NEXT YEAR ON THE U.S. FARMLAND MARKET: AN INFORMATIONAL APPROACH

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Abstract: This paper formulates an information measure for changes in asset values and applies the formulation to farmland values in the United States for 1960-99. The results indicate that changes in asset values contained significant information following the Russian wheat sale in the early 1970s and the financial crisis in agriculture in the mid 1980s. Further, information about preceding year's asset value largely explains the regional distribution of current year's farmland values.

Keywords: information measurement, farmland values

1. Introduction

Measuring the informational content of asset values is not new. Theil and Leender (1965) and Fama (1965) both present methodologies for measuring the informational content of stock markets based on informational measures (Theil, 1967). Both studies focused on information in asset prices based on the number of stocks advancing, remaining constant or declining from one trading day to the next. Based on these measurements, Theil and Leender concluded that stock markets in Amsterdam were not informationally efficient while Fama concluded that the New York stock market was efficient. This study departs from the formulation in these studies to examine the information content of changes in relative asset values. Our formulation allows for a regional decomposition of the information in asset value changes. The informational measure is then applied to farmland values in the United States. The results indicate that significant information in farmland values in the United States occurred during the mid 1970s and mid 1980s.

2. Measurement of Information

The general formulation of the information measure is presented in detail in Theil (1967). The information measure used by both Theil and Leenders and Fama can be expressed as

$$I = \sum_{i=1}^{N} p_i \ln\left(\frac{p_i}{q_i}\right) \tag{1}$$

where I is the information index (or the information inequality), p_i is the posterior probability, q_i is the prior probability, and N is number of observations. The information approach assumes that the two sets of probabilities embody the effect of a signal. As described in Theil and Leenders, I measures the information in that signal or, more precisely, the difference between the distribution functions resulting from observing some signal. In both Theil and Leenders and Fama, the difference in the number of stocks advancing, remaining constant, or declining between two time periods provided evidence of trends in the stock market. If the measure of information was small, the stock market possessed a memory.

The specific application of the information index in equation 1 is one of a host of uses to which information inequality has been applied. Theil (1967) demonstrates how the index could be applied to measure income inequality. Other studies such as Theil (1989) built on this application. In this application, q_i is defined as the share of income to group i (usually defined by a geographic region such as a state or country) and p_i is defined as the population share in region i. In addition to demonstrating the versatility of the information measure, these applications emphasize the measure's decomposability. Specifically, grouping the geographic regions into C different groups ($c = 1, \cdots C$) such that each state belongs to one group, it is possible to show that

$$
\begin{aligned}
I &= \bar{I} + I_R \\
I_R &= \sum_{c=1}^{C} Q_c \ln\left(\frac{Q_c}{P_c}\right) \\
Q_c &= \sum_{i \subset c} q_i,\ P_c = \sum_{i \subset c} p_i \\
\bar{I} &= \sum_{c=1}^{C} Q_c I_c \\
I_c &= \sum_{i \subset c} q_i / Q_c \ln\left(\frac{q_i / Q_c}{p_i / P_c}\right)
\end{aligned}
\tag{2}
$$

where $\bar{I}$ is the average inequality in each region, I_R is the inequality across regions, Q_c is the relative share of q_i in region c, P_c is the relative share of p_i in region c, and I_c is the inequality within region c. Equation 2 allows for the decomposition of the information in the signal into an average within region measure and a measure of the information in the signal across regions.

3. Measurement of Information in Asset Values

We propose to measure the relative information in asset values by comparing the relative value in the share of asset values across time periods. Specifically, we define $v_{i,t}$ as the relative share of asset values in state i at time t:

$$
v_i = \frac{V_{i,t}}{\sum_{i=1}^{N} V_{i,t}} = \frac{a_{i,t} l_{i,t}}{\sum_{i=1}^{N} a_{i,t} l_{i,t}} \tag{3}
$$

where $V_{i,t}$ is the total value of farmland in state i at time t, $a_{i,t}$ is the acres of farmland in state i at time t and $l_{i,t}$ is the price of land per acre in state i at time t. We can then define a measure of relative change in asset prices over time as

$$
I = \sum_{i=1}^{N} v_{i,t+1} \ln\left(\frac{v_{i,t+1}}{v_{i,t}}\right). \tag{4}
$$

This inequality then measures the relative persistence in the spatial value of land prices. From equation 3 it is apparent that the changes in information index may be the result of either relative changes in farmland prices or spatial changes in the acres of farmland in each state. Accordingly, a similar measure as presented in equation 4 can be derived to analyze relative changes in the total acres in farmland in each state.

Table 1 presents the information measure utilizing the regional decomposition[1] presented in equation 2. Farmland values in each state were taken from the *Balance Sheet of the Farm Sector* published by the United States Department of Agriculture, Economic Research Service. The total inequality, average regional inequality, and across-region inequality are also presented graphically in figure 1. These results indicate two periods of significant information in the change in asset values. The first corresponds with the 1973-78 period and the second period is from 1983-89. The second period corresponds with the financial crisis in the agricultural sector during the 1980s. Harl (1990) and others have suggested that the combination of expansionist fiscal policy and tight monetary policy during this time period resulted in significant losses in agricultural equity. Particularly hard hit were the regions that were dependent on export markets for grains such as the Corn Belt, Lake States, and Northern Plains. The first period corresponds to several changes in the agricultural sector. First, the grain markets in 1973 experienced dramatic

[1] The regions used in this study are the10 farm production regions used by the Economic Research Service. The ten regions include the Northeast (Connecticut, Delaware, Maine, Massachusetts, Maryland, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont), the Lake States (Michigan, Minnesota, and Wisconsin), the Corn Belt (Illinois, Indiana, Iowa, Missouri, and Ohio), the Northern Plains (Kansas, Nebraska, North Dakota, and South Dakota), Appalachia (Kentucky, North Carolina, Tennessee, Virginia, and West Virginia), the Southeast (Alabama, Florida, Georgia, and South Carolina), the Delta (Arkansas, Louisiana, and Mississippi), the Southern Plains (Oklahoma and Texas), the Mountain States (Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, and Wyoming), and the Pacific States

increases as a result of increased exports of grain to Russia. Second, the period roughly corresponds with the oil crisis. Finally, the entire period 1973-78 is typically cited as a period of excessive inflationary pressure on farmland prices. Thus, the exact cause of the relative change in information cannot be assigned *a priori*.

The foregoing discussion implicitly attributes all the informational value to changes in farmland prices. However, as implied in equation 3 another possibility is that regional changes in farmland have affected farmland values. Figure 2 presents the information index applied to relative acres. This figure demonstrates that the information in relative changes of acreage is small except in 1975 and 1993. The realignment in 1993 can be traced to an adjustment in accounting for Indian land. One possible explanation of the anomaly in 1975 is the redefinition of the farm. In 1975, a farm was redefined as an entity with agricultural sales of $1,000 or more. In either case, the results support the conclusion that the information fluctuations (relative persistence in the spatial values of land) presented in figure 1 are largely the result of fluctuations in farmland prices rather than to changing relative acres of farmland in each state.

4. Conclusions and Suggestions for Further Research

This study examines the persistence of asset values using an informational approach similar to that developed by Theil and Leender (1965). However, while Theil and Leender focus on the number of stocks that advance, stay constant, or decline, we examine the change in relative value of each asset. Specifically, we ask whether the share of the value of an asset in one year is a good indicator of the share of that asset in the next year. It is our contention that this formulation is more consistent with the original

(California, Oregon, and Washington). In addition, while Alaska and Hawaii are not typically

question posted by Theil and Leender and Fama (1965), that is whether information exists in the asset market from day to day (or in our application from year to year). While our application focuses on farmland markets in the United States, the procedure can be extended to broader capital markets. Further, the decomposition of the informational approach could be used to examine whether informational content exists for various market segments (i.e., does more information exist in technology stocks than in manufacturing stocks).

For the example developed in this study, information about the preceding year's farmland values largely explains the regional distribution of this year's farmland values. Therefore, the preceding year's farmland values are a good leading indicator for forecasting future farmland prices. The exceptions are the emergence of regional financial stress in the Corn Belt, Lake States, and Northern Plains during the 1980s and the regional changes that emanated from the Russian grain deal of 1973. Another spike in the informational inequality in 1993 can be largely attributed to statistical changes in the definition of farmland.

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used because of idiosyncratic factors, we include these states as a separate region.

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Table 1. Information Inequality for Farmland Values over time

Year	Northeast	Lake States	Cornbelt	Northern Plains	Appalachia	Southeast	Delta States	Southern Plains	Mountain States	Pacific States	Alaska & Hawaii	Average Inequality	Regional Inequality	Total Inequality
1961	602	17	331	127	246	334	42	196	608	2	6	243	237	480
1962	32	102	99	216	183	2	191	0	465	16	18	121	102	222
1963	57	28	116	835	85	213	245	351	748	170	1161	269	138	407
1964	665	31	435	1087	532	337	315	75	1228	237	1534	478	322	799
1965	596	10	338	1234	547	700	214	1081	770	909	13	596	206	802
1966	940	24	716	395	297	121	540	183	478	2	37	399	190	589
1967	749	123	186	300	705	499	1059	54	595	241	1	374	211	585
1968	68	51	166	118	189	634	87	383	260	212	41	198	125	322
1969	385	61	314	75	164	6	142	16	581	57	1	189	116	306
1970	184	202	156	149	19	182	395	202	350	48	151	174	214	388
1971	81	104	584	174	69	355	527	150	292	21	115	270	228	498
1972	385	70	365	727	46	7	137	682	1524	84	0	406	309	715
1973	2258	1152	716	876	476	373	251	306	378	66	1	661	400	1062
1974	390	317	471	285	1972	2027	972	57	2697	132	887	747	1508	2254
1975	1184	2216	1147	1335	373	1325	1737	2	2516	265	2486	1178	1575	2753
1976	978	316	1298	444	359	877	1670	89	2189	441	1106	868	654	1522
1977	662	238	1142	3341	1475	653	21	2272	1952	152	31	1170	165	1336
1978	1164	530	1771	6865	83	61	510	2807	1947	36	1	1587	170	1757
1979	341	231	1128	4157	569	72	413	4	1682	866	203	1057	1062	2119
1980	1260	455	1012	2150	1446	1901	399	383	1575	167	1585	1018	856	1874
1981	704	481	2505	840	1413	2621	1773	1181	3154	188	1520	1465	607	2072

[a]Numbers represent 100,000 times the actual index measure.

Source: Authors' computations based on the USDA/ERS Farmland Values from the Balance Sheet of the Farm Sector.

Table 1. Information Inequality for Farmland Values over time (continued)

Year	Northeast	Lake States	Cornbelt	Northern Plains	Appalachia	Southeast	Delta States	Southern Plains	Mountain States	Pacific States	Alaska & Hawaii	Average Inequality	Regional Inequality	Total Inequality
1982	653[a]	53	546	1418	441	368	923	1739	1414	8	298	684	255	939
1983	256	427	329	1300	419	557	491	1925	788	265	34	648	376	1025
1984	408	220	1283	1330	1359	511	572	317	821	69	74	733	1150	1883
1985	342	165	688	353	729	261	225	1	757	204	57	396	664	1059
1986	154	121	370	370	890	161	796	327	311	15	3	307	394	701
1987	351	11	144	400	543	358	316	29	1496	449	181	354	115	469
1988	430	1	412	431	437	68	301	127	422	129	62	271	401	672
1989	49	339	377	1928	49	685	828	202	654	112	12423	567	867	1434
1990	515	156	615	818	409	757	366	43	392	14	13015	454	514	968
1991	380	415	312	84	97	147	769	3	673	2127	484	505	577	1083
1992	367	799	599	487	215	171	208	0	378	519	51	395	631	1026
1993	251	203	2336	35	198	91	99	60	161	1	701	502	627	1129
1994	217	220	1502	243	202	297	888	250	183	145	1939	445	975	1420
1995	113	103	1944	516	68	379	712	183	1897	237	3211	734	1766	2500
1996	289	1611	1047	384	140	49	87	145	476	1	19	462	368	829
1997	438	361	152	983	174	24	338	1451	1044	354	46	469	1058	1526
1998	1710	165	1112	806	1288	509	441	479	508	52	0	675	1680	2355
1999	247	407	616	2287	225	75	280	59	258	318	52	542	308	850
2000	426	615	743	268	125	228	147	502	396	143	342	376	708	1084
2001	1138	404	979	192	369	405	320	726	781	37	300	542	430	972
2002	1420	588	247	241	398	1204	98	4	1703	48	1881	569	1241	1810

[a]Numbers represent 100,000 times the actual index measure.

Source: Authors' computations based on the USDA/ERS Farmland Values from the Balance Sheet of the Farm Sector.

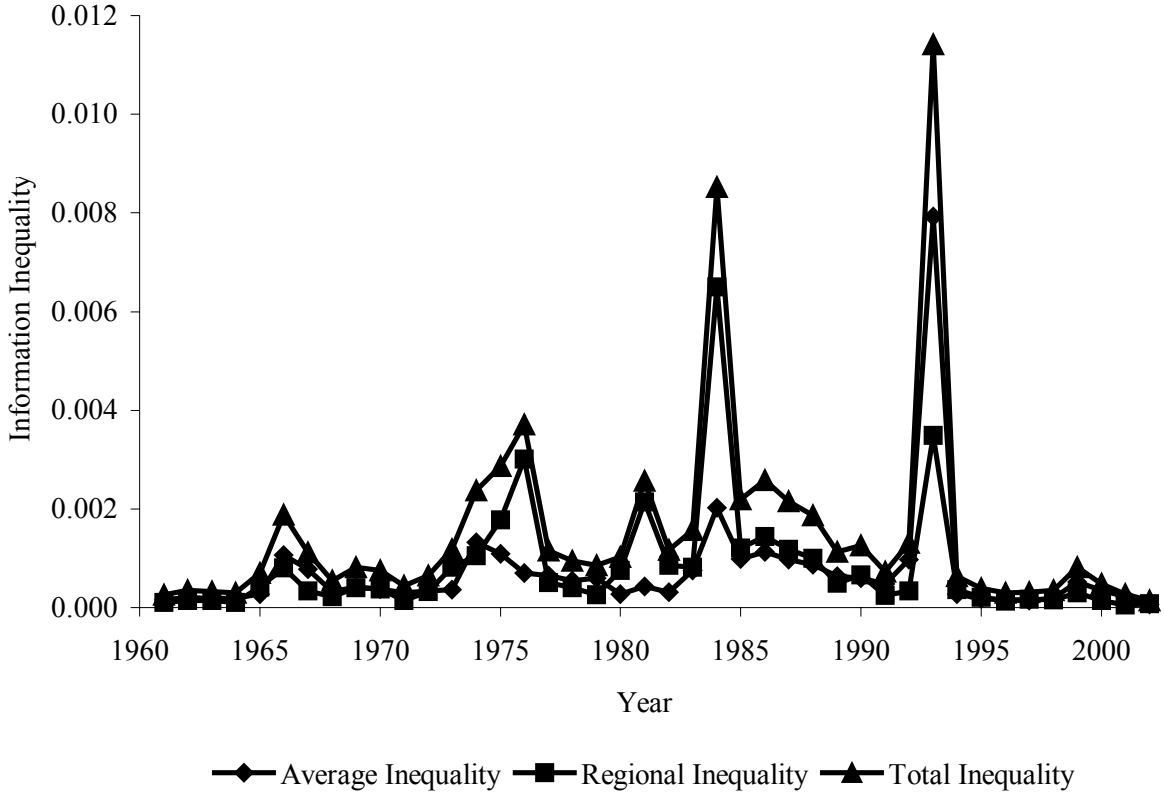

Figure 1. Total, Regional, and Average Information in Land Values over Time

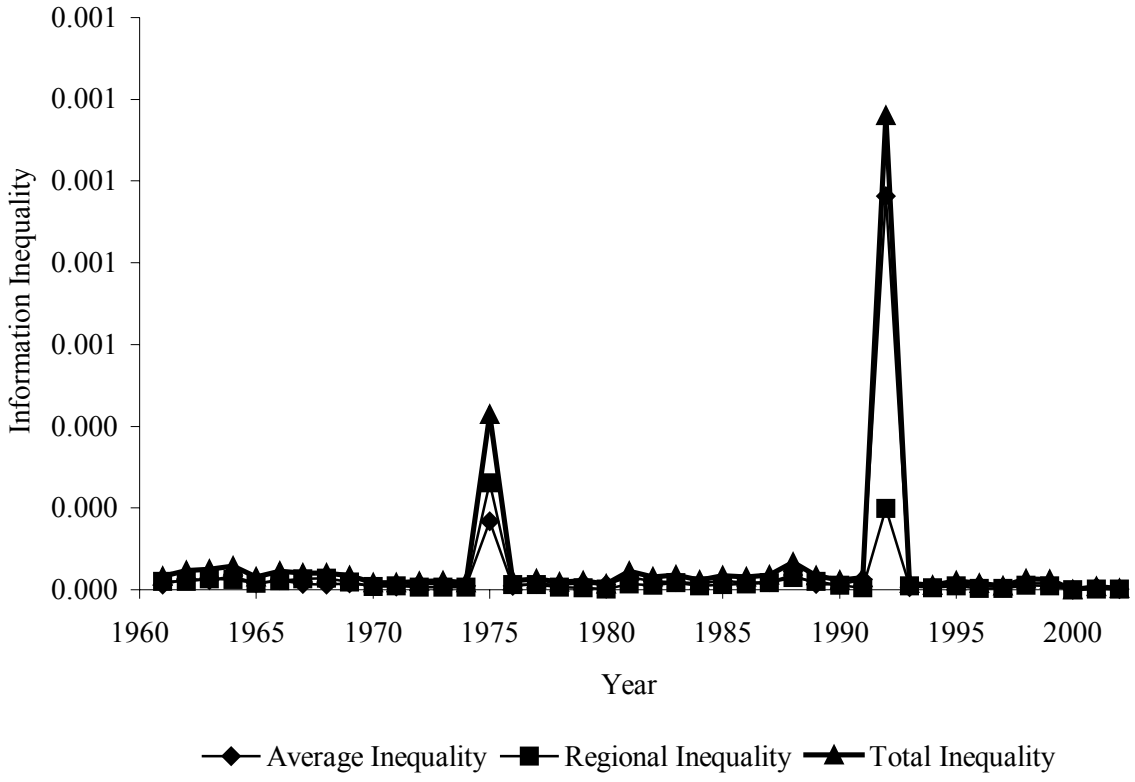

Figure 2. Total, Regional, and Average Information in Land Area over Time