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Abstract

This study investigates nonparametrically the optimizing behavior of a sample of 289 Kansas farms under profit-maximizing and cost-minimizing hypotheses. The results do not support strict adherence to either optimization hypothesis. However, evidence against cost-minimizing behavior seems to be far less substantial than that against profit-maximizing behavior.

A Nonparametric Analysis of Cost Minimization and Profit Maximization Behavior for a Sample of Kansas Farms

Traditional analysis of production behavior hypothesizes that firms maximize profits (and minimize costs) subject to technological constraints. Traditional analysis uses profit maximization and/or cost minimization as a maintained hypothesis. Analysis usually proceeds by postulating a functional form to represent the technological production function and employing parametric statistical techniques to estimate the unknown parameters from observed data. In this paper, a nonparametric approach is applied to observed farm-level production data to examine the maintained hypotheses of profit maximization and cost minimization. The approach is not a statistical test. Rather, it checks a set of inequalities that ensure the existence of a production function that can rationalize a set of data in the context of the optimization hypothesis.

The approach is based on previous works by Hanoch and Rothchild, Afriat (1967, 1972), and Diewert and Parkan, which provide a basis for investigating the productive efficiency exhibited by observed behavior prior to estimation of parametric models. More recently, the nonparametric approach has been repopularized by Varian (1984). Few studies have empirically applied the nonparametric approach in production analysis, and those that have usually used aggregate data. Fawson and Shumway conducted a nonparametric investigation of the consistency of agricultural production behavior for U.S. subregions, with the joint hypothesis of profit maximization, convex technology, and monotonic nonregressive technical change. They found that the data from 1939 to 1982 had been inconsistent with the hypothesis of profit maximization.

Chavas and Cox (1988) applied the nonparametric approach and extended it by incorporating output-augmenting (Hicks-neutral) technical change to analyze U.S. agricultural technology. Profit maximization without technical change was rejected for most periods, again using aggregate U.S. data. They interpreted this as strong evidence of technical change. In another study, Chavas and Cox (1990) nonparametrically analyzed productivity in U.S. and Japanese manufacturing using the "augmentation hypothesis" in modeling technical change[1].

Another related article by Young, Shumway, and Goodwin studied whether or not statistical differences occur among a group of Texas producers, some of whom perceived themselves as profit maximizers and some whom did not. Results suggested that those who were profit maximizers had larger herd sizes and acreage, and earned a greater percent of their income from farming.

A limitation of previous studies addressing optimizing behavior and the structure of technology for producers is that they typically used aggregate data. The use of aggregate data to characterize individual agents' optimization problems causes problems because of the possible introduction of aggregation bias. That is, individual agents may face different technologies and objectives that are not recognized when aggregate data are used. In addition, different producers may face different market conditions. Such aggregation bias is recognized as an important limitation in tests of neoclassical optimizing behavior.

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[1] That is, technical progress increases the effectiveness of inputs in the production of output.

The purpose of this study is to use individual time-series farm-level data to evaluate producers' optimizing behavior (cost minimization and/or profit maximization). This paper applies nonparametric techniques to analyze agricultural technology and production behavior for a sample of 289 Kansas farms, using farm-level annual data for an eighteen year period, 1973 to 1990.

Nonparametric Production Analysis

Nonparametric production analysis does not specify a parametric form for the relationship between inputs and outputs. All data are checked for consistency with the maintained hypothesis. Consider a competitive firm's decision problem:

$$(1)\ \text{Maximize } \pi(p,A,h) = p'x$$
$$\text{Subject to} \quad g(x,A) \geq h,$$

where x is a netput decision vector (positive elements represent outputs whereas negative elements represent inputs), and p is the vector of corresponding prices. Technology is represented by g(x,A), where A > 0 is a technology index, and h is a scaler. The indirect objective function of maximizing profits is given by $\pi(p,A,h)$. It is assumed that technology is strictly decreasing and concave in x.

The firm is observed choosing the vector of netputs (x) T times, with each observation characterized by market prices p_t and technology (h_t, A_t). The nonparametric approach tests the consistency of the observed decisions $X = \{x_1, \ldots, x_T\}$ with optimization problem (1).

Profit Maximization

When h is equal to zero, the technology $g(x,A)$ in (1) denotes the implicit production frontier. In the absence of technical change, $A_t = 1$, for $t=1,\ldots,T$, and $g(x_t,1) = 0$. Profit maximization then implies that $p_t'(x_t-x_s) \geq 0$, for all s and t. This is Varian's weak axiom of profit maximization (1984, p.584). The interpretation of this axiom is that: if profits have been maximized given p_t, then $p_t'x_t$ should be greater than or equal to the profits $p_t'x_s$ generated by any other set of outputs and inputs evaluated at p_t.

Cost Minimization

Consider the competitive firm which minimizes costs:

(2) Minimize $c(w,y,A) = w'x$

Subject to $g(x,A) \geq y$,

where x is the vector of inputs used in the production function $g(x,A)$ to produce output y, subject to input market prices w. Varian (1984) then shows that if $y_s \geq y_t$, then cost minimization implies that $w_t'x_s \geq w_t'x_t$ for all s and t. Inputs x_t minimize the costs over all choices that can at least produce y_t. This is Varian's weak axiom of cost minimization.

Data and Methodology

The nonparametric approach was applied to 289 Kansas farms data from 1973 to 1990. The optimizing behavior of the farms was determined. Specifically, consistency with profit maximizing and cost minimizing behavior was tested for each of the farms. The analysis included eight input measures: family and hired labor, land and structures, seed, fertilizer, pesticides, machinery, feed, and energy. The analysis assumed two outputs: crops and livestock. Price indexes on inputs and outputs were obtained from USDA's Kansas Agricultural Statistics and Agricultural Prices. Physical quantities of input use were obtained by dividing farm cash operating expenses from farm management records (Langemeier) by the corresponding prices. Output quantities were obtained by dividing farm accrual revenues by the corresponding prices.

Given 18 years of data, the nonparametric tests involve 306 price-output comparisons. One of the limitations of the nonparametric test is that one violation suggests that the optimization hypothesis is violated for the entire farm. Thus, we examine the frequency of violations rather than searching for absolute adherence to the optimizing hypothesis. The test also assumes constant technology.

Results

The number of cost minimization violations for individual farms ranged from 0 to 49, with a mean of 16.99 violations per farm (Figure 1). The standard deviation of violations was 10.69 (Table 1). The median number of violations was 16, with the mode number of violations being 0 (Table 2). The results suggest strict adherence to cost minimization occurred for eighteen farms. Roughly 30 percent of the farms had fewer than 10 cost minimization violations each, 67 percent had 20 or fewer cost minimization violations, and 89 percent had 30 or fewer cost minimization violations.

The number of profit maximization violations for individual farms ranged from 150 to 175 (out of 306), with a mean of 158.61 violations per farm

(Figure 2). The standard deviation of violations was 4.94 (Table 1). The median number of violations was 158, with the mode number of violations being 155 (Table 3). Unlike the results for cost minimization, strict adherence to profit maximization was violated for every farm and the mean number of profit maximization violations was large. Only 20 farms out of 289 had fewer than 50 percent of the maximum total violations. Of the 18 farms with no cost minimization violations, the average profit maximization violations were 158.3, which is not substantially different than the average number of violations for all farms.

Because strict adherence to profit maximization was rejected on all farms, additional tests of the structure of production technology could not be performed. The tests for separability, homotheticity, and constant returns break down if profit maximization is not strictly satisfied.

A possible explanation for the results of this study may lie in the economic environment Kansas farmers participated in during the 18 years of the study. High inflation, energy price shocks, volatile interest rates, and a changing policy environment could have forced disequilibrium for a period of time, as farmers adjusted to the extreme instability. The nonparametric methodology involves a comparative static approach. Thus, extreme shocks and the associated adjustment costs as farmers adapted to a new environment may have caused a temporary abandonment of normal behavioral motivation. Farmers violated the cost minimization hypothesis significantly less often than they did the profit maximization hypothesis. This may provide some evidence that the profit maximization hypothesis is less appropriate for modeling farmer decision making than the cost minimization hypothesis. Finally, we can note that attempts to remove aggregation biases from nonparametric considerations of optimizing behavior failed to resolve perceived departures from cost minimization and profit maximization common in such studies (e.g. Chavas and Cox, Fawson and Shumway).

Conclusions

This article applied Varian's nonparametric analysis of technology and production behavior on a sample of 289 Kansas farms for the period 1973 through 1990. Strict adherence with the hypotheses of profit-maximization and cost-minimization was rejected. However, 18 farms strictly adhered to the cost minimization hypothesis. The average number of cost minimization violations was about 10 times less than the number of profit maximization violations. The analysis do not enable us to make inferences that attach a probability to rejection of the null hypotheses. Despite this shortcoming, the nonparametric approach has provided insight into the production decisions of a sample of Kansas farmers. These farmers seem to operate with stronger cost-minimizing motivations than profit-maximizing ones[2].

The results of this study may make economic sense, particularly in view of the farm economy in the 18 years of the study. Different economic environments prevailed that could have forced necessary changes in behavioral motivation in agricultural production. Results from nonparametric studies can be used prior to parametric analysis to investigate certain hypotheses and complement traditional parametric procedures of production analysis.

The results of the nonparametric approach can be used to obtain results consistent with the classical theory of statistical hypothesis testing.

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[2] The assumption of profit-maximization is more restrictive than the assumption of cost-minimization; the former implies the latter, but not vice versa.

Varian (1985) attributes the inconsistency of observed data with the underlying optimizing model to the possibility of measurement errors in the factor demands. He advocates an approach that seeks the minimal perturbation of the data that satisfies the inequalities implied by the underlying theory. In their study, Shumway and Fawson obtained goodness-of-fit measures of the strength of the evidence against the null hypotheses.[3] This is one avenue of future research. In addition, the approach used in this study assumes constant technology. Another future avenue of research could examine whether farmers' optimizing behavior is consistent with the profit maximization and the cost minimization hypotheses allowing for nonregressive technical change.

[3] Originally developed in the context of consumption analysis by Afriat (1967).

Table 1. Summary Statistics on the Number of Cost Minimization and Profit Maximization Violations.

	Hypothesis	
	Cost Minimization	Profit Maximization
N	289	289
Mean	16.99	158.61
Median	16.00	158.00
Mode	0.00	155.00
Standard Deviation	10.69	4.94
Maximum	49.00	175.00
Minimum	0.00	150.00

Table 2. Number and Frequency of Cost Minimization Violations for 289 Kansas Farms.

Number of Cost Minimization Violations	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	18	6.2	18	6.2
1	1	0.3	19	6.6
2	0	0.0	19	6.6
3	6	2.1	25	8.7
4	4	1.4	29	10.0
5	10	3.5	39	13.5
6	6	2.1	45	15.6
7	16	5.5	61	21.1
8	9	3.1	70	24.2
9	15	5.2	85	29.4
10	4	1.4	89	30.8
11	5	1.7	94	32.5
12	9	3.1	103	35.6
13	11	3.8	114	39.4
14	11	3.8	125	43.3
15	10	3.5	135	46.7
16	16	5.5	151	52.2
17	16	5.5	167	57.8
18	3	1.0	170	58.8
19	14	4.8	184	63.7
20	10	3.5	194	67.1
21	9	3.1	203	70.2
22	5	1.7	208	72.0
23	7	2.4	215	74.4
24	9	3.1	224	77.5
25	7	2.4	231	79.9
26	10	3.5	241	83.4

Table 2. (Cont.)

Number of Cost Minimization Violations	Frequency	Percent	Cumulative Frequency	Cumulative Percent
27	6	2.1	247	85.5
28	7	2.4	254	87.9
29	3	1.0	257	88.9
30	1	0.3	258	89.3
31	3	1.0	261	90.3
32	4	1.4	265	91.7
33	5	1.7	270	93.4
34	0	0.0	270	93.4
35	2	0.7	272	94.1
36	0	0.0	272	94.1
37	2	0.7	274	94.8
38	4	1.4	278	96.2
39	0	0.0	278	96.2
40	0	0.0	278	96.2
41	2	0.7	280	96.9
42	0	0.0	280	96.9
43	3	1.0	283	97.9
44	0	0.0	283	97.9
45	1	0.3	284	98.3
46	1	0.3	285	98.6
47	2	0.7	287	99.3
48	1	0.3	288	99.7
49	1	0.3	289	100.0

Table 3. Number and Frequency of Profit Maximization Violations for 289 Kansas Farms.

Number of Profit Maximization Violations	Frequency	Percent	Cumulative Frequency	Cumulative Percent
150	2	0.7	2	0.7
151	4	1.4	6	2.1
152	14	4.8	20	6.9
153	16	5.5	36	12.5
154	25	8.7	61	21.1
155	31	10.7	92	31.8
156	27	9.3	119	41.2
157	15	5.2	134	46.4
158	26	9.0	160	55.4
159	24	8.3	184	63.7
160	18	6.2	202	69.9
161	15	5.2	217	75.1
162	6	2.1	223	77.2
163	15	5.2	238	82.4
164	12	4.2	250	86.5
165	11	3.8	261	90.3
166	5	1.7	266	92.0
167	6	2.1	272	94.1
168	4	1.4	276	95.5
169	5	1.7	281	97.2
170	2	0.7	283	97.9
171	1	0.3	284	98.3
172	2	0.7	286	99.0
173	1	0.3	287	99.3
174	1	0.3	288	99.7
175	1	0.3	289	100.0

Figure 1. Number of Violations of the Cost Minimization Hypothesis on Kansas Farms: 1973–1990

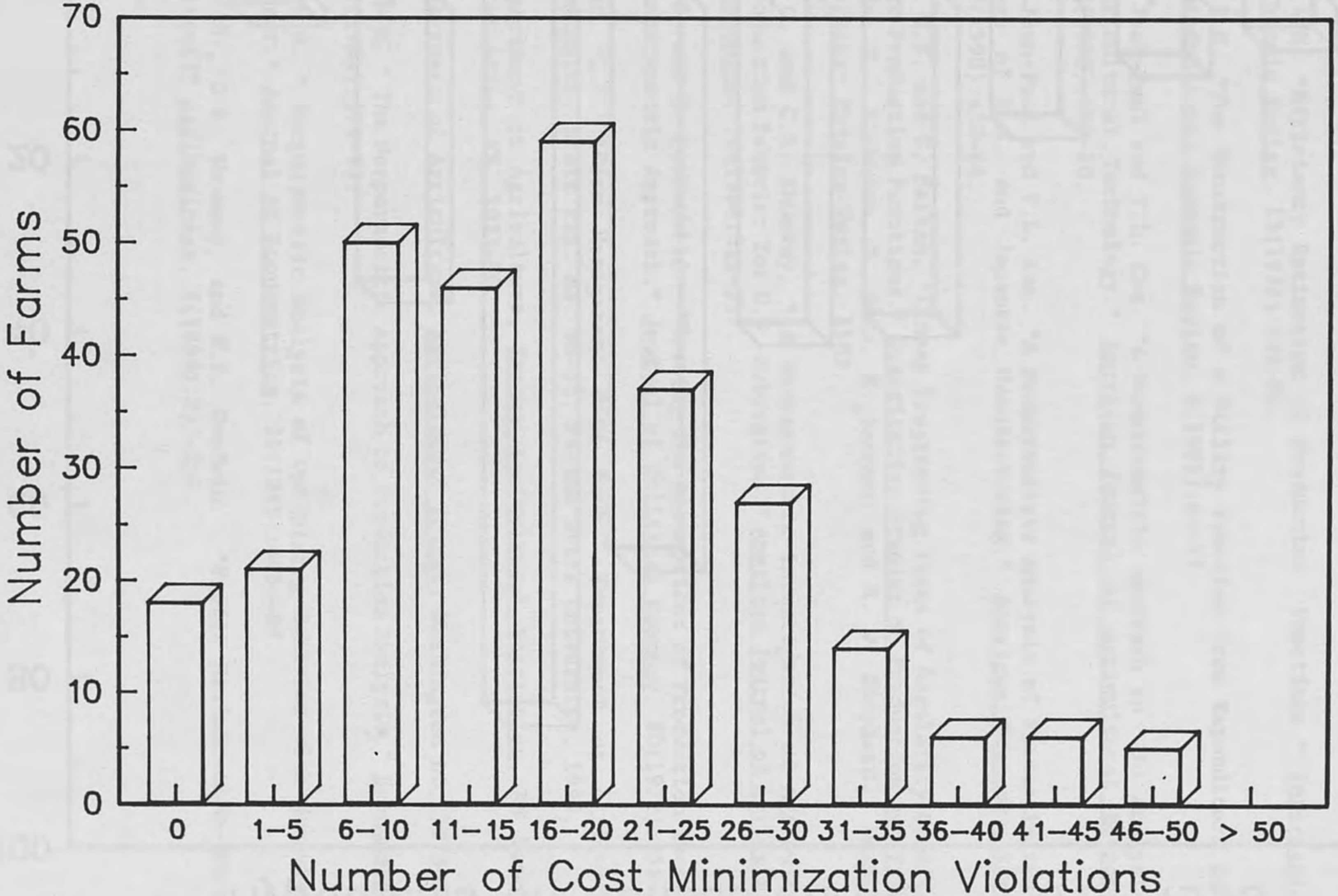
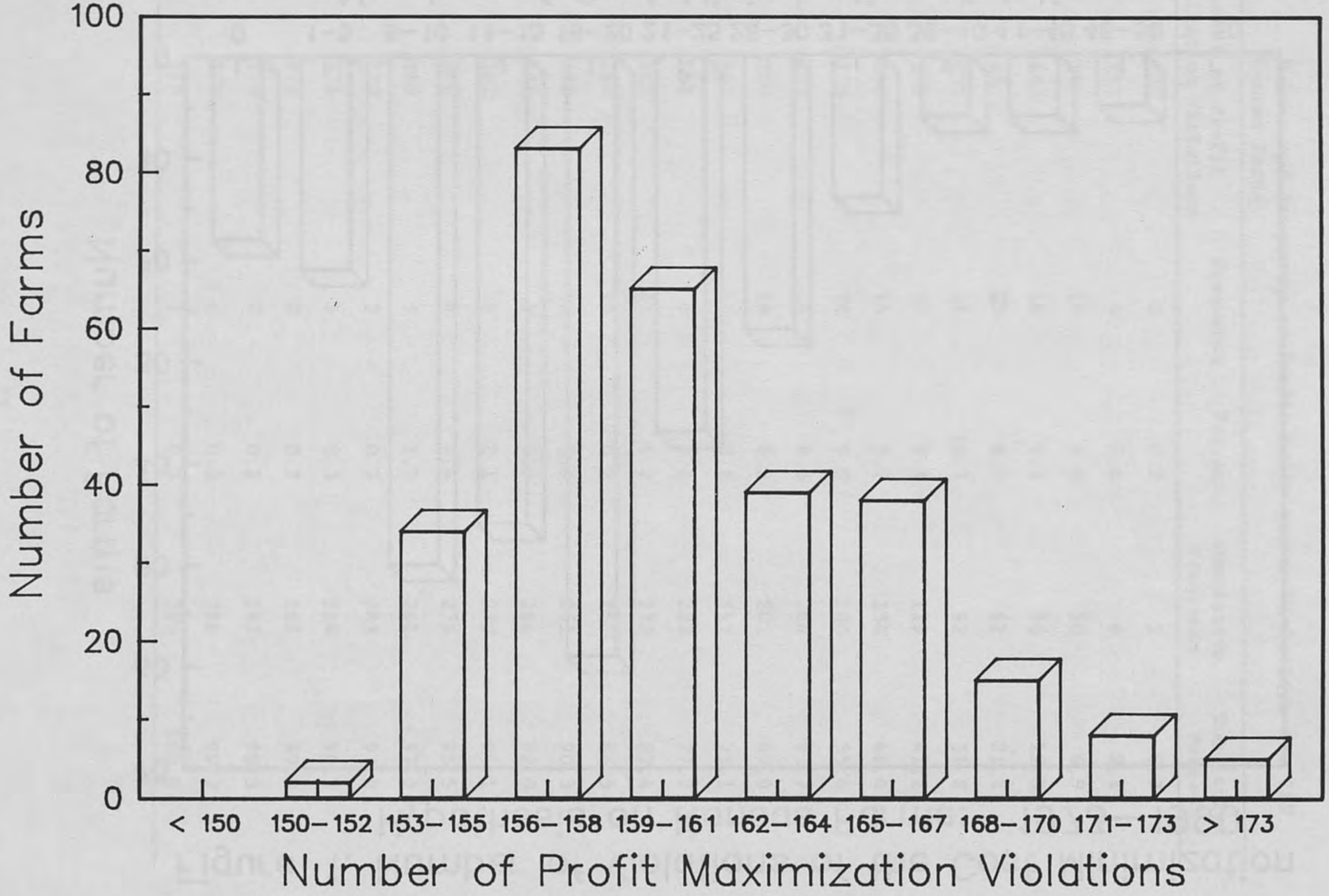


Figure 2. Number of Violations of the Profit Maximization Hypothesis on Kansas Farms: 1973–1990



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