345,105	199,738	311,747	212,818	105,356	67,182	2,131,554
2000	5,246,947	568,238	313,986	326,019	185,987	291,703	205,776	106,030	69,326	2,067,066
Equilibrium	5,412,574	572,957	305,201	300,520	162,444	242,159	168,187	89,078	60,893	1,901,439

Table 9—Actual and projected number of farms, by acres per farm, 1974, 1978, 1982

Year	Acres per farm								Total farms
	1-49 acres	50-99 acres	100-179 acres	180-259 acres	260-499 acres	500-999 acres	1,000-1,999 acres	2,000 plus acres	
	Number of farms								
1974 actual	507,797	384,762	443,122	253,232	362,866	207,297	92,712	62,225	2,314,013
1978 actual	542,787	355,755	403,292	233,854	347,777	213,209	97,800	63,301	2,257,775
1982 actual	636,917	343,775	367,877	211,485	315,025	203,925	97,395	64,577	2,240,976
1982 maximum	554,384	347,231	388,534	225,846	340,892	215,331	100,492	64,418	2,237,128
1982 minimum	557,846	339,406	376,525	219,268	334,161	215,111	101,488	64,571	2,208,377

Table 10—Relative distributions and quotients for actual and projected farms, 1974, 1978, 1982

Year	Acres per farm								Distribution quotient
	1-49 acres	50-99 acres	100-179 acres	180-259 acres	260-499 acres	500-999 acres	1,000-1,999 acres	2,000 plus acres	
	Distribution								*Quotient*
1974 actual	0.2194	0.1663	0.1915	0.1094	0.1568	0.0896	0.0401	0.0269	0.0715
1978 actual	.2404	.1576	.1786	.1036	.1540	.0944	.0433	.0280	.0447
1982 actual	.2842	.1534	.1642	.0944	.1406	.0910	.0435	.0288	.0000
1982 maximum	.2478	.1552	.1737	.1010	.1524	.0963	.0449	.0288	.0365
1982 minimum	.2526	.1537	.1705	.0993	.1513	.0974	.0460	.0292	.0316

tions are identical; unity indicates they are quite different.

The distribution quotient for the minimum flow projection to 1982 is smaller than that for the maximum flow projection, indicating that the minimum flow projection more closely approximated the actual. The quotient which compares the actual 1974 with the actual 1982 distribution is 0.0715, indicating that the distribution of U.S. farms by acres per farm did not change much during the 8-year interval. Both projections from 1974 to 1982 are closer to the actual 1982 distribution than to the 1974 distribution, indicating that the 1974-78 trend forms a useful basis for characterizing the entire 1974-82 period.

Assessing the Applicability of the Transition Matrix to Earlier Periods

The pattern of structural change described by the 1974-78 probabilities explains changes between previous censuses reasonably well. Three censuses, 1974, 1969, and 1964, were projected from their previous censuses. The distribution quotients compare the actual distribution with the associated projection in each of the 3 years. The minimum flow matrix consistently made better predictions than the maximum flow matrix (table 11).

In each case, the actual proportion of farms under 50 acres was below the projected level enough to account for most of the value of the quotient; the projections also consistently overestimated farms above 500 acres and underestimated farms from 50 to 500 acres. These divergences are consistent with the view that the trend toward a reduced proportion of farms in the middle-sized classes has accelerated since the sixties. That acceleration is reflected in the pattern of divergences encountered in the projections to 1982, which underestimated the proportion of farms in the smaller size class and overestimated the proportion of farms in the middle range. However, the divergences between the actual and projected proportions are relatively small in all cases and seem to be closely related to fluctuations in the smallest size class which, as noted earlier, appears to be very sensitive to definitional changes.

Table 11—Distribution quotients for 1974, 1969, and 1964 projected from the previous Census

Projection	Maximum flow	Minimum flow
	Quotient	
1974 from 1969	0.0266	0.0237
1969 from 1964	.0301	.0222
1964 from 1959	.0281	.0088

Several things affect the outcome for shortrun projections: the structure of the longitudinal farms, the structure of the nonlongitudinal farms, the arbitrary assumption of the size of the pool of potential operators from which entrants come and to which exiters go, the size classes and time interval selected for analysis, and the initial distribution of farms. All these factors changed during the 1959-74 interval under consideration, and each doubtless had an effect on the outcome. However, the last mentioned—the initial distribution of farms—affects the shortrun path in a predictable way. Any initial distribution will be moved toward equilibrium. Inasmuch as the 1964 distribution is closer to equilibrium than the 1959 distribution, it is not surprising that the projection from 1959 to 1964 moved the distribution in the correct direction. The same phenomenon occurs with projections from the actual 1935 distribution. Each projected distribution is closer to the projected longrun equilibrium, which in turn is not far from the actual 1974 distribution. That is, the Markov chain estimated for 1974-78 moves the actual 1935 distribution toward the actual 1974 distribution. The projections make the adjustment more rapidly than actually occurred, however, in about half the actual number of years.

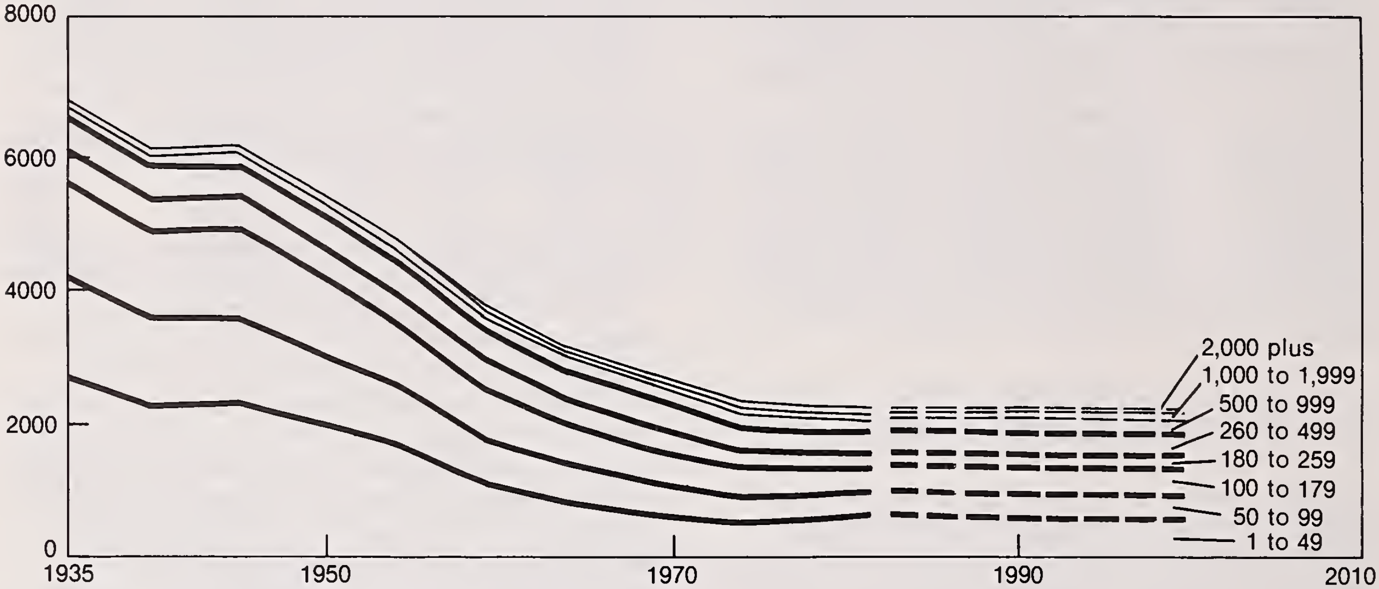
A Longrun Perspective

Figure 1 shows the number of farms by size in acres per farm since 1935. The figure makes clear the rapid descent in farm numbers during 1935-74 and the subsequent leveling. It also indicates projections to 2000 using the maximum flow matrix. Figure 2 shows the relative distributions associated with the data in figure 1, and the data appear in table 12. Table 12 also reports the distribution quotient which compares each distribution with the actual 1982 distribution. As one traces these quotients

Figure 1

Farms by Size, 1935-82, with Projections

Number of farms (1000)



Historical data from Bureau of the Census; projections from table 6.

backwards through time from 1982, the difference from 1982 increases, indicating that the farther one looks into the past, the greater the difference in farm structure becomes.

The proportion of farms under 50 acres increased in 1982 to about that of 1959. Hence, from 1964 to 1978, the proportion of such farms was smaller than in 1982, and from 1935 to 1954 the proportion was larger. The absolute share of these farms was large, and the rate of change from one census to the next was rapid, so this difference is the most important single contributor to the size of the distribution quotient from 1935 through 1978, with the single exception of 1959. After 1959, the second major difference is that there were proportionately fewer farms of 50-180 acres than in 1982. Before 1959, the second major difference is that there were proportionately more farms of 260-500 acres than in 1982.

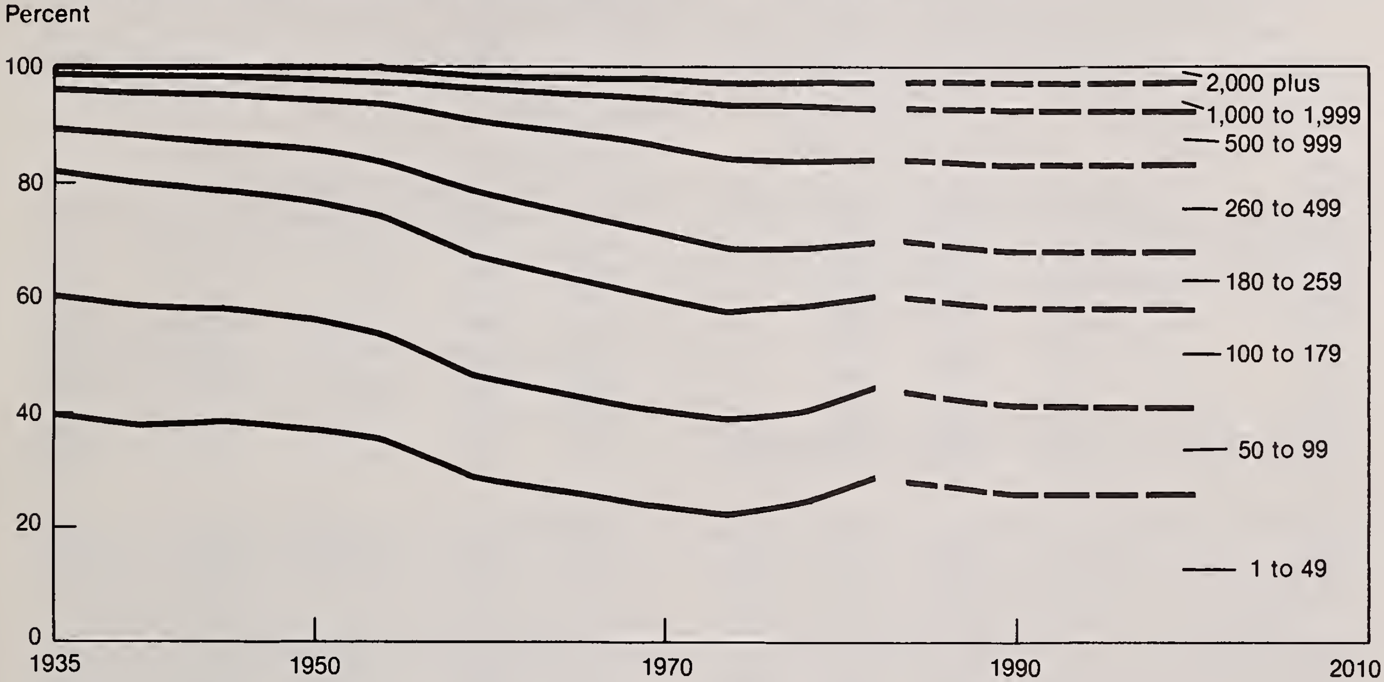
The distribution quotients for projected distributions for 1990, 2000, and longrun equilibrium, under both sets of assumptions, illustrate the extent to which the change in farm size distribution stabilized during 1974-78 (table 12 and see figs. 1 and 2). When the 1974-78 trends are projected forward, they suggest that the future number and distribution of farms by acres per farm will be more like the present than the present is like the past.

Conclusions

We analyzed longitudinal data on U.S. farms to evaluate changes in size by acres per farm during 1974-78. The data reveal considerable stability among these farms, both at the individual and aggregate levels. For individual farms remaining in operation, the most likely outcome after 4 years was that each would remain in the same size class as before. Among those changing size classes, most changed into an adjacent class. Only a small fraction of continuing farms exhibited dramatic changes in acreage during 1974-78. However, the number of shifts in size was more than one would expect from

Figure 2

Percentage Distribution of Farms by Size, 1935-82, with Projections



Historical data from Bureau of the Census; projections from table 6.

the number of transactions per year in farm real estate, suggesting that leasing is important in explaining the changing structure of farms. Changes in farm size displayed a great deal of symmetry. For every farm moving up from a smaller to larger class, another farm was likely to move in the other direction. Relative stability in the size distribution is suggested when the 1974-78 pattern of change is assumed to continue indefinitely. This symmetry and stability suggest a substantially different view of structural change in agriculture than the 1935-74 trend toward fewer and larger farms would suggest.

Tendencies toward a bimodal distribution are evident, but longrun projections suggest they are moderate. The 1974-78 data do not support the view that the mid-sized farms will disappear. Based on the 1974-78 data, projections to 1982 also suggest that the comparative stabilization of structural change occurring in 1974-78 continued in 1978-82.

One projection examined here uses longitudinal farms only, and two others make alternative assumptions about entry and exit of nonlongitudinal farms. We experimented with other assumptions about nonlongitudinal farms, and found that all methods treating nonlongitudinal farms in a uniform and consistent manner led to approximately the same results. Even so, none of the assumptions used exactly captures the actual distribution of nonlongitudinal farms, and projections were sensitive to nonuniform assumptions, such as that losses were concentrated among mid-sized farms.

The longrun implications of this analysis turn on the stability of the transition probability matrix estimated for 1974-78. If the longrun transition probabilities remain close to those estimated here, then the structure of U.S. agriculture will change little from what it is today. However, the transition probabilities could change. The significantly changed conditions in U.S. agriculture—from the

Table 12—Relative distribution by size in acres per farm, 1935 to longrun equilibrium, and quotients with 1982 = base year

Year	Acres per farm: 1-49 acres	50-99 acres	100-179 acres	180-259 acres	260-499 acres	500-999 acres	1,000-1,999 acres[1]	2,000 plus acres	Distribution quotient
	Distribution								*Quotient*
Actual:									
1935	0.3955	0.2120	0.2111	0.0744	0.0695	0.0246	0.0130	0	0.2168
1940	.3755	.2116	.2147	.0797	.0752	.0268	.0165	0	.2000
1945	.3838	.1975	.2048	.0842	.0808	.0297	.0193	0	.1844
1950	.3652	.1945	.2047	.0905	.0887	.0338	.0225	0	.1627
1954	.3549	.1807	.1993	.0970	.1008	.0401	.0273	0	.1356
1959	.2850	.1773	.2082	.1117	.1271	.0539	.0213	.0154	.0861
1964	.2597	.1718	.2004	.1126	.1429	.0666	.0269	.0191	.0752
1969	.2328	.1685	.1984	.1124	.1536	.0790	.0333	.0219	.0804
1974	.2194	.1663	.1915	.1094	.1568	.0896	.0401	.0269	.0715
1978	.2404	.1576	.1786	.1036	.1540	.0944	.0433	.0280	.0447
1982	.2842	.1534	.1642	.0944	.1406	.0910	.0435	.0288	.0000
Maximum flow:									
1990	.2514	.1544	.1711	.0993	.1511	.0972	.0460	.0295	.0328
2000	.2519	.1544	.1707	.0990	.1507	.0973	.0463	.0298	.0324
Equilibrium	.2519	.1544	.1706	.0990	.1507	.0973	.0463	.0298	.0323
Minimum flow:									
1990	.2559	.1515	.1619	.0937	.1463	.0998	.0494	.0315	.0232
2000	.2749	.1519	.1577	.0900	.1411	.0996	.0513	.0335	.0217
Equilibrium	.3015	.1606	.1581	.0850	.1274	.0885	.0469	.0320	.0310

[1]Includes all farms of 1,000 acres or more, 1935-54.

low real interest rates and rising asset values, exports, and farm income of the seventies to the high real interest rates, declining asset values, and lower exports and farm income of the eighties—suggest that the pattern of change since 1982 may differ from the pattern of 1974-82. Yet, the relative stability exhibited by U.S. agriculture during 1974-82 makes it less likely that its structure in the near future will be as radically different as had been expected based on 1935-74 trends. For example, Lin, Coffman, and Penn projected on the basis of trends through 1974 that between then and the year 2000 the number of 100-499-acre farms would drop by 493,000, a 47-percent decline (*10*, p. 11). Projections based on 1974-78 data suggest a drop in this size class of less than one-third that figure over the same period.

The general stability observed during 1974-78 points to the critical role in structural change played by entry, exit, and the few continuing farms undergoing rapid change. Relatively minor changes among these farms have potentially significant longrun implications. We are now developing more detailed data on the characteristics of continuing as well as entering and exiting farms in the 1974-78 and 1978-82 periods from Census data. These additional data will allow an exploration of questions such as the stability of the transition probabilities estimated here, the characteristics of changing versus stable farms, the patterns of change among other variables such as sales, tenure, and enterprise mix, and the interrelationships among changes in these variables.

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Appendix: Raising a Matrix to Fractional Powers

One problem encountered in projecting farm size distributions was that of raising a probability transition matrix estimated on a 4-year interval to fractional powers in order to produce transition matrices describing periods not in 4-year multiples. No generally available microcomputer software of which we are aware offers direct procedures for taking fractional powers of an asymmetric matrix. This section briefly describes the method used here to project 5-, 16-, and 26-year intervals from a 4-year matrix, as well as some alternative methods.

A method described by Waugh and Abel (*13*) adapts matrices to the binomial expansion and approximates the final value from the first few terms of the expansion. Their algorithm has the advantage of being relatively easy to write in a programming language such as BASIC if more efficient software is not available.

A second method for calculating the square root of an asymmetric matrix P of rank n is to think of it as the product of two identical matrices B, where each element of the original matrix may be written:

$$P_{ij} = \sum_{k=1}^{n} b_{ik} b_{kj}$$

This method yields a system of n^2 equations in n^2 unknowns. Lloyd Teigen suggested to us that one can solve this system using commercially available microcomputer software for solving nonlinear simultaneous systems, such as TK!Solver. We found the method to work well for a 3-by-3 test, but coding and iterating for the 9-by-9 problem became tedious.

A third approach allows us to write:

$$P = A \Gamma A^{-1}$$

where A is a matrix of eigenvectors of P and Γ is the associated diagonal matrix of eigenvalues of P. The inverse of the matrix of eigenvectors will exist if the transition probability matrix (P) is not defective. The eigenvectors (A) will be linearly independent, and the inverse (A^{-1}) will therefore exist, if there are as many distinct eigenvalues as there are rows in the transition probability matrix (P). In the case of the asymmetric matrices used here, most commercial software packages do not offer direct solution procedures for calculating eigenvalues and eigenvectors. Most of the software for both mainframe and microcomputers calculate eigenvectors only for symmetric matrices. One exception is SPEAKEASY, in both the mainframe and microcomputer versions.

The integer power P^2 can be written:

$$\begin{aligned} P^2 &= A \Gamma A^{-1} A \Gamma A^{-1} \\ &= A \Gamma I \Gamma A^{-1} \\ &= A \Gamma^2 A^{-1} \end{aligned}$$

Similarly:

$$P^r = A \Gamma^r A^{-1}$$

for any integer r. Therefore, once A and Γ have been derived, P^r can easily be obtained by taking powers of scalars on the diagonal of Γ.

Consider the square root $P^{0.5}$ written as:

$$P^{0.5} = A \Gamma^{0.5} A^{-1}$$

To show that $P^{0.5}$ is indeed the square root, multiply the right hand side by itself:

$$\begin{aligned} P &= A \Gamma^{0.5} A^{-1} A \Gamma^{0.5} A^{-1} \\ &= A \Gamma^{0.5} \Gamma^{0.5} A^{-1} \\ &= A \Gamma A^{-1} \end{aligned}$$

The procedure can be extended to the q^{th} root for any integer q:

$$P^{1/q} = A \Gamma^{1/q} A^{-1}$$

Complex roots will not arise so long as the eigenvalues are positive. P can be raised to any rational power $k = r \div q$ for any integer r and q by raising the scalar eigenvalues to the desired fractional power:

$$P^{r/q} = A \Gamma^{r/q} A^{-1}$$

Four-year transition probability matrices estimated for this study were reduced to the fourth root to approximate 1-year transition matrices. Complex roots were not encountered; positive roots of the eigenvalues were used. For both the 9-by-9 matrices developed to account for farms not included in the longitudinal set, the 1-year transition matrices contained negative elements. The average annual move was, therefore, not a true Markov process. One interpretation is that the actual annual transition probabilities may not have been constant during 1974-78; it would take at least two different Markov chains with nonnegative probabilities to move annually from the 1974 to 1978 distribution. Projections incorporating annual patterns of farm growth, decline, entry, and exit, such as those reported here, imply that the apparent cycles within the 4-year observation period will recur indefinitely. The matrix $P^{1.25}$ does behave as a Markov process, however, with all probabilities positive. It was used to project the behavior of the system over 5-year intervals. Similarly, P raised to the 6.5 power was used to project from 1974 to 2000.

The Federal Hop Marketing Order and Volume-Control Behavior

By R.J. Folwell, R.C. Mittelhammer, F.L. Hoff, and P.K. Hennessy*

Abstract

The Hop Administrative Committee of the hop marketing order has been reasonably accurate in projecting quantities supplied and demanded and in formulating their recommended salable percentage to the Secretary of Agriculture. The Federal Hop Marketing Order has helped stabilize hop acreages and nominal hop prices and has reduced cyclical variation in production. Acreage and production stabilization may indicate a more stable decision environment leading to a more efficient resource allocation.

Keywords

Marketing order, volume control, spectral analysis, bootstrapping, hops

Introduction

The Agricultural Marketing Agreement Act of 1937 as amended allows agricultural producers to collectively pursue orderly marketing programs[1] to stabilize producer prices and income, with the goal of improving producer welfare. Orderly marketing programs are to be used for raising farm prices toward parity, according to the act. The legislation also requires that consumer interests be protected.

Marketing orders provide producers with a variety of methods for achieving orderly marketing, including quality and quantity (volume) regulations, container standardization, promotion, research and development, regulation of unfair trade practices, and provision of price and other market information. The volume-control regulations have been among the most controversial aspects of marketing orders and have recently come under intense scrutiny by consumer advocates, the Federal Trade Commission, the Department of Justice, and political groups who have become increasingly concerned with the possibility that producers are exercising monopoly power by restricting quantities to the extent of unduly increasing commodity and consumer prices.

This article analyzes the behavior of the Hop Administrative Committee (HAC) in executing the volume-control provision of the U.S. Hop Marketing Order.[2] Specifically, the article analyzes the following:

(1) The U.S. Hop Marketing Order, emphasizing the method by which volume-control decisions are made;

(2) The accuracy of market projections made by the HAC and used in the volume-control decisionmaking process; and

(3) The stabilization effects of HAC policies on acreage, prices, production, and sales.

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[1]"Orderly marketing" is defined as the coordination of the total supply of a commodity over time, form, and spatial markets in such a way as to achieve the market objectives of sellers (*8*). Note: Italicized numbers in parentheses refer to items in the References at the end of this article.

[2]The responsibility and authority to issue regulations lies with the Secretary of Agriculture under the Agricultural Marketing Agreement Act. However, industry participants normally initiate actions to be taken under an order's provisions. Such industry initiatives arise out of administrative committees which work with the U.S. Department of Agriculture (USDA) and carry out the programs. The members of such committees usually are growers and handlers who are nominated and elected by the industry and appointed by the Secretary of Agriculture.

The U.S. Hop Industry and Marketing Orders

The characteristics of the U.S. hop industry make it unique compared with other sectors of American agriculture. Hops are a perennial crop produced by fewer than 240 farmers concentrated in the States of Washington, Idaho, Oregon, and California. The investment cost of establishing an acre of hops is high relative to other agricultural crops. The cost was estimated at between $3,500 and $4,000 in 1982, not including the cost of harvesting, picking, drying, and packaging equipment (*7*). Most hops are sold under long-term forward contracts that specify annual prices and are made as much as 7 years in advance of delivery.

The market for hops is oligopolistic; only eight major buyers currently operate in the U.S. market. The largest two buyers account for approximately two-thirds of all hops sold.

The only major use of hops is to produce malted beverages, with only a commercially insignificant amount used to produce pharmaceutical products. In 1984, five brewers accounted for 88 percent of beer sales. Because there is no substitute for hops in the production of malted beverages, the demand for and indirectly the supply of hops tend to be inelastic. The high degree of inelasticity contributes to the potential for large price variability in hop markets (*6*).

On July 7, 1966, Federal Marketing Order No. 991 was approved by more than two-thirds of the U.S. hop producers (*10*). The intent of the order was to establish a more orderly marketing process that would induce price stability so as to improve the gross returns of producers. The order became effective in the 1966-67 marketing year, defined here as spanning September 1 through August 31.[3]

The order divided the U.S. hop-producing region (Washington, Idaho, Oregon, and California) into four districts, each composed of one producing State. Thirteen growers from these districts make up the Hop Administrative Committee (HAC). Seven growers are from Washington State, while two growers from each of the remaining three States make up the remainder of the committee. The main responsibilities of the HAC are to recommend to the U.S. Secretary of Agriculture the policies to be administered under the provisions of the marketing order, to report any violators thereof to the Secretary, and to recommend amendments to the order as needed.

Volume-Control Provision

Prior to March 1 of each year, the HAC and a Handler Advisory Board (HAB) meet to adopt a marketing policy for the ensuing marketing year.[4] The HAC decides the quantity of hops that can be marketed during the marketing year from the upcoming hop harvest. The volume decision is based on the HAC's perception of the quantity of hops required to establish orderly marketing conditions. As required by Federal Marketing Order No. 991, the HAC must consider these factors in establishing the salable quantity of hops:

(1) Prospective stock carry-in,

(2) Desirable stock carryout,

(3) Prospective imports and exports,

(4) Anticipated consumption, and

(5) Any other relevant factors that affect marketing conditions (*10*).

The HAC presents its volume recommendation to the Secretary of Agriculture for final approval and implementation.

The most important factor to individual hop growers is the allotment percentage, which is the share of an individual producer's hop base allotment that can be marketed in the marketing year. One can calculate the allotment percentage by taking the salable quantity recommended by the HAC and approved by the Secretary of Agriculture and

[3]The official marketing year, as noted in the *Federal Register*, runs from August 1 through July 31. However, all published hop statistics refer to September 1 through August 31. In this article, the latter period will be maintained as the marketing year because of the availability of September 1 stock data and other data from the Crop Reporting Board of USDA's Statistical Reporting Service.

[4]The HAB consists of five hop handlers (dealers) who are elected by a vote of all hop handlers to act in an advisory capacity to the HAC.

dividing it by the total of all producer base allotments established in 1966 (59.27 million pounds). The HAC must review its marketing policy prior to August 1 and recommend any increase in the salable quantity it feels that marketing conditions warrant (*10*). The Secretary of Agriculture may issue a salable quantity and allotment percentage based on the HAC's recommendation or other available information. Producers may transfer their base allotment from one location to another. Producers may also transfer all or part of an allotment base from themselves to another producer on a temporary or permanent basis. Hops exceeding the level of allotment controlled by a producer are reserve hops and can only be sold through a reserve pool market controlled by the HAC.

HAC/HAB Joint Marketing Policy Meetings

A joint HAC/HAB marketing policy meeting is held each January to recommend both the salable quantity and other marketing policy guidelines pertaining to quality control, research and development, and reserve pools, all of which go into effect in the marketing year.

The HAC uses a balance sheet approach, or equivalently, a quantity-supplied, quantity-demanded approach, to determine salable quantity. Essentially, the HAC makes two projections for the upcoming marketing year: (1) total hop quantity demanded of U.S. hops and (2) total quantity supplied to the U.S. market from sources other than upcoming domestic production. Subtracting the latter from the former projection defines the projected domestic production required for an equilibrium of quantities supplied and demanded. The HAC then adjusts the projected production requirement upward by an amount considered sufficient to compensate for production falling short of announced salable quantity. Finally, the HAC adjusts the production requirement to reflect "any other relevant factors that affect marketing conditions" to arrive at the final production recommendation (*10*).

The following discussion explains the projection process in more detail, identifying the various components of the demand and supply projections and describing how they enter into the balance sheet calculation of the salable quantity recommendation. We frequently refer to various time periods relevant to the recommendation process (table 1), where "$t+1$" refers to the hop marketing year (September 1 to August 31) following the January policy meeting.

The balance sheet used at the policy meeting in determining the salable quantity for marketing year $t+1$ is illustrated in table 2. Prior to the policy meeting, the HAC manager and staff with a statistical subcommittee of HAC members assemble all known market information. All supply and demand information is known for the previous marketing year, $t-1$. Only carry-in stocks (CI_t) and salable production (SPR_t) are completely known for marketing year t, where salable production is the quantity of hops arising from the previous August-September harvest that is eligible for sale. Other supply and demand components, both for years t and $t+1$, are unknown and must be estimated by the HAC at the January meeting.

Neither the HAC statistics subcommittee nor the HAC staff members use a formal statistical model for forecasting unknown market variables. Rather, HAC forecasts have been based on subjective evaluation of market trend information and represent consensus forecasts of the HAC members.[5]

The subjective forecasts are interrelated and are made in sequence. First, the HAC forecasts imports ($\hat{IM}_t$), brewery consumption ($\hat{BC}_t$), exports ($\hat{EX}_t$), and a balancing item ($\hat{BI}_t$)[6] for marketing year t. Then total supply of hops in t (TS_t) is forecast as:

$$\hat{TS}_t = CI_t + SPR_t + \hat{IM}_t \quad (1)$$

and total demand for hops in t (TD_t) is forecast as:

$$\hat{TD}_t = \hat{BC}_t + \hat{EX}_t + \hat{BI}_t \quad (2)$$

The level of carry-in stocks for the subsequent marketing year, $t+1$, is then forecast as:

$$\hat{CI}_{t+1} = \hat{TS}_t - \hat{TD}_t \quad (3)$$

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[5]The HAC has contracted for the construction of an econometric structural model of the industry both to generate a better understanding of market forces and to provide supplementary information for forecasting market outcomes.

[6]The main components of the balancing item include minor uses of hops in pharmaceuticals and as perfume bases, plus a year end statistical adjustment.

Table 1—Time framework in U.S. hop industry

Occurrences	Marketing year t-1				Marketing year t												Marketing year t + 1	
	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
HAC/HAB quarterly meetings			X			X			X[1]			X			X			X
Harvest				X	X											X	X	
Market information known at the January, t, market policy meeting	All information for marketing year t-1				9/1 stocks; 11/1 stocks; 9/1-11/1 imports, exports, and brewery consumption													
Projections made by HAC/HAB								Updated projections for t; Projections for t + 1										

[1]Joint HAC/HAB marketing policy meeting.

Table 2—Marketing policy balance sheet

Supply and demand component	Year t-1	Year t
Supply:		
Carry-in 9/1	CI_{t-1}	CI_t
Salable production[1]	SPR_{t-1}	SPR_t
Imports	IM_{t-1}	$\hat{IM}_t$[2]
Total supply	TS_{t-1}	$\hat{TS}_t$
Demand:		
Brewery consumption[3]	BC_{t-1}	$\hat{BC}_t$
Exports[3]	EX_{t-1}	$\hat{EX}_t$
Balancing item[4]	BI_{t-1}	$\hat{BI}_t$
Total demand	TD_{t-1}	$\hat{TD}_t$
	Year t	Year t + 1
Supply:		
Carry-in 9/1	CI_t	$\hat{CI}_{t+1}$
Imports		$\hat{IM}_{t+1}$
Total net supply		$\hat{TNS}_{t+1}$
Demand:		
Brewery consumption		$\hat{BC}_{t+1}$
Exports		$\hat{EX}_{t+1}$
Balancing item		$\hat{BI}_{t+1}$
Desirable carryout[5]		$\hat{CO}_{t+1}$
Total demand		$\hat{TD}_{t+1}$
Salable quantity:		
Gross trade requirement		$\hat{GTR}_{t+1}$
Special allotment for Fuggle hops		SFA_{t+1}
Balance		$\hat{GTR}_{t+1}-SFA_{t+1}$
Potential available not produced		$\hat{PANP}_{t+1}$
Salable quantity		$\hat{SQ}_{t+1}$
Salable percentage computed		$\hat{SPC}_{t+1}$
Salable percentage recommended		$\hat{SPRC}_{t+1}$

[1]Quantity of hops produced that is available to the market under that year's salable percentage.
[2]All projections are indicated as such by a hat (^) above them.
[3]Demand component estimates are for both fresh hops and hop extract. Extract is based on the ratio of pounds of fresh hops to 1 pound of hop extract. In this research, the authors used total demand components (fresh plus extract).
[4]Includes other minor uses and year-end statistical adjustments.
[5]Pounds of hops the HAC/HAB deems necessary to maintain orderly marketing conditions in future years.

The purpose of the projection procedure (1) – (3) is to generate the carry-in forecast, $\hat{CI}_{t+1}$. Forecasts of imports, brewery consumption, exports, and a balancing item are then made for marketing year t + 1, together with a determination of a desired carryout level, $\hat{CO}_{t+1}$, which represents the pounds of hops in stock the HAC deemed necessary to maintain orderly marketing conditions in future years. Then, the total net supply ($\hat{TNS}_{t+1}$) of hops in marketing year t + 1 is defined as:

$$\hat{TNS}_{t+1} = \hat{CI}_{t+1} + \hat{IM}_{t+1} \quad (4)$$

Note that $\hat{TNS}_{t+1}$ is the projected total supply of hops in marketing year t + 1, not including net domestic hop production. Total demand for hops in year t + 1 is defined as:

$$\hat{TD}_{t+1} = \hat{BC}_{t+1} + \hat{EX}_{t+1} + \hat{BI}_{t+1} + \hat{CO}_{t+1} \quad (5)$$

Then, the gross trade requirement for marketing year t + 1, $\hat{GTR}_{t+1}$, representing the HAC's forecast of the pounds of hops needed from domestic producers to produce an equilibrium of supply and demand, is defined as:

$$\hat{GTR}_{t+1} = \hat{TD}_{t+1} - \hat{TNS}_{t+1} \quad (6)$$

Adjustments are made to the $\hat{GTR}_{t+1}$ to arrive at the final salable quantity to be recommended to the Secretary of Agriculture for the marketing year t + 1. First, $\hat{GTR}_{t+1}$ is adjusted downward by 1 million pounds, reflecting a special allotment (SFA_{t+1}) granted to growers, primarily in Oregon, in 1972 for the production of Fuggle hops, a low alpha acid-type hop. The allotment has remained unchanged since 1972. The $\hat{GTR}_{t+1}$ is also adjusted upward by potential available not produced, $\hat{PANP}_{t+1}$. This is an adjustment the HAC makes to account for factors such as disease, winter kill, or drought or for growers not producing up to their allotted salable production which would otherwise drop realized domestic hop production below those levels required to balance supply and demand. The recommended salable quantity is then defined as:

$$\hat{SQ}_{t+1} = \hat{GTR}_{t+1} - SFA_{t+1} + \hat{PANP}_{t+1} \quad (7)$$

To distribute the salable quantity among individual producers, we can specify the salable percentage ($\hat{SPC}_{t+1}$) as:

$$\hat{SPC}_{t+1} = (\hat{SQ}_{t+1}/59{,}270{,}000 \text{ pounds of hops}) \times 100 \quad (8)$$

which represents the percentage of individual base allotments that determine the quantity of hops salable by individual producers. Finally, $\hat{SPC}_{t+1}$ may be adjusted to reflect other factors that affect hop marketing conditions, if the HAC determines such an adjustment is necessary.[7] Either $\hat{SPC}_{t+1}$ or its adjusted value then becomes the salable percentage recommended ($\hat{SPRC}_{t+1}$) to the Secretary of Agriculture. Upward adjustments to the ($\hat{SPRC}_{t+1}$) due to changing marketing conditions can be made prior to August 1. Decisions made at the HAC policy meetings have historically not been altered.

Information Set for Projections

The HAC projects expected imports by taking into account past levels of imports, quantities of previously contracted imports, currency exchange rates, domestic and foreign hop stocks, expected foreign hop crops, and breweries' philosophies.[8] We projected brewery consumption by examining past levels of brewery consumption, breweries' philosophies, brewery stocks, and total U.S. beer production. The HAC projects exports in light of past levels of exports, quantities of previously contracted exports, currency exchange rates, domestic and foreign stocks, brewing philosophies, and expected foreign hop crops. The balancing item is based primarily on its previous level and accounts for a small percentage of all hops. We projected the desirable carryout by considering previous carryout levels, brewery inventories and brewers' stockholding intentions, and the estimated quantity of hops necessary to counteract a crop failure in $t+2$ should it arise.[9]

The process used to calculate the recommended salable quantity is, at least officially, void of any price considerations. The hop marketing order does not contain authority for price setting even though the volume-control provisions, aimed at establishing orderly marketing, can influence prices and farmer incomes. However, the choice of a desirable carryout level is a subjective decision by the HAC aimed at achieving the somewhat intangible goal of "orderly marketing." Carryouts that are too large relative to inventory demand can depress prices, and too small a carryout can increase prices. Because an objective of the hop order is market stabilization, the HAC carryout decision must implicitly consider the effects of potential carryout levels on price changes.[10]

Accuracy of HAC Projections

The HAC uses a balance sheet approach (table 2) to record and calculate the projections of the various supply and demand components used to determine the salable quantity recommended to the Secretary of Agriculture. Because of this procedure for calculating salable quantity, the accuracy of the projections of market variables is important for two major reasons. First, the salable quantity the HAC recommends depends largely on the projections of the variables on the HAC balance sheet. In the *ex ante* sense, the salable quantity represents a quantity level that the HAC has decided is sufficient to create an equilibrium of total hop quantities demanded and supplied in the U.S. market. However, for the salable quantity to closely approximate equilibrium domestic quantity supplied *ex post facto*, the projections of total quantity demanded and total quantity supplied net of domestic production must closely approximate their true values realized in the upcoming marketing year. Second, in projecting values of the market variables, the HAC provides growers with an outlook of the market

[7]As an example of "other factors," the HAC felt that in the midseventies the European Economic Community was subsidizing hop growers. To counteract a potential erosion of U.S. market share, the HAC elected to increase the $\hat{SPC}_t$ (personal communication with Mr. Robert H. Eaton, Manager, U.S. HAC).

[8]"Breweries' philosophies" refers primarily to the quantity and type of hops various brewers use to flavor a barrel of beer.

[9]The HAC perceived the level of desirable carryout during the period covered in this analysis as being that level of hops in inventories together with the quantity of harvested hops in the new marketing year which would allow brewers about a 2-year supply in relation to beer production. In the recent past, this inventory level has been reduced because of higher interest rates and the cost of holding inventories.

[10]Until recently, the HAC has relied heavily on the rule of thumb of maintaining approximately a year's supply of hops as carryouts to ensure a reliable supply of domestic hops for brewing purposes. With increasing interest rates and accompanying increased cost of carrying inventory, the HAC has been compelled by industry participants to lower the carryout levels in recent years.

situation for the coming marketing year. The more accurate the projections, the more valuable is the market information function performed under the U.S. Hop Order.

Table 3 shows various goodness-of-fit measures comparing HAC projections with actual industry outcomes. The data available allowed an analysis of marketing year t projections for 1969-78 and marketing year t + 1 projections for 1969-79. The analysis does not include the special Fuggle allotment (SFA) because it is a constant. The balancing item, BI, was not individually analyzed because of its extremely minor role in overall demand.

HAC projections of variables in t are characterized by smaller mean absolute percentage errors (MAPE's), higher correlations with actual market outcomes, lower mean squared prediction errors (MSPE's) measuring the accuracy of percentage change predictions, and lower U-statistics measuring the ability to predict turning points, than corresponding projections for variables in t + 1. Except for carryout projections, a lesser proportion of the MSPE's is attributable to systematic errors in projection ($U^M + U^R$) than to random disturbances (U^D),[11] and the average percentage bias in projections, as measured by the mean percentage error (MPE), is smaller in magnitude for marketing year t projections. Thus, forecasts for marketing year t generally appear superior to corresponding forecasts for marketing year t + 1. This superiority probably reflects the additional uncertainties involved in predicting market outcomes further into the future and the fact that market conditions in the first third of marketing year t have already been observed at the time of the January HAC policy meeting. In terms of providing market outlook information, the HAC has been more adept at projecting the near term, where the average absolute percentage errors range from a low of 3.56 percent for brewery consumption projections for t to a high of 11.49 percent for export projections for t.

The projection of total net supply ($\widehat{TNS}$) has an average downward bias of 1.71 percent. Of the components of $\widehat{TNS}_{t+1}$, imports in t + 1 have been underestimated, whereas carryouts in t (carryouts in t = carry-ins in t + 1) have been slightly overestimated. The average absolute magnitude of the percentage error made by the HAC in projecting $\widehat{TNS}$, as indicated by the MSPE, is 4.82 percent. A large proportion ($U^M + U^R = 0.75$) of the 47.9 MSPE in projecting percentage changes is attributable to systematic errors so that an optimal linear correction applied to the projection would reduce the MSPE by 75 percent (*9*). the MSPE of the HAC projections was 87 percent (U = 0.87) of what it would have been had the HAC used a no-change extrapolation method of projection.[12]

Overall, the HAC seems to provide reasonably accurate projections of the general magnitude of $\widehat{TNS}_{t+1}$, and it has some success in projecting turning points in market outcomes. However, it does make systematic errors in predicting percentage changes that, if eliminated, could improve the accuracy of the projections. Underestimation of $\widehat{TNS}_{t+1}$ contributes to an overestimation of the domestic production required to equilibrate quantities supplied and demanded, as $\widehat{TNS}_{t+1}$ is the measure of supplies available from sources other than upcoming domestic production.

The projection of total demand ($\widehat{TD}_{t+1}$) has a slight average downward bias of 0.29 percent. The export component of $\widehat{TD}_{t+1}$ was underestimated, whereas brewery consumption was overestimated.[13] The average absolute magnitude of the percentage error made by the HAC in projecting $\widehat{TD}_{t+1}$ was 4.24 percent. Only 19 percent ($U^M + U^R = 0.19$) of the 27.9

[11] U^M, U^R, and U^D can be interpreted in the context of optimal linear correction of forecast changes in the variables. Optimal linear correction of the forecast changes means choosing a and b values that minimize the sum of squared errors in predicting actual changes, ΔA_t, with the linear (correction) function of predicted changes $\Delta P_t^c = a + b\Delta P_t$. Uncorrected forecasts correspond to a = 0 and b = 1. The proportional reduction in MSPE that would result from using the optimally linearly corrected predicted changes equals $U^M + U^R$, where U^M refers to the proportional reduction due to equalizing the mean of predicted and actual changes (which necessarily follows from the least squares fitting of a and b), and U^R refers to the proportional reduction due to adjusting the b coefficient from unity to its optimal value. The proportion of MSPE's attributed to random disturbances, U^D, is left unaffected by the optimal linear correction (see (*9*)).

[12] A "no-change extrapolation" means using $P_{t+1} = A_t$; that is, the value of a variable in period t + 1 is predicted to be equal to its value in period t.

[13] Desired carryouts in t have no projection errors, by definition, as that figure represents the level of carryouts demanded by the HAC for market stabilization. The actual carryouts can deviate from desired levels; this difference is portrayed in table 3.

Table 3—Statistical comparison of actual U.S. hop industry market statistics and HAC projections[1]

Variable	Actual		Projected		Actual vs. projected values[2]			Actual vs. projected percentage changes[3]				
	Mean	Coefficient of variation	Mean	Coefficient of variation	Correlation	Mean percentage error	Mean absolute percentage error	Mean squared prediction error	U^M	U^R	U^D	U
	1,000 lbs.	*Measure*	*1,000 lbs.*	*Measure*	*Measure*	*Percent*	*Percent*	*Measure*	*Measure*	*Measure*	*Measure*	*Measure*
Imports_t	12,315	11.88	12,104	7.89	0.72	1.08	6.00	72.0	0.064	0.001	0.935	0.74
Imports_{t+1}	12,721	15.19	11,632	11.10	.39	7.33	10.52	310.3	.261	.033	.706	.92
Exports_t	26,800	15.31	27,100	14.10	.64	−2.04	11.49	194.3	.010	.110	.880	.71
Exports_{t+1}	28,158	21.14	26,591	14.73	.15	2.50	17.14	592.7	.105	.347	.548	1.18
Brewery consumption_t	35,271	6.35	35,546	5.03	.68	−.94	3.56	37.5	.100	.236	.664	1.13
Brewery consumption_{t+1}	35,757	8.52	36,341	5.57	.26	−2.15	6.88	84.1	.051	.686	.263	1.66
Carryouts_t	36,920	25.94	37,301	26.72	.97	−.94	5.03	52.2	.095	.778	.126	.61
Carryouts_{t+1}	37,504	23.36	33,409	31.50	.46	9.72	22.90	677.3	.170	.645	.185	1.91
Total net supply_{t+1}	48,717	19.46	47,874	20.16	.93	1.71	4.82	47.9	.037	.712	.251	.87
Total demand_{t+1}	97,976	17.24	97,250	14.79	.95	.29	4.24	27.9	.030	.158	.812	.59

[1]Projection for marketing year t based on 1969-78 data, and projections for marketing year t + 1 based on 1969-79 data. Projections are made in January of marketing year t (Sept. 1 to Aug. 31).

[2]Mean percentage error = $(1/n)\ \Sigma\ (Y_t - \hat{Y}_t) \times 100/Y_t$, mean absolute percentage error = $(1/n)\ \Sigma\ |Y_t - \hat{Y}_t| \times 100/Y_t$.

[3]U^M, U^R, U^D are the mean bias, regression and disturbance proportion of mean squared prediction error, and U is Theil's inequality coefficient (*9*).

MSPE was attributable to systematic errors. The MSPE of the HAC projections was 59 percent (U = 0.59) of what it would have been had the HAC used a no-change extrapolation projection method.

Overall, the HAC has provided fairly accurate projections of the general magnitude of $\hat{TD}_{t+1}$ and has anticipated turning points with some success. However, in the case of $\hat{TD}_{t+1}$ projections, a component of $\hat{TD}_{t+1}$ is the HAC's desired carryout variable, the level of which is determined at the discretion of the HAC, and is thus "projected" without error. Because decreasing desired carryout contributes to a decrease in both projected and actual $\hat{TD}_{t+1}$, $\hat{TD}_{t+1}$ may be projected with enhanced accuracy.

When examining the issue of equilibrating quantities supplied and demanded, note that the average projected gross trade requirement (average projected $\hat{TD}_{t+1}$ – average projected $\hat{TNS}_{t+1}$ = 49,376, from equation (6) is greater than the actual gross trade requirement (average $\hat{TD}_{t+1}$ — average $\hat{TNS}_{t+1}$ = 49,259) by only 117,000 pounds, or by 0.2 percent of the average production requirement. However, table 3 reveals that realized carryouts exceed projected carryouts by an average 9.72 percent. The carryout projections for marketing year t + 1 are also characterized by the highest mean absolute percentage error and mean square prediction error of all the projections. They represent the poorest set of projections in terms of anticipating turning points and, next to carryout projections for t, they have the highest systematic error ($U^M + U^R = 0.82$). Thus, the HAC's desired level of carryouts has not been achieved on the average, nor do desired carryouts represent accurate estimates of actual carryouts in marketing year t + 1. Given the method for establishing the salable quantity of hop production, the discrepancy between desired and actual carryouts may be mostly the result of adjustments to the $\hat{GTR}_t$ (recall equation (6)). In particular, the $\hat{PANP}_t$ adjustment to account for shortfalls in production on allotments, coupled with hop growers supplying the full amount of hops specified by the final salable quantity level, may be a major factor in explaining why hop production exceeded noninventory demand and added to carryout stocks, thereby raising them above desired levels.

Analysis of HAC Market Stabilization

Has the control provision of the Federal Hop Order contributed to stabilizing the hop market, a principal objective of the order?

An empirical investigation of the stability question is complicated by data limitations. In particular, although basic hop statistics are available back to 1915, two World Wars, the Great Depression, Prohibition, and a previous Federal Hop Order all happened in the years prior to 1953. When one tries to analyze the effect of the hop order on the stability of the hop market, 1953-65 represents the only period with which the period of operation of Federal Order No. 991 can be relatively noncontroversially compared. Furthermore, a substantial crop failure for German hops in 1980 (resulting in unprecedented levels of spot prices and futures contract prices negotiated in 1980) together with a breakdown of futures contract markets in 1981 and 1982 for near-term delivery, were exogenous shocks that appear to disqualify all but the 1966-79 period as the Federal Order reference period for purposes of stabilization analysis.

We used two techniques to provide information on the effects of the HAC's implementation of the volume-control provision on stability in the U.S. hop market. First, we calculated variances of acreage harvested, production (in 1,000 pounds), real and nominal prices (season-average hop price in dollars per pound, deflated by an index of prices received by farmers, 1910-14 = 1.00), and real and nominal sales (hop sales in thousands of dollars, deflated by an index of prices received by farmers, 1910-14 = 1.00) after we applied a linear regression to each variable.[14] We then tested the null hypothesis of variance equality versus the alternative hypothesis of variance reduction from preorder to the Federal Order period using the standard F-statistic. Table 4 shows the results of the calculations and gives variances, F-ratios, and marginal significance levels (also called "probability values") of the hypothesis tests (see (*1*), p. 171, for the use of probability values as strength of evidence against the null hypothesis). We examined both nominal and real

[14]We removed trend by a linear regression of each variable on time for 1953-65 and for 1966-79. The residuals of these regressions represented the data series we examined.

prices and sales to provide two different perspectives on the stabilization issue. The analysis involving nominal prices and sales provides information on the variability of actual hop prices received and sales levels achieved by hop growers. The analysis of prices and sales deflated by the index of prices received by farmers provides information on variability relative to the general price level of agricultural commodities.

The variance analysis in table 4 provides strong statistical evidence that the variance in acreage harvested was reduced during the period in which the Federal Order was in operation, where the hypothesis of variance equality would be rejected in favor of variance reduction at as low a level of significance as 0.008. The allotment system does affect the decisions of hop growers regarding utilization of, and investment in, hop-growing capacity to the extent that capacity is reflected by land use. There is also evidence, albeit weaker than in the case of acreage, that production varied less in the Federal Order reference period, where the minimum significance level possible for rejection of the null hypothesis (0.168) results in only a one-in-six chance of rejection due to a type I error. Because production is also influenced by weather, disease, and pest effects that are not under the direct control of hop growers, the potential for stabilizing production by influencing growers' decisions on the environment may not be so directly effective as in the case of decisions about acreage harvested.

A rejection of variance equality and acceptance of variance reduction in the case of real sales is tenuous where acceptance of variance reduction is a decision involving slightly more than a one-in-four chance of committing a type I error, given the calculated F-ratio. Thus, there is only weak statistical support for the contention that Federal Order operations have contributed to increased stability of real sales of hops. There is essentially no statistical support for the hypothesis that nominal sales variation has been reduced in the Federal Order period.

Regarding variation in hop prices, there is no statistical evidence to support the contention that real price variation has been reduced in the Federal Order period. In fact, the calculated F-statistic might be used as weak statistical evidence in favor of an alternative hypothesis of a real-price variance increase in the Federal Order period. However,

Table 4—Tests of variance reduction between the pre- and post-Federal order reference periods

Variable	Unit	1953-65 variance[1]	1966-79 variance[1]	F-ratio	Marginal level[2]
Harvested acreage	Acres	1.1405×10^7	2.5764×10^6	4.4267	0.008
Production	1,000 lbs.	3.1610×10^7	1.7742×10^7	1.7816	.168
Real sales	$1,000	2.1192×10^6	1.5088×10^6	1.4046	.284
Real price	Dollars per lb.	3.4780×10^{-4}	4.9177×10^{-4}	.7072	.713
Nominal sales	$1,000	1.3955×10^7	1.2694×10^7	1.0993	.434
Nominal price	Dollars per lb.	2.0925×10^{-3}	9.8401×10^{-4}	2.1265	.105

[1]The reported variances are those of the residuals resulting from a linear regression where the dependent variable was one of the variables shown in the first column of this table and the independent variable was time (year).

[2]Marginal significance level represents the minimum significance level of the hypothesis test that would have resulted in the rejection of the null hypothesis of variance equality and acceptance of the alternative of variance reduction based on the observed value of the F-statistic (*1*). The F-ratio is defined with the preorder period variance in the numerator, the postorder period variance in the denominator, and the F-statistic has 11 numerator and 12 denominator degrees of freedom.

there is relatively strong statistical support for the hypothesis that nominal price variation has been reduced in the Federal Order period, where the conclusion of variance reduction involves only slightly more than a 1-in-10 chance of committing a type I error, given the calculated F-ratio.

We conducted a spectral analysis of detrended acreage, production, real and nominal sales, and real and nominal prices for the preorder (1953-65) and Federal Order (1966-79) reference periods. The spectral analysis technique provided estimates of the decomposition of variation in the variables across cyclical components of various frequency lengths, and thus allowed estimates of the degree to which variation was due to shortrun versus longrun variance components in each reference period. Given the perennial crop/longrun investment characteristics of hop production and the extremely inelastic hop supplies and demands (*6*), shortrun variability might be more difficult for hop markets to adapt to and more disruptive than longrun variability. Thus, the potential variance frequency decomposition information of spectral analysis appeared to be relevant.

The power spectrum estimator used four lags for the autocovariance function. We used the Parzen lag window generator to smooth the estimated spectrum (see (*2*), chapter 9, and p. 504). Estimates of power spectra from samples as small as in each of the reference periods can be subject to relatively high variation. Tractable variance estimates and hypothesis testing procedures are only asymptotically appropriate and would be highly suspect in this analysis. To provide finite sample variability estimates and to test hypotheses of power spectrum ordinate equality, we used the statistical technique of bootstrapping originated by Efron (*3*) to generate bootstrap distributions of spectrum ordinates. In particular, we generated 200 bootstrap samples of detrended acreage, production, real and nominal sales, and real and nominal prices for each reference period from a four-lag autoregressive structure (consistent with the four-lag autocovariance function used in the spectrum estimation). Then, we used these samples to generate a bootstrap distribution of 200 power spectra for each variable and for each reference period (*3*, *5*). Table 5 presents the natural logarithms of the means of the bootstrap power spectra distributions,[15] and figures 1-6 plot them. Table 5 also presents 90-percent confidence intervals for each power spectrum ordinate based on truncation of the upper and lower 5 percent of the observed bootstrap distribution of ordinates for each variable and for each reference period (*4*).

The horizontal axis in figures 1-6 measures frequency of cyclical components of the series; for example, a frequency of 0.25 refers to a cycle that is 1/4 completed in a year or to a cycle that has a duration of 4 years. The area beneath the antilog of the power spectrum curve in figures 1-6 and between two frequency points $f_1 < f_2$ (the integral of the density from f_1 to f_2) is an estimate of the variance contribution of cyclical components in the frequency interval (f_1, f_2) to the total variance of the respective series. The area under the entire antilogged power spectrum graph is the total variance of the series. When the power spectrum is expressed in logarithms, the power (the height of the power spectrum) associated with a data series A relative to the power associated with a data series B at a given frequency point f is a monotonically increasing function of the difference between the ordinates of the natural logarithms of the power spectra for A and B at frequency f. Thus, the gap between the graphs of the two logged power spectra in each figure is a measure of power reduction or increase across frequencies $(\exp(\ell n\ a - \ell n\ b) = a/b)$.

The point estimates of the power spectra in figures 1 and 2 indicate that, in the case of production and acreage, all frequencies had reduced power in the Federal Order reference period. The shapes of the power spectra suggest that much of the variability in both acreage and production was attributable to longrun cyclical variation in both reference periods. Examining the confidence intervals for the power spectrum ordinates presented in table 5, one can see that the difference in power at each frequency is significant in the case of acreage, because none of the spectrum ordinate confidence intervals overlaps.[16] For production, reduced variance contributed

[15]We transformed the power spectra into a logarithmic scale to facilitate graphing and interpreting the spectra.

[16]Using the Bonferroni probability inequality, one can make the statement of unequal ordinates at frequency f_i with a minimum of 80-percent confidence, given the use of a 90-percent confidence interval for each ordinate.

Table 5—Power spectrum ordinates and 90-percent confidence intervals, natural logarithmic scale[1]

Variable	Unit	Frequency	1966-79		1953-65	
			Ordinate	90-percent interval	Ordinate	90-percent interval
Acres harvested	Acres	0.0000[2]	15.96	(15.75, 16.14)	17.26	(16.60, 17.74)
		.0625[2]	15.94	(15.74, 16.11)	17.30	(16.67, 17.76)
		.1250[2]	15.86	(15.69, 16.02)	17.35	(16.78, 17.79)
		.1875[2]	15.72	(15.57, 15.87)	17.34	(16.81, 17.75)
		.2500[2]	15.47	(15.34, 15.61)	17.22	(16.70, 17.61)
		.3125[2]	15.13	(15.00, 15.26)	16.97	(16.43, 17.32)
		.3750[2]	14.75	(14.61, 14.89)	16.61	(16.06, 16.96)
		.4375[2]	14.44	(14.27, 14.63)	16.24	(15.56, 16.74)
		.5000[2]	14.32	(14.14, 14.53)	16.07	(15.28, 16.64)
Production	1,000 lbs.	.0000	17.88	(17.68, 18.06)	18.12	(17.57, 18.49)
		.0625	17.86	(17.67, 18.04)	18.15	(17.53, 18.50)
		.1250	17.80	(17.63, 17.94)	18.21	(17.58, 18.56)
		.1875	17.66	(17.53, 17.79)	18.21	(17.58, 18.56)
		.2500[2]	17.42	(17.32, 17.53)	18.12	(17.54, 18.46)
		.3125[2]	17.08	(17.00, 17.16)	17.91	(17.39, 18.25)
		.3750[2]	16.67	(16.59, 16.76)	17.63	(17.05, 17.98)
		.4375[2]	16.31	(16.17, 16.46)	17.37	(16.72, 17.85)
		.5000[2]	16.16	(15.97, 16.33)	17.25	(16.51, 17.82)
Real sales	$1,000	.0000	15.14	(14.61, 15.52)	15.42	(14.75, 15.86)
		.0625	15.16	(14.61, 15.54)	15.45	(14.80, 15.88)
		.1250	15.19	(14.70, 15.58)	15.50	(14.87, 15.92)
		.1875	15.17	(14.68, 15.52)	15.51	(14.91, 15.89)
		.2500	15.05	(14.51, 15.40)	15.41	(14.84, 15.79)
		.3125	14.84	(14.31, 15.16)	15.20	(14.66, 15.59)
		.3750	14.58	(14.02, 14.96)	14.93	(14.37, 15.40)
		.4375	14.35	(13.63, 14.79)	14.69	(13.85, 15.24)
		.5000	14.26	(13.46, 14.75)	14.58	(13.62, 15.17)
Real price	Dollars per lb.	.0000	-6.77	(-7.58, -6.21)	-6.80	(-7.23, -6.44)
		.0625	-6.77	(-7.56, -6.22)	-6.82	(-7.24, -6.46)
		.1250	-6.77	(-7.54, -6.25)	-6.87	(-7.28, -6.53)
		.1875	-6.82	(-7.53, -6.33)	-7.00	(-7.41, -6.67)
		.2500	-6.91	(-7.63, -6.46)	-7.23	(-7.63, -6.91)
		.3125	-7.06	(-7.79, -6.55)	-7.55	(-7.97, -7.23)
		.3750	-7.20	(-7.92, -6.65)	-7.93	(-8.46, -7.52)
		.4375	-7.30	(-8.16, -6.63)	-8.26	(-8.99, -7.70)
		.5000	-7.34	(-8.27, -6.64)	-8.39	(-9.27, -7.77)
Nominal sales	$1,000	.0000	17.56	(17.50, 17.61)	17.31	(17.06, 17.52)
		.0625	17.54	(17.49, 17.58)	17.35	(17.10, 17.54)
		.1250	17.46	(17.42, 17.48)	17.41	(17.23, 17.56)
		.1875	17.30	(17.28, 17.31)	17.41	(17.25, 17.50)
		.2500[2]	17.05	(17.02, 17.07)	17.31	(17.22, 17.38)
		.3125[2]	16.72	(16.66, 16.77)	17.09	(16.96, 17.21)
		.3750	16.36	(16.27, 16.44)	16.78	(16.43, 17.06)
		.4375	16.08	(15.96, 16.30)	16.49	(15.85, 17.02)
		.5000	15.98	(15.85, 16.12)	16.37	(15.52, 17.01)

See footnotes at end of table.

Continued—

Table 5—Power spectrum ordinates and 90-percent confidence intervals, natural logarithmic scale—Continued

Variable	Unit	Frequency	1966-79		1953-65	
			Ordinate	90-percent interval	Ordinate	90-percent interval
Nominal price	Dollars per lb.	.0000[2]	-5.72	(-5.83, -5.62)	-5.11	(-5.29, -4.97)
		.0625[2]	-5.74	(-5.84, -5.64)	-5.11	(-5.25, -4.98)
		.1250[2]	-5.82	(-5.89, -5.75)	-5.11	(-5.22, -5.03)
		.1875[2]	-5.97	(-6.02, -5.94)	-5.18	(-5.26, -5.03)
		.2500[2]	-6.24	(-6.28, -6.17)	-5.36	(-5.43, -5.30)
		.3125[2]	-6.57	(-6.68, -6.46)	-5.67	(-5.79, -5.56)
		.3750[2]	-6.95	(-7.18, -6.76)	-6.07	(-6.31, -5.82)
		.4375[2]	-7.27	(-7.62, -6.94)	-6.44	(-6.91, -6.02)
		.5000	-7.39	(-7.82, -6.98)	-6.61	(-7.21, -6.10)

[1]Power spectrum ordinates are the natural logarithms of the means of 200 bootstrap observations for each ordinate in each spectral estimation problem. The 90-percent intervals are generated by truncating the lower and upper 5 percent of the bootstrap observations and by taking logarithms of the remaining lowest and highest ordinates.
[2]Confidence intervals for the two reference periods did not overlap.

Figure 1

Natural Logarithm Power Spectrum of Hop Acres

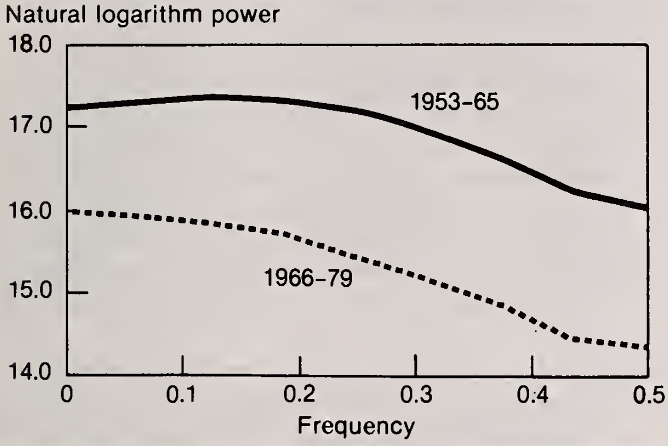
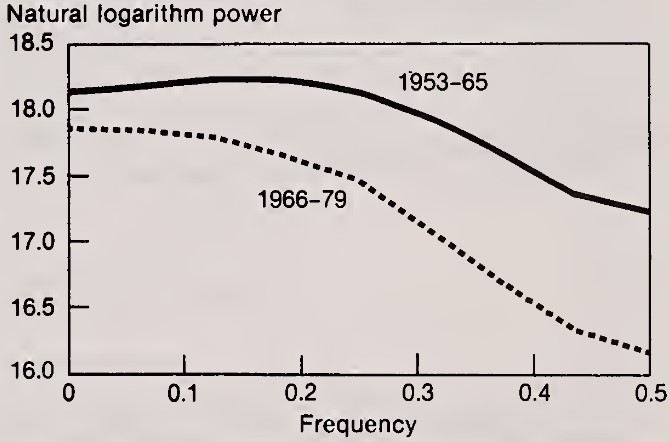


Figure 2

Natural Logarithm Power Spectrum of Hop Production



by shortrun cyclical variation (cycles of 4 years or less) is strongly supported; however, reduced variance contributed by longrun cyclical variation is not strongly supported.

The point estimates of the real sales power spectra indicate reduced power at each frequency level, where again most of the power is concentrated in longrun cycles. However, all confidence intervals overlap in this case; thus, at the confidence level used here, the statistical evidence does not support reduced power at each frequency. In the case of nominal sales, the point estimates of the power spectra indicate a power increase for longer run cyclical variation and a power decrease for shorter run cyclical variation. However, only the ordinates associated with 3- and 4-year cyclical variation are significantly different at the confidence level used here, with all other confidence intervals overlapping.

The point estimates of the real-price power spectra actually indicate a power increase in the Federal Order reference period, especially for shortrun cyclical variation. However, as in the case of real sales, all confidence intervals overlap, and, at the

Figure 3

Natural Logarithm Power Spectrum of Real Hop Sales

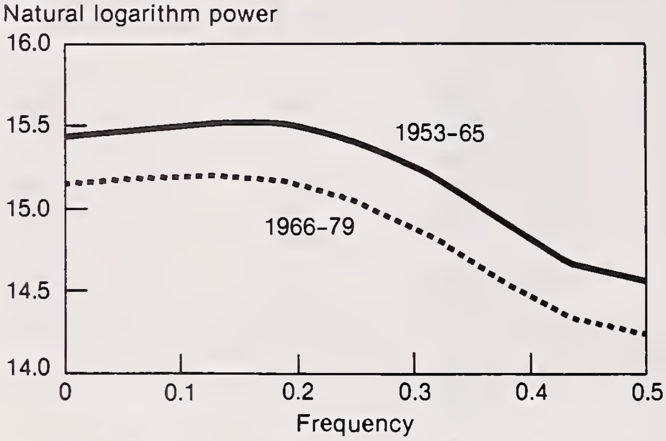


Figure 4

Natural Logarithm Power Spectrum of Real Hop Price

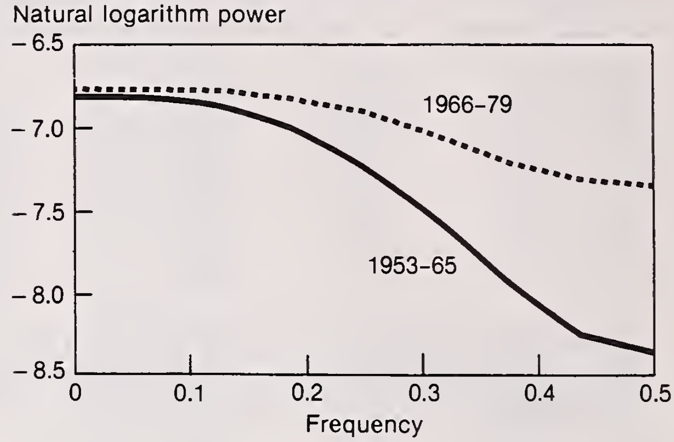


Figure 5

Natural Logarithm Power Spectrum of Nominal Hop Sales

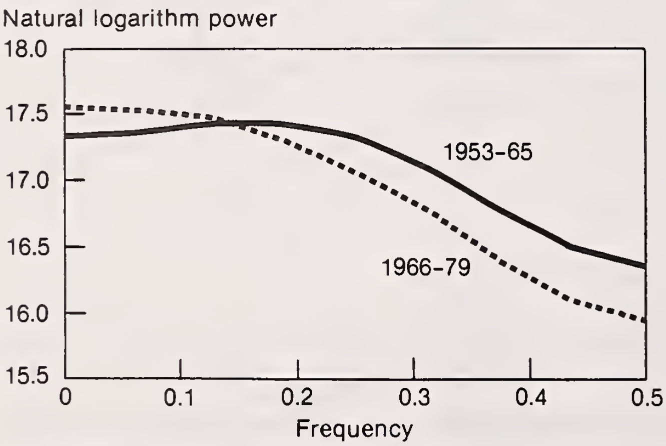
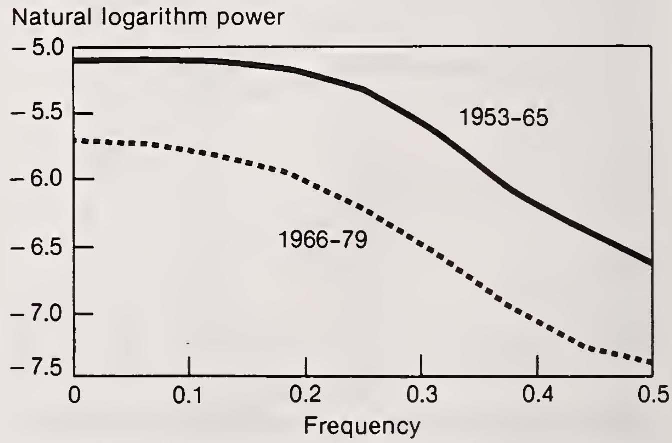


Figure 6

Natural Logarithm Spectrum of Nominal Hop Price



confidence level used here, statistical evidence does not support power increase at each frequency. The estimated ordinates of the nominal-price power spectra indicate reduced power across all frequencies. The confidence intervals suggest that the difference in power at each frequency, except the highest frequency, is significant.

Overall, the variance analysis suggests that the marketing order has contributed to both longrun (cycles greater than 4 years in length) and shortrun stabilization of hop acreage, as well as shortrun stabilization of hop production. There is not sufficient evidence to conclude that real and nominal sales and real price were more stable in the Federal Order reference period. However, there is notable support for the hypothesis that variation in nominal prices has been reduced overall, including both shortrun and longrun cyclical variation.

The statistical procedures used here were based on a relatively small number of observations; thus, in the case of real and nominal sales as well as in the case of longrun cyclical stabilization of production, failure to amass statistical evidence supporting stabilization may be the result of small sample size. The Federal Hop Order can only affect the supply response of U.S. hop producers and not the demand for, or the foreign supply of, hops. Thus, the order might be viewed as successful from a domestic supply viewpoint; however, because of changes in demand or foreign supply, the potential reduction in price, sales, and income variability may not be as pronounced. If the order had not been successful in modifying the domestic hop supply response, we cannot know whether the variation in price, sales, and income could have been of a greater magnitude than it was.

Conclusions

Although some market variable projections were subject to notable errors, the HAC's overall projections of quantities supplied and demanded for forthcoming marketing years were reasonably accurate when they are judged by standard goodness-of-fit measures used to assess forecast accuracy. However, the salable quantities the HAC ultimately recommended have caused larger carryout stocks than the projected carryout stocks that the HAC suggested as desirable levels. Given the overstated salable quantity recommendations and the resultant larger than desirable carryouts, one might suspect that the HAC has explicitly attempted to expand the size and market share of the U.S. production base. This philosophy has often been stated in the minutes of the HAC's marketing policy meeting.

We used a variance analysis together with a spectral analysis to analyze the question of whether the hop marketing order has helped stabilize hop acreages, production, prices, and sales. Contrasting two time periods before and after the inception of Federal Hop Order No. 991 (1953-65 and 1966-79, respectively), we found that the latter period was characterized by significantly less variation in hop acreages and nominal hop prices and by less short-run cyclical variation in production. There was insufficient statistical evidence to conclude that either real and nominal sales or real prices were more stable in the Federal Order period.

Despite the lack of evidence supporting stabilization of real and nominal sales and real price, stabilized acreage, production, and nominal prices may signal significant benefits to hop growers and, indirectly, to society at large. Given the long-term nature and the relativley large level of investment required in hop production capacity and the relatively long payback period required for amortization of such investment, large variability in acreage and production can be symptomatic of uncertainty and misallocation of hop production resources. The fact that acreage and production have been stabilized by the Federal Order may indicate a more stable decision environment leading to a more efficient resource allocation. The reduced variation in nominal prices may also facilitate more accurate predictions of future hop price levels and may improve the efficiency of resource allocation in hop production.

The question of whether the benefits of hop market stabilization exceed their costs requires a full accounting of social benefits and costs, and most important, a definition of the social decision function ultimately used to gauge the performance of the program. The study of volume-control behavior presented in this article suggests that, value judgments aside, the U.S. hop order has at least partially met its principal challenge of stabilizing the hop market and has also served a reasonably accurate market information and outlook function.

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In Earlier Issues

Exit and entry, if they occur, certainly affect the net changes in the number of farms and changes in total production. The change in the number of farms has a major effect on the results from the application of two widely used concepts in agricultural supply analysis studies: the representative farm concept and the Markov process concept. Too often agricultural supply analysis studies have not taken sufficient account of the dynamic nature of changes in supply as caused by both exit and entry of firms.

G. J. Conneman and D. H. Harrington
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Measuring Backward and Forward Linkages in the U.S. Food and Fiber System

By Mark Henry and Gerald Schluter*

Abstract

The interindustry flows required to support the output of the U.S. food and fiber system are decomposed into backward and forward linkages. Our purpose is to evaluate the relative importance of farm versus food- and fiber-processing activities. For the United States in 1977, backward linkages accounted for 11 percent ($80 billion) of nonfarm business activity of the food and fiber system. Forward linkages dominated, accounting for 89 percent ($626 billion).

Keywords

Linkages, input-output, food and fiber system

Introduction

A hypothesis in the development literature is that investment in sectors with large interindustry linkages will promote more rapid economic growth than investment in a broad array of sectors of the economy (*12, 13*).[1] Hirschman defined two types of linkages that promote economic development:

1. The input-provision, derived demand, or *backward linkage (BL) effects*—that is, every nonprimary economic activity will induce attempts to supply through domestic production the inputs needed in that activity.

2. The output-utilization or *forward linkage (FL) effects*—that is, every activity that does not by its nature cater exclusively to final demands will induce attempts to utilize its outputs as inputs in some new activities (*5*, p. 100).

Attempts to test the linkages hypothesis have led to a lively debate on how to measure linkages (see *2, 7, 8, 9, 12, 13*).[2]

A related issue in developed economies concerns the stimulative effects of exports and domestic consumption of raw versus processed goods (*1, 10*). Our purpose here is to estimate the BL and FL effects in the U.S. food and fiber system to evaluate further the relative importance of farm versus food- and fiber-processing activities. Beyond their use as descriptive indicators of the interrelatedness of sectors in the U.S. economy, linkage measures help us trace the repercussions of change in a given industry through its impacts directly and indirectly on all sectors.

For the United States, it is appropriate to differentiate between BL and FL because of the composition of final demand for U.S. farm products. Farm exports of raw commodities have substantial impacts through BL effects on nonfarm sectors. In contrast, exports of raw commodities do not generate domestic FL effects like those attributable

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[1]Italicized numbers in parentheses refer to items in the References at the end of this article.

[2]This debate centers on the issue of how linkage indexes should be constructed. Jones makes a strong case that BL indexes are measured best by the column sum of the usual Leontief inverse (*7*). Jones also claims that FL indexes are measured best by row sums of the "output" inverse—that is, a matrix inverse derived from assuming constant output shares as the "technical output" coefficients. However, as Yotopoulos and Nugent (*13*) show, the selection of a linkage index procedure partly depends on the research objectives at hand. Given that there is no unique index or procedure for estimating linkages for all research needs, we proceed to decompose selected input-output flows in a developed economy. Our purpose is to estimate the relative importance to the U.S. economy of sectors that are input suppliers to agriculture versus sectors that utilize the output of agriculture.

to personal consumption for food and fiber in the United States. As we will demonstrate, FL effects in the U.S. food and fiber system are substantially larger than all BL effects. The linkages between the farm and nonfarm industries in the United States are dominated by FL effects generated by domestic personal consumption of food and fiber products. Our FL measure traces the linkages from raw farm sales to nonfarm processors and distributors of food and fiber to final users. This FL notion is a measure of nonfarm output that results from the need to process and deliver the farm goods sold to domestic processors during the year. In terms of domestic income and employment effects, significant benefits are obtained from the promotion of domestic consumption and exports of processed food relative to raw farm commodities.

Linkages in the Food and Fiber System

Building on the work of Davis and Goldberg (*3*), since 1967 the Economic Research Service (ERS) of the U.S. Department of Agriculture (USDA) has developed an input-output (IO) measure of economic activity associated with the food and fiber sectors of the U.S. economy (*4*).[3] ERS has constructed Personal Consumption Expenditures (PCE) and export final demand vectors for food and fiber products. These vectors are used with the Leontief inverse to obtain total gross output in the economy attributable to these final demand expenditures. Because these estimates are on a current account basis, neither capital investment for replacement nor net investment is considered, although we could incorporate these elements as additional final demand expenditures.

[3]"In 1957, Professors John Davis and Raymond Goldberg of the Harvard Business School coined the term 'agribusiness' as a reference to businesses related to agriculture. Davis and Goldberg identified these businesses by their contribution to the economic activity required to support the eventual delivery of food, clothing and shoes, and tobacco to domestic consumers and to support agricultural exports. They measured this economic activity using input-output analysis. When the Economic Research Service presented this type of measure in the early 70's they used a term other than 'agribusiness.' They chose 'Food and Fiber System' and estimated the equivalent of 17.8 million workers were employed in this system in 1967 (tables 1, 5). This accounted for 22 percent of total civilian employment compared with Davis and Goldberg's 41 percent in 1947 and 37 percent in 1954" (*4*, p. 1).

The estimation procedure for the output of the U.S. food and fiber system for a year when an I-O table exists is straightforward IO analysis. Thus:

$$Q = (I-A)^{-1}Y$$

where:

Q = an nxl vector of sector outputs required to deliver the final demand of the food and fiber system;

$(I-A)^{-1}$ = an nxn total requirements matrix;

Y = an nxl vector of final demand of the food and fiber system identified by sector of origin, 1977 levels in 1977 prices; and

n = the number of economic sectors, 79 for this analysis.

If it is necessary to estimate output of the food and fiber system for a year subsequent to a published table, one must work with less information. The only new information required is annual real (constant dollar) estimates of the final demand for the food and fiber system.

The disaggregation of the nonfarm component of the output of the food and fiber system is obtained by use of the following procedure.

First, partition the technology matrix into farm and nonfarm subsectors:

$$A = \begin{array}{c:c} A_{11} & A_{12} \\ \hdashline A_{21} & A_{22} \end{array} \qquad (1)$$

where:

A_{11} represents the 2 by 2 partition of intrafarm-sector direct requirement purchases; sector 1 is livestock, and sector 2 is crops;

A_{12} is the 2 by 77 partition of nonfarm-sector direct requirement purchases from the farm sector;

A_{21} is the 77 by 2 partition of farm-sector direct requirement purchases from the nonfarm sector; and

A_{22} is the 77 by 77 partition of intra-nonfarm-sector direct requirement purchases.

Then, rewriting the commodity balance equation yields:

$$\begin{bmatrix} Q_1 \\ Q_2 \end{bmatrix} = \begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix} \begin{bmatrix} Q_1 \\ Q_2 \end{bmatrix} + \begin{bmatrix} Y_1 \\ Y_2 \end{bmatrix} \quad (2)$$

where:

Q_1 = total commodity output of farm sectors 1 and 2;
Q_2 = total commodity output of nonfarm sectors 3, 4,. . ., 79;
Y_1 = final demand for farm commodities 1 and 2; and
Y_2 = final demand for nonfarm commodities 3, 4,. . ., 79.

Second, let the farm sectors be exogenous (let Q_1 be known); then we can solve for nonfarm output (see (*6*) for a more complete explanation of this technique).

$$Q_2 = A_{21} Q_1 + A_{22} Q_2 + Y_2 \quad (3)$$

or:

$$Q_2 = (I-A_{22})^{-1} (A_{21} Q_1 + Y_2) \quad (4)$$

Finally, disaggregate equation (4) into BL's or FL's:

$$BL = (I-A_{22})^{-1} (A_{21} Q_1) \quad (5)$$
$$FL = (I-A_{22})^{-1} Y_2 \quad (6)$$

Here, BL represents the nonfarm output required to support inputs to the farm sector. FL represents nonfarm output required to support delivery to the food and fiber system's final demand by nonfarm sectors.

Business Activity Linked to Farm Production

Table 1 presents the BL's and FL's of farm production with the rest of the food and fiber system. Thus, the livestock and livestock products and crops industries are excluded because they represent mainly farm production. Total nonfarm business activity associated with BL's and FL's was $706 billion in 1977 (column total).

The linkages of the food and fiber system are represented by BL and FL levels and linkage shares. For example, $826 million in output of the farm equipment industry (#44) (repair parts, because output related to farm capital expenditures is excluded) was required to support the output of the food and fiber system. Of that total, 91 percent or $754 million, was used to support farm production—the BL. About $72 million or 9 percent was used to support the processing and distributing activities of farm output—the FL.

Metal containers (#39) provide another example. The industry had $6 billion in sales related to the food and fiber system. About 8 percent of these sales, or $495 million, were oil cans, metal pesticide cans, and so on, which supported farm production. The other 92 percent, or $5.5 billion, were food containers used in processing and distributing farm output.

Although some industries would appear wholly FL's or BL's, that is not usually the case. Food processing (#14) is not 100-percent FL's because its output includes manufactured feeds. These feeds (processed grain and oilseed products) represent an input to the livestock and livestock products industry and thus represent a BL.

For the United States in 1977, BL's accounted for 11 percent (about $80 billion) of nonfarm business activity of the food and fiber system. FL's dominated, accounting for 89 percent ($626 billion).

Implications

The export market for U.S. cash grains is important to large segments of the farm sector and the farm supply sectors. However, domestic PCE of food and fiber products of the U.S. farm sector dominates the export markets in two ways: size of final demand (table 2) and linkage effects (table 1). Thus, policy at the macroeconomic level or farm-specific policy enhancing consumption of U.S.-processed food products relative to exports of raw farm products will generate greater output effects on the U.S. economy.

Table 1—Proportion of total sectoral food and fiber system business activity attributable to backward and forward linkages, 1977

Sector[1]	Business activity	Backward linkages		Forward linkages	
	Million dollars	*Million dollars*	*Share*	*Million dollars*	*Share*
3 Forestry and fishery products	2,793.9	145.2	0.05198	2,648.7	0.94801
4 Agricultural, forestry, and fishery services	4,802.3	4,054.3	.84425	747.9	.15575
5 Iron and ferroalloy ores mining	310.0	70.9	.22872	239.1	.77128
6 Nonferrous metal ores mining	382.6	129.7	.33896	252.9	.66104
7 Coal mining	1,721.7	384.4	.22328	1,337.3	.77672
8 Crude petroleum and natural gas	10,903.0	4,072.5	.37351	6,830.6	.62649
9 Stone and clay mining and quarrying	578.4	255.9	.44253	322.4	.55747
10 Chemical and fertilizer mineral mining	313.0	154.1	.49247	158.8	.50753
11 New construction	0	0	0	0	0
12 Maintenance and repair construction	8,879.5	2,468.0	.27794	6,411.6	.72206
13 Ordnance and accessories	22.7	2.8	.12388	19.9	.87612
14 Food and kindred products	180,496.0	12,046.0	.06674	168,449.0	.93326
15 Tobacco manufactures	10,610.0	.2	.00003	10,610.0	.99997
16 Broad and narrow fabrics, yarn, and thread mills	12,856.0	166.5	.01295	12,690.0	.98704
17 Miscellaneous textile goods and floor coverings	992.8	184.0	.18537	808.8	.81463
18 Apparel	34,684.0	24.1	.00070	34,660.0	.99930
19 Miscellaneous fabricated textile products	786.4	77.0	.09800	709.3	.90199
20 Lumber and wood products, except containers	2,193.5	379.3	.17292	1814.2	.82708
21 Wood containers	255.5	152.2	.59576	103.3	.40424
22 Household furniture	8.7	1.7	.19883	7.0	.80117
23 Other furniture and fixtures	15.4	3.8	.24952	11.6	.75048
24 Paper and allied products, except containers	9,839.6	931.8	.09470	8,907.8	.90529
25 Paperboard containers and boxes	5,824.0	518.9	.08911	5,305.1	.91089
26 Printing and publishing	3,179.4	307.4	.09671	2,871.9	.90328
27 Chemicals and selected chemical products	10,505.0	9,311.6	.56415	7,193.9	.43585
28 Plastics and synthetic materials	5,448.0	435.0	.07984	5,013.0	.92015
29 Drugs, cleaning and toilet preparations	1,672.3	261.6	.15647	1,410.7	.84353
30 Paints and allied products	464.0	92.8	.19999	371.2	.80001
31 Petroleum refining and related industries	12,103.0	4,532.7	.37452	7,570.0	.62548
32 Rubber and miscellaneous plastic products	6,837.6	1,078.3	.15770	5,759.3	.84230
33 Leather tanning and finishing	1,151.0	6.3	.00553	1,144.6	.99447
34 Footwear and other leather products	5,170.3	27.1	.00525	5,143.1	.99474
35 Glass and glass products	3,422.0	250.1	.07308	3,171.9	.92691
36 Stone and clay products	1,169.8	297.7	.25452	872.0	.74548
37 Primary iron and steel manufacturing	4,968.9	932.5	.18767	4,036.4	.81233
38 Primary nonferrous metals manufacturing	3,481.9	737.3	.21175	2,744.6	.78825
39 Metal containers	6,019.5	495.4	.08231	5,524.0	.91769
40 Heating, plumbing, and structural metal products	660.8	188.1	.28468	472.7	.71532
41 Screw machine products and stampings	1,274.1	174.7	.13712	1,099.4	.86288
42 Other fabricated metal products	2,284.5	526.7	.23055	1,757.8	.76945
43 Engines and turbines	382.0	138.3	.36203	243.7	.63797
44 Farm and garden machinery	825.9	753.5	.91233	72.4	.08767
45 Construction and mining machinery	269.9	75.7	.28071	194.1	.71929
46 Materials handling machinery and equipment	128.2	19.2	.15000	190.0	.85000
47 Metalworking machinery and equipment	408.1	70.1	.17199	337.9	.82801
48 Special industry machinery and equipment	604.8	100.1	.16552	504.7	.83448

Continued—

Table 1—Proportion of total sectoral food and fiber system business activity attributable to backward and forward linkages, 1977 (Continued)

Sector[1]	Business activity	Backward linkages		Forward linkages	
	------ *Million dollars* ------		*Share*	*Million dollars*	*Share*
49 General industrial machinery and equipment	634.2	196.0	0.30905	438.2	0.69095
50 Miscellaneous machinery, except electrical	901.2	191.3	.21234	709.9	.78766
51 Office, computing, and accounting machines	162.5	21.7	.13370	140.8	.86630
52 Service industry machines	488.4	64.2	.13149	424.2	.86851
53 Electric industrial equipment and apparatus	528.5	135.4	.25621	393.1	.74379
54 Household appliances	120.2	17.3	.14453	102.8	.85547
55 Electric lighting and wiring equipment	294.3	62.6	.21300	231.6	.78700
56 Radio, TV, and communication equipment	248.2	36.2	.14591	212.0	.85409
57 Electronic components and accessories	385.5	67.5	.17517	318.0	.82483
58 Miscellaneous electrical machinery and supplies	529.2	380.6	.71917	148.6	.28083
59 Motor vehicles and equipment	1,296.0	310.1	.24115	975.9	.75886
60 Aircraft and parts	169.6	28.1	.16585	141.5	.83415
61 Other transportation equipment	365.6	45.7	.12527	319.8	.87474
62 Scientific and controlling instruments	198.8	39.0	.19641	159.7	.80359
63 Optical, ophthalmic, and photographic equipment	394.7	48.6	.12336	346.0	.87664
64 Miscellaneous manufacturing	1,419.8	70.6	.04972	1,349.2	.95027
65 Transportation and warehousing	24,278.0	3,539.1	.14577	20,739.0	.85423
66 Communications, except radio and TV	5,022.3	692.7	.13793	4,329.5	.86207
67 Radio and TV broadcasting	30.6	3.8	.12672	26.7	.87328
68 Electric, gas, water, and sanitary services	15,757.0	3,560.0	.22593	12,197.0	.77407
69 Wholesale and retail trade	142,632.0	6,853.1	.04804	135,778.0	.95195
70 Finance and insurance	9,625.1	2,733.3	.28397	6,891.9	.71603
71 Real estate and rental	19,624.0	7,881.7	.40163	11,743.0	.59837
72 Hotels, personal and repair services (except auto)	2,343.6	304.9	.13012	2,038.7	.86988
73 Business services	28,601.0	3,589.8	.12551	25,011.0	.87449
74 Eating and drinking places	72,229.0	489.6	.00677	71,739.0	.99322
75 Automobile repair and services	4,039.7	636.6	.15760	3,403.1	.84240
76 Amusements	2,799.1	173.8	.06210	2,625.3	.93789
77 Health, education and social services and nonprofit organizations	1,089.2	438.2	.40231	651.0	.59769
78 Federal Government enterprises	2,021.8	222.6	.11010	1,799.2	.88990
79 State and local government enterprises	354.6	33.9	.09576	320.6	.90423
Total	706,276.0	79,906.0	.11314	626,369.0	.88686

[1]See (*11*) for the Standard Industrial Classification for each of the 79 sectors listed.

To support this view, we estimate the BL and FL effects of each of the five major components of final demand of the food and fiber system. This procedure involves reestimating equations (5) and (6) after substituting Q_1 and Y_2 obtained by using one of the five final demand components—for example, raw farm exports. Table 3 shows the results, summed over all sectors.

Comparing columns (1) and (2) in table 3 reveals that PCE expenditures and processed food exports generate nonfarm output that is about twice that of corresponding final demands. However, raw farm exports and resulting nonfarm output are about equal in magnitude. As expected, inspecting columns (3) and (4) shows that nonfarm sectors which are forward linked to agriculture benefit most from

Table 2—Final demand of food and fiber sector, selected elements, 1977

Input-output sector	PCE	Exports	Imports	Sector
	Million dollars			*Type*
1 Livestock	2,511	199	-360	Farm level
2 Other agriculture	7,726	12,523	-1,047	Farm level
14 Food-kindred products	113,507	7,308	-8,358	Processing-manufacturing
74 Eating-drinking	67,477	81	0	Retail trade-processing

Source: (*11*).

Table 3—Linkage effects of major types of final demand for food and fiber in the United States, 1977

Type	(1) Food and fiber system final demand, 1977	(2) Resultant nonfarm total gross output	(3) Nonfarm linkages	(4)
			Backward	Forward
	Billion dollars			
Personal consumption expenditure:				
Domestic food	255.9	499.0	60.8	438.2
Other food and fiber	114.4	213.9	10.0	204.0
Exports:				
Raw	15.5	15.7	11.2	4.5
processed food	8.2	17.5	2.8	14.7
Imports	-18.1	-39.8	-4.8	-35.0
Total	375.9	706.3	80.0	626.4

processed food exports. Nonfarm sectors that are backward linked to agriculture benefit most from raw farm exports. One must be careful interpreting a transfer from raw to processed exports. For example, a $1-billion reduction in raw exports would decrease nonfarm output less than the increase in nonfarm output from a $1-billion increase in processed exports. However, because only a fraction of the reduced raw exports would be needed as input to the food processing industry, raw farm "surplus" would increase. An increase of $3-5 billion in processed exports might be required to completely utilize the raw farm export transfer to domestic processing.

Expansion of a dollar's worth of processed exports as a substitute for a dollar's worth of raw exports will stimulate forward-linked sectors, depress backward-linked sectors, and reduce the demand for raw farm products. Total *nonfarm* output would increase because the FL effects are stronger than the BL effects. However, the value of farm sales would fall initially because not all the reduction in raw farm exports would be utilized as input to the food-processing sectors. Of course, we are considering only "first-round" effects; general equilibrium effects on prices and outputs are unknown. In contrast to this substitution scenario, if processed exports are expanded without reducing raw exports, the linkage effects obtained provide substantially more stimulus to the food and fiber system than export expansion of raw farm products.

Expanding domestic PCE for food relative to raw exports of food would have effects like those described when one compares processed exports and raw exports. A policy dilemma is evident. A $1-dollar expansion of domestic PCE or processed exports will yield more total nonfarm output than will a $1-dollar expansion of raw exports. However, both backward-linked nonfarm sectors and the farm sector would produce more from a $1-dollar expansion of raw exports. At least in terms of first-round effects, policy that stimulates domestic PCE while dampening foreign demand for raw exports can be expected to have uneven sectoral impacts. Farm sectors and backward-linked nonfarm sectors suffer relative to forward-linked nonfarm sectors. However, even small growth rates for domestic PCE for food combined with the sheer size of domestic PCE for food (about 17 times as large as raw export demand) could provide the demand stimulus for raw farm products required to offset declining raw farm exports.

Although not undertaken here, the identification of sectoral winners and losers under alternative macroeconomic policy scenarios is an important issue and one that economists can conveniently analyze using the linkage framework developed in this article. An additional area for research is the identification of processed food items for which the

United States has a comparative advantage. There may be few of these items so that FL effects are not available through trade. Still, given the nonfarm benefits of increased trade in processed foods, this is another important research area.

Finally, there are several limitations to our use of IO analysis in identifying linkages. First, there are the usual restrictive assumptions needed with static IO production functions with fixed proportions. Second, there is the omission of capital expenditures for farm equipment. third, there is the inherent problem of defining what comprises the food and fiber system of the United States.

Use of the static IO model is dictated by the lack of a substitute framework that has empirical content for detailed accounting of interindustry flows. Furthermore, IO is internally consistent and thus provides reliable, albeit static, insight into interindustry linkages. The omission of capital expenditures in the final demand vector understates BL in the U.S. economy, yet is consistent with earlier efforts at USDA to reflect current account linkages.

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Farmland Ownership and the Distribution of Land Earnings

By Robert F. Boxley*

Abstract

Although the number of U.S. farms has declined substantially over the past four decades, the number of farmland owners and the proportion of rented farmland have remained relatively constant. In 1978, there were an estimated 3.9 million farmland owners, but fewer than 2.5 million farm operators. Of the nearly 1.9 million landlords in 1979, about one-third leased land to operators of farms with sales of $100,000 or more, and three-fourths rented to operators with sales over $20,000. Because land constitutes the major financial asset of the farm sector, widespread agricultural landownership by nonoperator landlords provides a mechanism for a substantial transfer of agricultural earnings and wealth away from farm operators and, potentially, away from the farm sector.

Keywords

Farmland ownership, farm numbers, farm tenure, landlords

Considerable debate surrounding the 1985 farm bill has focused on farm program objectives and the distribution of program benefits. The number of farms is now about 2.3 million, while the farm population is near its lowest level ever. The agricultural sector is increasingly integrated into the rest of the economy. In 1978, only slightly over half the respondents classified as "farmers" by the Bureau of the Census considered farming their primary occupation. More entrepreneurial functions, including ownership of production assets, are now provided by those outside the traditional farm sector.

In this policy environment one has difficulty knowing who the intended beneficiaries of farm programs either are or should be. To the extent that land and other production factors are provided by individuals other than farm operators, for example, the true number of participants in agricultural production processes may be understated by traditional measures, and the actual distribution of factor earnings may be obscured. Other distributional issues raised by these statistics include questions of whether it is possible to design programs to help specific farmers or groups of farmers without conveying windfall benefits to unintended recipients.

This article examines changes in U.S. farmland ownership and tenure over this century. It analyzes differences in the distribution of farm operators and farmland owners in 1979 and examines how land earnings may have been shared then. Finally, it discusses some implications of differences in the distribution of claims to asset earnings for farm policy, data collection, and research.

Changes in Farm Tenure and Ownership

The statistics on farm numbers are familiar to most observers of the American agricultural scene. From a peak of 6.8 million farms enumerated in the 1935 Agricultural Census, the number of farms has fallen to about 2.3 million currently (*4*).[1] From the perspective of asset control and contributions to agricultural production, however, one must consider the substantial change in farm numbers over time within the context of the relative stability of the

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[1]Italicized numbers in parentheses refer to items in the References at the end of this article.

number of farmland owners and the percentage of farmland leased.

Data on farmland ownership are fragmentary. Only a few Agricultural Censuses provide sufficient information to allow us to infer ownership estimates from tenure data.[2] Wunderlich (*9*) has prepared estimates for four such Census years (table 1). For 1900, he estimates there were at least 3.7 million farmland owners, and possibly as many as 4.4 million. In 1945, his estimate ranges from 4.8 to 5.2 million. (These are range estimates because Census data do not always enable us to fully account for either operators who are also landlords or for rented land subleased to other operators.) In 1969 and 1978, the *Census of Agriculture* yielded estimates of 3.7 million and 3.9 million farmland owners, respectively.

The number of farm operators was 5.7 million in 1900, which fell to fewer than 2.5 million in 1978. In 1900 and 1945, however, about 2.0 million of the farm operators were "full" tenants—that is, operators who owned none of the land they operated. By 1969, the number of full tenants had fallen to fewer than 300,000. Thus, the number of farm operators who own at least some of the land they farm has ranged from 4.0 million to 2.2 million over the last eight decades (table 1). The number of nonoperator-owners has grown from 700,000 or fewer in 1900 to 1.7 million in 1978.

Since 1900, the amount of farmland operated under lease has been relatively constant. However, the relationships between farm operators and farmland owners has changed far more. Of the 4.0 million operator-owners in 1945, 82 percent were full owners; relatively few were part owners (662,000). The number of nonoperator-owners was small in 1945, especially in relationship to the large number (1.9 million) of tenant operators. However, nearly half (908,000) these tenants were sharecroppers, who mainly supplied farm labor. Thus, nonoperator-owners probably played a major role in supplying production assets and management to this segment of farm operators.

Table 1—Farmland owners and operators, selected years

Item	1900	1945	1969	1978
	Millions			
(1) Farmland owners	3.7-4.4	4.8-5.2	3.7	3.9
(2) Farm operators	5.7	5.9	2.7	2.5
(3) Full tenants	2.0	1.9	.3	.3
(4) Operator-owners[1]	3.7	4.0	2.4	2.2
(5) Nonoperator-owners[2]	0-.7	.8-1.2	1.3	1.7
	Percent			
Farmland leased	31.6	37.7	35.7	39.9

[1]Line (2) less line (3).
[2]Line (1) less line (4).

Source: Operator data are from (*4*, tables 538 and 539, p. 377); ownership data are from (*9*).

Between 1945 and 1978, both the number of claimants and the nature of claims to agricultural earnings changed substantially. Tenants declined nearly 1.6 million, and the number of full owner-operators fell by more than half. The decline in the number of operator-owners was partially offset, however, by the growth in the number of nonoperator-owners. Thus, farmland owners in 1978 exceeded farm operators by nearly 1.4 million.

Because theoretically the labor, management, and production assets of operators are all residual claimants, it is difficult to determine if the distribution of factor returns has changed relative to changes in the number of farm operators and farmland owners. The *Economic Indicators of the Farm Sector* (*5*) series indicates that 66 percent of the total returns to labor, management, and production assets of operators were imputed to their labor in 1945. Only slightly over 25 percent of the total accrued to production assets. In 1978, by contrast, 73

[2]The other sources of landownership information are the two national ownership surveys the U.S. Department of Agriculture (USDA) conducted in 1946 and 1978 (*2*). The 1946 survey sample frame was developed from the 1945 *Census of Agriculture*. It yielded an estimate of 5.2 million landowners, consistent with Wunderlich's upper limit (*9*). The 1978 survey, which was developed from an area sample frame, surveyed all rural land (*1*). In that survey, 6.9 million respondents identified themselves as farmland owners. Although the disparity between Wunderlich's estimate for 1978 and the *Farmland Ownership* survey is large, the estimates are not necessarily inconsistent, given definitional and sample frame differences.

percent of total income was allocated to production assets.

Melichar has argued that the *Economic Indicators* series overestimates the proportion of residual returns that can be imputed to production assets, especially in recent years. He calculates that only 41 percent of 1978 income from labor, management, and assets should be imputed to assets (*3*, table 112.1). Even Melichar's estimates, however, indicate some shifts in the proportion of factor returns accruing to land. Furthermore, the relative contribution of land to the value of all production assets increased—from 57.5 percent in 1945 to 75.2 percent in 1978.

The Distribution of Landlords by Value of Farm Sales[3]

There were nearly 1.9 million farm landlords in 1979 (*6*). These landlords were predominantly associated with large-scale commercial farm operations (table 2). According to the "1979 Farm Finance Survey," 32 percent (591,000) of all landlords leased to operators of farms with sales of $100,000 or more; 61 percent rented to operators with sales of $40,000 or more, and nearly 75 percent rented to operators with sales over $20,000. Landords outnumbered farm operators on farms with sales of $100,000 or more by a ratio of 2.1 to 1. However, operators held most of the land, supplying about 56 percent of it in farms with sales of over $20,000 (table 3).

Landlords renting land to farm operators with sales of $100,000 or more were the majority of suppliers of rented land (table 4), receiving 59 percent of all rent. They also received the highest gross return (4.7 percent) on the value of their rental land and buildings.

In the aggregate, landlords received gross rents equivalent to 4.1 percent of the value of their land

[3]In this article I distinguish between "landlords" and "nonoperator-owners" depending on the data source. The terms are nearly synonymous as most landlords are also nonoperator-owners. However, some landlords both operate farms and rent land. The "1979 Farm Finance Survey" (*6*) does not provide the information needed to separate operator- and nonoperator-landlords but, according to the "Summary and State Data" of the *1978 Census of Agriculture* (*7*), 11 percent of all farm operators (mostly full-owners) also rented land to other farmers.

Table 2—Farm operators and landlords, by value of sales, 1979

Sales class	Operators	Landlords	Cumulative distribution	
			Operators	Landlords
	Number		*Percent*	
$500,000 and over	23,890	51,902	1.0	2.8
$200,000-499,999	78,702	180,864	4.3	12.5
$100,000-199,999	173,737	358,522	11.7	31.6
$40,000-99,999	373,676	549,119	27.6	60.9
$20,000-39,999	257,919	242,013	38.6	73.8
$10,000-19,999	270,845	169,333	50.1	82.8
$5,000-9,999	302,512	134,330	62.9	90.0
$2,500-4,999	326,277	88,596	76.8	94.7
Under $2,500	546,667	99,905	100.0	100.0
Total	2,345,225	1,874,584	— —	— —

— — = Not applicable.

Source: (*6*).

Table 3—Acres of land owned and rented, by tenure and value of farm sales, 1979

Sales	Farmland		
	Owned by operators	Rented from landlords	Proportion rented
	1,000 acres		*Percent*
$100,000 or more	238,231	189,498	44.3
$20,000-$99,999	179,614	140,148	43.8
Under $20,000	135,094	45,839	25.3
Total	552,939	375,485	40.4

Source: (*6*).

Table 4—Distribution of number of landlords, acres rented, rent received, and gross return on value of rented land and buildings

Sales	Landlords	Acres rented	Rent received	Gross return on value[1]
		Percent		
$100,000 or more	31.6	50.5	59.0	4.7
$20,000-$99,999	42.2	37.3	36.1	4.0
Under $20,000	26.2	12.2	4.9	2.1
Total	100.0	100.0	100.0	4.1

[1]Rent received as a percentage of value of land and buildings rented to others. Includes landlords not receiving rent.

Source: (*6*).

and buildings in 1979.[4] These gross rents may translate into a relatively low rate of income return to real estate assets. Estimates from the *Economic Indicators* series indicate that all landlords received $6.1 billion in net rents in 1979—including $0.7 billion in rent received by operator-landlords (*5*). This amount is equivalent to a 2.3-percent return on the Census-estimated value of all rental land and buildings. For comparison, Melichar estimates that all farm production assets earned an income return of 2.7 percent in 1979, whereas the U.S. Department of Agriculture (USDA) calculates the income return to equity value of farm production assets to have been 3.7 percent (*3*, *5*). By these standards, farm landlords appear to have earned a lower rate of return on their real estate assets than farm operators earned on all production assets.

Capital gains represent the other component of land returns. Over the past several decades, capital gains (primarily in real estate) have been the main component of growth in U.S. farm wealth. Between 1971 and 1979, real capital gains on farm assets, in 1983 dollars, totaled $465 billion (*3*). More than a third of these gains were given up between 1980 and 1984, but a substantial amount of new wealth remains as a legacy of agricultural production, marketing, and farm policy developments of the seventies. Farm landlords probably shared proportionately in these gains and losses.

Who Are the Farm Landlords?

A reasonable assumption is that many farm landlords are either retired farm operators or widows and heirs of former farmers. If so, one can argue that separating landownership from farm operations has few distributional consequences, as farm assets are still under the effective control of the family. Unfortunately, information to determine if this hypothesis is true is limited. Two sources are the "1979 Farm Finance Survey" (*6*) and the 1978 survey of *Farmland Ownership in the United States* (*1*). The "1979 Farm Finance Survey" compares landlords and farm operators, whereas the *Farmland Ownership* survey compares nonoperator-landlords and all farmland owners.

Some results from the two surveys support an "extended family" hypothesis. For example, both surveys indicate that the average farm landlord is likely to be older (24.2 percent over age 65 for landlords compared with 16.6 percent for farm operators) or female (23 percent compared with 5.2 percent). Nearly 20 percent of landlords reported their occupation in the "1979 Farm Finance Survey" (*6*) as "retired farmer," whereas the *Farmland Ownership* survey classified 45.8 percent as "retired" (from all occupations). The *Farmland Ownership* survey indicated that nonoperator-landlords were more likely to have inherited land or to have received land as a gift than were all farmland owners (38.2 percent compared with 22.5 percent for all farmland owners). Nonoperator-landlords also tended to have owned their land for longer periods than all farmland owners.

Offsetting these statistics is other evidence from the *Farmland Ownership* survey that, at the upper end of the size distributions, nonoperator-landlords tended to hold proportionately more land and more highly valued land. The incidence of family ownerships was lower. Relatively more landlords were sole proprietors, and the incidence of nonfamily corporations was slightly higher among landlords than among all farmland owners. Thus, the survey statistics do not rule out the possibility of a

[4]According to the "1979 Farm Finance Survey," landlords received $10.9 billion in gross rents in 1979 (*6*). They paid out just over $3.0 billion in operating expenses and $1.7 billion in capital expenditures.

landlord population that consists of two groups: one in which landlord status is a transitional role in the farm/family life process and another for which it is solely a business or investment.

Some Implications

Most measures of the economic health of the farm sector focus on a relatively small number of indicators, including such measures as farm numbers, size of the farm population, and distribution of farm sales. From a larger perspective—that of the ownership of the factors of production—such measures are incomplete and possibly misleading. If landlords are considered, the number of claimants to factor returns in agriculture, particularly among the Nation's largest farms, is substantially greater than a count of farm operators alone would suggest. Thus, the "farm" clientele for agricultural policy, though still small, is larger, more dispersed, and more stable over time than is immediately apparent.

These observations are important because of the role of land as a residual claimant to agricultural earnings. Widespread agricultural landownership by nonoperator-owners provides a mechanism for substantial transfer of agricultural earnings and wealth away from farm operators and perhaps away from the farm sector. Conversely, to the extent that landlords have other wealth or income sources, they may help to stabilize the agricultural sector during periods of financial difficulty.

The continued search for efficiency in agricultural production could lead to further functional specialization among farm operators and landlords and, conceivably, to the separation of management and risk-bearing functions from asset ownership functions. Anecdotal reports of extensive farming operations established on those principles are common (*8*). Whether or not such arrangements become the norm for commercial agricultural operations should depend partly on how operators and landlords agree to share income and wealth returns. Data that identify these farm and nonfarm linkages are needed.

Many unanswered questions about the efficiency and distributional consequences of widespread factor ownerships remain. Economic theory suggests that each factor in a competitive economy will be paid according to its marginal value of productivity. But, theory needs to be related to actual agricultural conditions regarding such considerations as returns to scale, mobility of labor, and transfer of land among farms to achieve size efficiencies. Much of the secular rise in farmland earnings has presumably been captured by landowners. If farm programs are changed, how will the resulting changes in farm income be distributed among the owners of the factors of production? What do these changes imply for political forces promoting or resisting program changes?

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Research Review

Future Agricultural Technology and Resource Conservation

Burton C. English, James A. Maetzold, Brian R. Holding, and Earl O. Heady (eds.).
Ames: Iowa State University Press, 1984, 604 pp., $26.65.

Reviewed by Roger W. Hexem*

Nearly 300 academicians, business people, farmers, scientists, and technicians participated in a 3-1/2-day symposium in December 1982 to discuss and project the state of America's agriculture in the years 2000 and 2030, the associated impacts on resource use and productivity, and the possible changes in environmental quality. This monograph is a compilation of papers presented, remarks by discussants, and deliberations by work groups—53 papers or reports—viewed as state-of-the-art discussions of agricultural technology and resource conservation.

Heady, in his keynote address, asks: "Given the demand prospects for our agricultural commodities and the resources which produce them, is the permanent base of our productivity threatened and are our stock resources being depleted too rapidly?" He also provides a more specific focus by stating that results from the symposium can provide inputs for large-scale modeling by the Center for Agricultural and Rural Development (CARD) at Iowa State University and the Soil Conservation Service (SCS) for USDA to use in making periodic appraisals of the country's agricultural resources and in developing a national soil and water conservation program. So, participants made little effort to integrate assessments and projections of components of production and consumption processes. This integration would be addressed in the model development phases.

In his summary and synthesis, Tweeten states that solutions to resource conservation problems do not respect disciplinary boundaries and that technical problems of production and resource care are more tractable than economic, social, and political problems. Specialists at the symposium present optimistic scenarios for continued growth in agricultural productivity which, if past trends continue, will increase output and, through substitutions for natural resources, will conserve land and water resources. However, serious conservation problems will likely persist.

The symposium was organized around nine subject areas—soil management technology, tillage, and crop rotation practices; land use; water resource technology and management; adoption and diffusion of soil and water conservation practices; crop technology; crop nutrition technology; pest management technology; machinery technology; and red meat, dairy, poultry, and fish technology. Given the range of disciplines and the large number of participants, the papers are rather uneven in their scope, level of detail, and authors' adherence to purpose. Readers will benefit from discussions of a wide range of subjects, rather extensive bibliographies, and identification of research needs.

Larson and others describe recent trends in land use, consequences of soil erosion, and needs for better soil management. Young expands the discussion by examining the effects of soil erosion on crop yields and critiquing current modeling efforts to estimate these relationships, particularly the usefulness and limitations of the USDA's Erosion Productivity Impact Calculator (EPIC) model.

Castle and Batie provide general discussions of land use issues, including those related to resource conservation. They do not, however, make any projections of land use trends. As discussants, Sampson and Raup remind us of difficulties in anticipating unexpected circumstances when we project land use and agricultural production. The members of the Land Use Work Group focus on conditions influencing land use conversions; they also decline to project such conversions.

Jensen and Rogers identify current water uses and issues related to irrigated agriculture. Rogers states that the United States does not face a crisis in providing water for agriculture over the next 50 years. However, serious dislocations and disruptions may occur locally. Rogers also formulates four scenarios of irrigated acreage in the year 2000. Martin and the Water Resource Work Group stress that water supply-demand conditions must be based on economic relationships. The agricultural sector

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used about 83 percent of U.S. water consumption in 1975. There is substantial potential for improving the efficiency of water consumption, particularly in the East. According to the work group, most increases in acreage of irrigated cropland will be in the Midwest and East.

In the chapter dealing with crop technology, Heichel states that genetic improvements have accounted for 50-60 percent of yield increases for the principal crops in the past 50 years. The rest has been due to improved management and cultural practices. No startling increases in productivity are expected by 2000 or 2030. Heichel cites studies supporting either a gradual deceleration of productivity or, conversely, a continuing increase in capacities for improved yields. These contradictory trends result from differences in procedures used by researchers, crops studied, and time periods covered. Frey asserts that significant progress can be made in developing stress-tolerant cultivars so that some lands currently on the margin of profitability can be farmed profitably. There is also potential for reducing worldwide production losses of 10-20 percent annually caused by diseases and insects. The work group projects percentage changes in yields for major U.S. crops by 2000 and 2030. The highest "most probable" yield gains are expected for rice; the lowest, for alfalfa and cotton. Soybean yields, for example, are projected to be 60 and 120 percent higher by 2000 and 2030, respectively. About two decades are now required to move technologies from research stages to widespread implementation.

Several participants examining crop nutrition technology stress the increasing importance of nutrient management in increasing crop yields, especially because of rising costs for fertilizer and growing concerns about nutrient movement in soil runoff and percolation which affects environmental quality. Both Randall and Englestad cite the importance of soil testing and the need for more awareness of nutrient availability in the subsoil. Randall states that the key to the long-term success of using reduced tillage, at least in much of the Corn Belt, is the proper management of soil fertility. Nutrient cycling of crop residue is becoming more important. The associated work group projects yield changes for major crops to 2000 and 2030 in the 10 production regions. Projections reflect several changes in technology and management such as expansions in supplemental irrigation; shifts to no till; and improvements in fertilizer formulation, placing, and timing. Yield increases are projected for all regions. Highest increases for corn and soybeans, for example, are projected for the Delta and Southeast where current yields are relatively low.

Leeper and Andaloro emphasize that man's disruption of a seemingly stable ecosystem results in parts of the system reacting violently. Integrated Pest Management (IPM) promises to reduce or subdue such reactions through more discriminating use of pesticides. They stress the need for knowing more about crop-pest relationships for individual crops. IPM must also be profitable to users.

Frisbie focuses on pest management in conservation tillage. Such tillage basically alters the structure of the agroecosystem, especially the microclimate at and near the soil surface. Frisbie reviews changes in the management of weeds, diseases, insects, and other pests that have come about with adoption of conservation tillage.

The Pest Management Technology Work Group estimates that preharvest losses of production to pests are around 30 percent for field crops and as high as 37 percent if we include fruits, vegetables, and specialty crops where losses are most severe. Current IPM practices can reduce pest control costs by 10-25 percent or by as much as 90 percent in a few situations where pesticides are currently used intensively. Most progress in improving IPM during the next 20 years will benefit production of high-value, specialty crops. The work group also estimates changes in yields resulting from improvements in pesticide technology. Increases of up to 10 percent can be obtained for most crops if current technology is used more widely. An additional 5- to 15-percent increase in yields is predicted as farmers adopt technological improvements in pest control. About 7-10 years are required to discover new chemicals and to make them widely available. Totally new strategies based on development of basic biological information require more than 20 years before practical applications are realized.

In his assessment of machinery technology, Twist does not anticipate any great changes in basic design of tillage tools by 2000. Hunt emphasizes that the evolution of farm machinery technology has been continual rather than revolutionary. Farm machines are currently operated at about 95 percent of efficiency. Technology required in 2000 and 2030 mostly seems to be available already. However, more knowledge of the efficient application of the technology to a changing agriculture is needed. According to the Machinery Technology Work Group, better applications of pesticides should increase productivity by 2 and 5 percent by 2000 and 2030, respectively. Improvements in fertilizer placement should increase yields by 2 and 7 percent, respectively, in 2000 and 2030.

Three speakers address recent and projected changes in animal agriculture and in consumption of animal products. Touchberry reminds attendees that application of existing technology could markedly increase the efficiency of production as well as total production. He sees a "colossal" potential for improving food production with aquaculture. Hansel believes that increased production per animal will be achieved largely through discoveries in forage production and utilization, animal reproduction and genetics, and animal physiology and nutrition. He sees a trend toward fewer ruminants and the utilization of improved forages, industrial byproducts, and even waste products as significant portions of ruminant diets. Van Arsdall points out that the historical complementary relationship between livestock and crop production is being disrupted by technological improvements which create gains from specializing in crop or livestock production and by economies of size. Work group members also recognized this relationship; they believe that a strong animal agriculture is essential to resource conservation and is complementary with good conservation practices. Work group members developed projections of productive efficiencies for producing animal products. They also identified possible regional shifts in production.

Rates and timing for adapting or adopting existing and emerging technologies affect the structure and performance of the agricultural sector. The rates are conditioned by several personal, economic, and institutional factors. Several speakers discuss and critique the adoption/diffusion model as applied to adoption of conservation technologies.

Nowak distinguishes between "item" and "system" innovations. System innovations diffuse much more slowly, but most future technologies discussed are of the item type. Existing institutional arrangements are usually sufficient to promote adoption of item, but not system, innovations. Nowak adds that future technologies will enhance the potential to farm currently marginal land in an economically viable manner, but that rates of soil and water degradation will likely increase. He provides several strategies to promote adoption of soil conservation practices.

Van Es discusses the differences between private and public costs and benefits associated with adopting conservation measures. He also addresses the issue of mandatory controls for reducing soil erosion.

Heffernan questions several assumptions of the adoption/diffusion model as they relate to soil conservation issues. He states that the greatest utility of the model may be in suggesting new areas of research.

According to the work group members, the symposium is probably the first formal recognition of the need for good interaction between the technological and socioeconomic aspects of resource conservation. They identified the following issues: new approaches are needed to help farmers identify the nature and magnitude of conservation problems; solutions to problems are needed that include alternatives from which individuals can choose those most appropriate to their operations; more local involvement is needed (a "bottom-up" approach involving communities, organizations, and individual farmers rather than a "top-down" approach); and a package of options including cross-compliance, cost-sharing, technical assistance, tax incentives, and others is needed to solve or ameliorate resource conservation problems.

Some readers will be disappointed to see relatively little discussion of future economic conditions—demand, trade, economic policy, and cost/return scenarios. But, specific discussions of such issues were beyond the symposium's objectives.

Economies of Scale, Competitiveness, and Trade Patterns within the European Community

Nicholas Owen. Oxford, England: Clarendon Press, 1983, 193 pp., $39.00.

Review by Stephen W. Hiemstra*

Seldom is theory integrated with empirical efforts so as to excite the imagination. Nicholas Owen's study of European Community (EC) integration is such a work. Throughout the book, theory and statistical study yield strikingly compatible conclusions. The result is fodder for the mind—a fulfillment of an instinctive yearning for simplicity and justification. The appeal of this work accordingly extends beyond the fraternity of European analysts. Owen's work is the dissertation we all wish we could have written.

Owen's proposition is this: the benefits of EC integration have been underestimated because theorists have focused on marginal rather than on longrun average costs. Ex post facto, the theorists' focus on marginal costs is intuitive because high-cost producers have exited the market and no measurable benefit from integration beyond the trade created by tariff reduction is evident. Ex ante, the process of structural change in regional markets and the incentive for low-cost producers to expand production is extensive. In this case, the focus on longrun average costs, borrowed from Wonnacott,[1] more closely matches an industry's experience over a period of years.

This proposition is founded in the observation that trade within the EC in goods, such as automobiles, has grown at a rate four times the rate of growth in production. Europeans, as Owen further observes, trade different styles of clothing and different makes of cars, but not clothing for cars. The high growth rate of trade and its composition are inexplicable in terms of traditional notions of comparative advantage because the factor endowments of EC member states are almost identical. In their chagrin, theorists have more typically attributed this trade to consumers' preference for variety and have neglected possible cost advantages accruing to specialization and economies of scale.

Two further observations lend credence to this proposition. First, Owen provides convincing evidence to support the hypothesis that wage and productivity advantages held by the United States over the EC member states are closely associated with market size and plant economies of scale. Second, in a statistical testing of European census data, trade performance (measured as exports minus imports divided by total trade) is significantly correlated with relative plant size, relative industry size, and average labor productivity. This statistical test was interesting because it showed: (1) one-seventh to one-half of trade was related to scale economies; (2) economies were more important at the plant than at the firm level; and (3) the effect was more pronounced in the long than in the short run. As expected, larger plants were the most important contributors to this effect.

Having made a general case for his proposition, Owen set his computer printouts aside and turned his attention to case studies of three EC industries: cars, trucks, and consumer durables. In each case, the effects of integration were: (1) to accelerate product specialization and the adoption of technologies having significant scale economies, (2) to eliminate regional price differentials and product idiosyncracies, (3) to extend the market shares of low-cost producers at the expense of high-cost producers, and (4) to lower unit costs in both the importing and and exporting member states. A doubling of a firm's output was estimated to result in cost reductions ranging from 10 percent (cars) to 20 percent (trucks and washing machines). Horizontal and vertical integration of firms yielded meager economies relative to the economies associated with increased plant scale. Nontariff barriers were reported to be the primary impediment to a more rapid integration of regional markets.

In wrapping up his analysis, Owen used several interesting performance measures. The first was a ratio which measured resource savings due to trade. This ratio measured the difference in the value of trade before and after integration and

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[1]Ronald J. and Paul Wonnacott, *Free Trade between the United States and Canada* (Cambridge, MA: Harvard Univ. Press, 1976).

divided that difference by the value of trade following integration. Values for this ratio ranged from 48 percent for trade in trucks to 54 percent for trade in washing machines.

A second measure of interest was a method for calculating the increase in competitiveness due to integration. This measure was derived from the observation that production cost performance improves naturally over time because of on-the-job learning, new investment, and improvements in technology. In separate markets, cost performance will differ and will improve at differing rates. With the integration of markets, by contrast, we expect to see a convergence of these learning curves. One can accordingly measure the improvement in competitiveness by projecting the rates of improvement in cost performance before integration. These rates can then be compared with actual performance. The difference is attributed to market integration. Adding the induced cost savings to the resource savings due to trade measured above, Owen reported a resource benefit of 135 percent of the trade value for refrigerator trade between Britain and Italy.

In assessing the overall impact of integration on economic growth in the EC-6,[2] Owen divided trade benefits into two categories of cost reductions: those due to better utilization of capacity and those due to scale effects. From his case studies, he noted that costs could be reduced up to 20 percent because of a doubling of volume. He took this figure and attributed the other 80 percent of cost reductions to scale effects measured by direct and indirect resource savings (that is, a conservative assumption relative to the 135-percent reduction reported for refrigerators). Drawing on other studies, Owen assumed that the integration increased trade in the EC-6 by 40-50 percent of its 1962 level, and he projected this rate of increase to obtain an estimate of 100-125 percent of the 1962 level for 1980. Taking the value of this trade and allocating it between better utilization of capacity and improved scale, he estimated that EC integration had added 5-12 percent to the growth of the manufacturing sector in the EC-6 by 1980. By similar methods, he estimated that integration had added 3-6 percent to EC-6 GDP growth by 1980. This estimate compares with 0.7-percent added growth obtained by concentrating wholly on the effects of tariff reduction.

Albeit well executed, Owen's approach suffers from the weaknesses inherent in the case study approach. Arguments from the specific to the general are usually lengthy. The author is compelled to make numerous assumptions which are difficult to assess, and reliance on previous work is necessary. In this study, we are not, for example, told why the automobile, truck, and consumer durable industries were selected for analysis or the degree to which they are representative of the manufacturing sector. An important consideration in this respect is: how representative are the levels of pre-integration tariffs, capacity utilization, and previous export levels? If each of the countries studied maintained large export markets prior to integration, then market integration could have done nothing more than diverted trade from these export markets to EC markets. It is also conceivable, if export subsidies were removed with integration, that overall capacity utilization would have actually declined. In either case, Owen's focus on longrun average costs rather than on marginal costs would lose its appeal. Nevertheless, Owen's judgment appears sound in discussions we observe, and it is fair to assume that it is sound in areas not observed.

I recommend this book to readers interested in trade, market structure, and integration. The book reads well and is occasionally quite humorous to Americans unaccustomed to British euphemisms and parlance. The price of the book is high and, fortunately for the reviewer, reflects its value.

[2]Belgium, France, Italy, Luxembourg, Netherlands, and West Germany.

Federal Price Programs for the American Dairy Industry: Issues and Alternatives

Jerome Hammond and Karen Brooks. Department of Agricultural and Applied Economics, University of Minnesota for the National Planning Association and the Food and Agriculture Committee, 1985, 36 pp., $4.50.

Reviewed by Richard F. Fallert*

This well-written, easy to read report gives a general history of current dairy programs, describes the basic features of these programs, gives some insights into their economic impact, and examines the likely effects of some periodically proposed modifications and alternatives. The report should be useful to many people interested in a quick review and background of dairy programs and their effects.

The report is organized into four parts: basic features of the Federal dairy price programs (the price-support program, Federal milk marketing orders, and the interaction of price supports and orders), effects of dairy industry regulations (price supports and Federal orders), import controls, and policy alternatives.

The price-support alternatives include a purchase program with producer assessments for some program costs, simple reduction in the support price, price supports through deficiency payments, payments for reducing milk production, return to the basic dairy program under the 1949 Agricultural Act, and complete elimination of all dairy price supports.

The Federal milk marketing order provision changes addressed in the report include abolition of classified pricing and pooling of returns, nationwide pooling of returns from classified pricing, and elimination of exclusionary features of Federal orders such as "down allocation" and "compensatory payments."

All the effects of alternative dairy regulations are based on research at the University of Minnesota; only one other reference is cited. One runs the risk then, especially in the evaluation of the Federal milk order program, of presenting effects of alternative Federal order provisions and of generalizing on the merits of a national milk marketing order by presenting conclusions based on only limited analysis.

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The report traces the history of the price-support program from World War II. Two basic problems associated with the program are highlighted. First, the price range provided for by the law did not always allow the Secretary of Agriculture to choose a price low enough to prevent large accumulations of surplus dairy products by the Commodity Credit Corporation. Frequently, the support price, especially in the early eighties, was too high and production exceeded commercial demand; Government stocks and costs consequently expanded. Another problem cited by the authors is that price supports have kept consumer prices higher than they would otherwise have been, thereby reducing commercial demand and encouraging sales of alternative fats and imitation dairy products.

The report traces the history of Federal milk marketing orders from the early thirties. A major problem cited in the report is that the classified pricing system acts to increase prices to producers in some fluid markets and reduce prices to others. Producers in the upper Midwest and possibly the Chicago market are probably adversely affected. Orders also have provisions that favor local milk supplies over distant sources and that stifle adoption of alternative technologies such as reconstituted milk. The authors describe the complex mechanisms of marketing orders and present the effects on manufacturing grade (Grade B) producers. Under the marketing order program, handlers must pay a specified Class I price for milk used in fluid milk products, and the difference between that price and the lower price of milk used to produce manufactured dairy products is the Class I differential. Class I prices differ among the 44 marketing orders now in existence. However, the price of manufacturing milk is determined in a national market because manufactured dairy products are storable and transportation costs are low compared with raw milk as much of the water is removed in the manufacturing process.

Class I prices currently differ among marketing orders, generally increasing with distance from a single basing point in Eau Claire, WI. Minimum Class I prices per hundredweight are now equal to $0.90 more than the Wisconsin base price of manufacturing milk plus $0.15 per 100 miles distance from the basing point. Because actual transportation costs are more than twice the amount on which intermarket Class I prices are based, over-order premiums are negotiated between producer cooperatives and handlers to cover the added costs of interorder milk movements.

Although not originally designed to act in concert, the interactions between the Federal milk marketing order program and the dairy price-support program have important effects on the industry. The authors suggest that there is substantial textbook or theoretical price discrimination in the classified pricing system which discourages fluid milk product consumption, increases Grade A milk supplies in high-cost areas, and increases Grade A milk use in manufactured dairy products which drives down manufacturing grade (Grade B) prices. They further suggest that one way of compensating producers in low-cost areas is to maintain a relatively high support price under the price-support program. Without the support price, producers in the low-cost areas would probably be more concerned about marketing order provisions that adversely affect their markets.

The authors do not point out that price enhancement through pure textbook price discrimination under Federal orders has been reduced over the years by holding the minimum Class I differential constant since 1968, whereas the manufacturing grade milk price has tripled. The average minimum Federal order Class I differential in the overall system declined from 33 percent of the average Federal order Class I price in 1968 to about 14 percent of the Class I price in 1984. Meanwhile, costs of transporting milk and servicing the fluid milk market have increased, primarily because of energy costs and inflation. The allowance for transportation on intermarket shipments built into the Federal order price structure is probably less than half the current cost of shipping raw milk. However, transportation allowances are curently figured from a single pricing point in Eau Claire, WI, and, with the large buildup of excess Grade A milk, a number of price basing points closer to fluid milk demand areas would likely evolve under competitive conditions.

Another point not mentioned by the authors which concerns the equity of returns among producers in different regions is that the weighted-average price received for all milk marketed in Minnesota, as a percentage of the U.S. all milk price, increased from 82 percent in 1968 to 95 percent in 1984. In contrast, this price relationship decreased from 133 percent to 120 percent in Florida over the same period.

The authors emphasize the economic distortions of the classified pricing system, but fail to recognize the overriding distortions of marketwide pooling of producer returns and the associated lack of incentives for delivering milk to the fluid milk market—the original primary purpose of orders. Under marketwide pooling, the minimum average (blend) price received by producers is calculated on a marketwide basis, combining into one total the utilization of all handlers and the total receipts from all producers in the market. Under this pooling system, any additional revenue (except revenue from over-order charges) from Class I sales by a handler is shared among all producers in the market. The overall effect is a reduced incentive to service the fluid milk market and a reduced incentive to shift milk into products with the highest use value. Marketwide pooling also reduces the incentive for optimal location of manufactured dairy product plants because the cost of milk used in hard manufactured dairy products is the lower Class III price regardless of plant location.

The authors seem more concerned about distributive equity of returns among regions than about incentives for efficient milk flows among markets when they suggest that nationwide pooling of returns from classified pricing could resolve some of the producer inequities resulting from classified pricing. They do not recognize the location value of milk, and they ignore problems of intraorder pricing that would arise under nationwide pooling. They also erroneously indicate that administration of a nationwide pool would not be difficult. In reality, the current problem of getting milk needed for fluid use away from manufacturing would worsen. Manufacturers of butter, nonfat dry milk, and cheese would have even less incentive for

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