Economic Impacts of Selected Water Pollution Control Rules on Michigan Beef Feedlots of Less Than 1,000-Head Capacity
Michigan State University Agricultural Experiment Station and Cooperative Extension Service
Research Report
D. L. Forster, L.J. Connor, Agricultural Economics ; J. B. Johnson, Agricultural Research Service, USDA
Issued April 1975
16 pages

APRIL 1975

RESEARCH REPORT 270 FARM SCIENCE

FROM THE MICHIGAN STATE UNIVERSITY
AGRICULTURAL EXPERIMENT STATION EAST LANSING AND ECONOMIC RESEARCH SERVICE, U.S.D.A.

Economic Impacts of Selected Water Pollution Control Rules on Michigan Beef Feedlots of Less Than 1,000-Head Capacity

D. L. Forster, L. J. Connor and J. B. Johnson[1]

SUMMARY

The purpose of this study was to investigate some of the economic impacts involved under selected water pollution control rules with the potential of being directed at Michigan beef feedlots of less than 1,000-head capacity. Four alternative water pollution rules with the potential for application to Michigan beef feedlots of less than 1,000-head capacity were investigated. The rules were:

A. Require beef feedlots of less than 1,000-head capacity to control runoff from a 10-year, 24-hour storm by 1977 and a 25-year, 24-hour storm by 1983. (This is an extension of the federal effluent limitations guidelines currently applicable to feedlots with capacities of 1,000 or more through a permit program established by EPA under rulemaking authority for point source dischargers.)

B. Require that beef feedlots of less than 1,000-head capacity have facilities to control runoff from a 25-year, 24-hour storm by 1977. (In effect, this is an alternative to Rule A. Feedlots would move directly to provide control for the more extreme rainfall event rather than follow the iterative process described in Rule A.)

C. Require that firms of less than 1,000-head capacity have the facilities to control runoff for rainfall over a 6-month period by 1977.

D. Require that firms of less than 1,000-head capacity be prohibited from spreading solid wastes in the winter, plus have retention facilities to control runoff for rainfall over a 6-month period.

Major findings are discussed in terms of both the static and multiperiod economic impacts. In the static analysis, empirical findings of the model indicate:

1. Increases in annual costs per head of fed beef production attributable to implementation of these selected rules generally vary by feedlot capacity and type of housing technology.

---

[1]Respectively, assistant professor, Department of Agricultural Economics, Ohio State University (formerly graduate assistant, Michigan State University); professor, Department of Agricultural Economics, Michigan State University; and agricultural economist, Economic Research Service, USDA, East Lansing, Michigan.

a. For the drylot unpaved feedlots, which comprise over 52% of all Michigan feedlots, additional annual costs per head sold resulting from the control of the 10-year, 24-hour rainfall event (part 1, Rule A) were $5.09 for the 100-head capacity feedlot, $1.61 for the 500-head capacity feedlot, and $1.13 for the 900-head capacity feedlot.

b. Economies of size are realized in the annual costs incurred through implementation of part 1, Rule A (described above), and, more generally, under most provisions of all rules for all types of housing technology.

c. There are variations in the increases in annual costs incurred which are a function of the type of housing technology. For example, in contrast to the drylot unpaved housing system (described in 1-a above), feedlots with drylot paved housing systems incurred annual cost increases per head sold of $4.65, $1.19 and $0.73, respectively, for the 100-head, 500-head and 900-head capacity feedlots.

2. Additional capital outlays per head capacity required for adoption of technology necessitated by the implementation of each control rule varied by feedlot capacity and housing technology.

a. Economies of size are realized in the per-head capital outlays for water pollution control facilities.

b. Capital outlays per head for point source runoff control systems by type of housing technology are highest for open lots, followed by drylot unpaved and drylot paved systems. Cold confinement housing systems, when properly managed, would not be expected to have point source runoff control problems.

c. Capital outlays per head for solid (or slurry) waste storage facilities by type of housing technology are highest for cold confinement systems, followed by drylot paved, drylot unpaved and open lot systems.

In the multiperiod analysis, a more complete assessment of the economic impacts of alternative water pollution control rules was achieved. A 20 feedlot sample, representative of the Michigan beef feeding industry, was simulated over a 12-year period (1974-1985 inclusively), both in the presence and absence of water pollution control rules. The effects of rule implementation on the average simulated firm's total beef output and equity level over the 12-year period were contrasted with levels that would have been realized by the average simulated firm in the absence of rule implementation.

1. Changes in the level of fed-beef production for the average simulated firm, by rule, relative to production in the absence of implementation of the rules are:

Item	Rule A	Rule B	Rule C	Rule D
Production decrease (head)	7	7.2	37.7	38.3
Decrease in total production (percent)	0.167	0.17	0.90	0.91

2. These changes in fed beef production for the 12-year period for the average simulated firm were expanded to determine shifts in the aggregate supply curve of fed beef. Under the assumptions that the response to water pollution control rules on Michigan feedlots are representative of those of all U.S. feedlots of less than 1,000 head, it was shown that the price increases to individual consumers would be nominal. (The calculations employed assumed larger feedlots would not increase production foregone by smaller feedlots adjusting to these rules; if, in fact, large feedlots do increase production, the consumer price increase would be even less evident.)

3. Equity change over the planning period was calculated for the average simulated firm under implementation of each of the rules and in their absence. Equity changes measured were appreciation in base period assets and growth in the firm asset structure during the planning horizon attributable to the investment of net cash inflows generated during the period. The effect of implementing each of the four is measured in present value of the equity loss. (Equity loss is the equity level of the firm operating in the absence of rule implementation less equity conditions in the presence of each rule.)

Item	Rule A	Rule B	Rule C	Rule D
Present value of equity loss (dollars)	3,734	3,911	4,800	5,990
Future equity loss per dollar of 1974 net worth (dollars):				
— 1974 net worth of $220,000	0.0169	0.0178	0.0218	0.0272
— 1974 net worth of $105,000	0.0313	0.0331	0.0474	0.0546

a. Present value of equity loss for the average simulated firm would be greatest when solid wastes were stored to limit the potential of field runoff from farmlands to which wastes are applied (part 1, Rule D). It is also evident that firms should sequentially adjust to recently announced EPA effluent guidelines (Rule A) rather than immediately provide control for the 25-year, 24-hour storm (Rule B).

b. Implementation of the rules on beef feedlots will be regressive. Postdiction of the simulation model with prior economic performance (and available farm record data) indicates that the 1974 equity levels for Michigan feedlots averaged $220,000. Equity loss for a firm with this equity level would be $0.0169 per dollar of 1974 equity through the 1974-1985 period if Rule A was implemented. However, for an alternate sample of 20 feedlots with an average of $105,000 in 1974 equity, the equity loss per dollar of 1974 equity would be $0.0313. Similar relations hold for Rules B, C and D. By reducing the mean initial equity of the average simulated feedlot, the equity losses relative to initial equity levels increase. Due to the economies of size associated with particular pollution control facilities, the smaller firm suffers substantially more than the large firm.

INTRODUCTION

Society is increasingly demanding the protection and/or enhancement of environmental quality. Legislative and administrative actions to provide legal mechanisms for pollution control at federal and state levels have become commonplace.

Passage of the Water Pollution Control Act Amendments of 1972 provided additional authority to the U.S. Environmental Protection Agency (EPA) for the control of water pollution. Certain provisions of these amendments are directed at agriculture and provide EPA with certain authority to limit water pollution from specified types of agricultural production.

Beef feedlots are among the agricultural production processes subject to EPA rulemaking authority for point source pollution control. Recent EPA rulemaking has provided effluent limitations guidelines for beef feedlots. The Water Pollution Control Amendments of 1972 provide EPA with authority to establish permit programs through which to implement these point source water pollution controls. Additionally, these amendments also require EPA to announce acceptable methods and practices for the control of nonpoint water pollution sources. EPA recently announced suggested methods and practices for the control of runoff from farmland to which livestock wastes are applied.

Increasing emphasis is being placed on research to analyze the economic impacts of rules to control water pollution. Decision makers who develop rules for environmental protection and enhancement need information on changes in economic performance incurred by firms required to adjust and the ensuing industry and consumer price effects so they appraise alternative rules.

The objective of this study was to analyze the economic impacts on fed-beef producers and consumers of alternative water pollution control rules on beef feedlots of less than 1,000-head capacity. Feedlots analyzed included those typical in physical and financial characteristics of Michigan; the Michigan feedlots considered are similar to those in major feeding areas of other north central and eastern states. Static and multiperiod models were utilized in this study. In the static analysis, additional capital requirements and changes in annual production costs attributable to compliance with alternative water pollution control rules were determined for particular capacity-type housing technology combinations.

In the multiperiod analysis, a sample of Michigan feedlots with identifiable physical and financial characteristics was simulated over the 1974-1985 period to reflect the performance of Michigan feedlots through time under each of the pollution control rules. Aggregate performance under rule implementation was then contrasted with continued industry performance in the absence of water pollution control rules. The impacts of the alternative rules were analyzed in terms of their effects on the equity position of the simulated firms, capital structure of the simulated firms, and numbers of slaughter cattle produced by the simulated feedlots.

Investigating the effects of the rules on the equity positions allowed an approximation of the losses that feedlot operators would suffer upon complying with these rules. The effects of the rules on the capital structure of the simulated feedlots were used to detect any change in the amount of durable assets (e.g., buildings, tractors) induced through implementation of the alternative rules.[2] The effects of the rules on feedlot production were investigated to determine the impact these rules might have on shifts in the aggregate beef supplies and prices paid by consumers for beef.

Federal Water Quality Amendments of 1972

In October 1972, the Congress of the United States passed the Federal Water Pollution Control Act Amendments that became Public Law 92-500. The primary aim of the act was to restore and maintain the chemical, physical and biological integrity of the nation's waters (10). It required EPA to establish rules that would provide guidelines for effluent limitations to be achieved by point sources of waste discharge into navigable waters and tributaries. Feedlots are explicitly included as a point source category, making them subject to the National Pollution Discharge Elimination System (NPDES).

The measurement of the maximum allowable rate of discharge from a point source is referred to as an effluent limitation. Under terms of the 1972 Water Pollution Control Act Amendments, a two-level program of effluent limitations has been established for each category of existing point sources. The first level is identified as attainable by a technology referred to as the "best practicable technology currently available." This level is to be achieved by July 1, 1977. The second level of effluent limitation is attainable by technology identified as the "best available technology economically achievable." By July 1, 1983, this technology must be utilized by point sources.[3] EPA was given the task of establishing effluent guidelines and identifying technologies within 1 year of the 1973 enactment.

After several months of debate, the EPA established the final effluent limitations guidelines for existing point sources and for new point sources in the feedlot category. Final guidelines were published in the February 14, 1974, *Federal Register* to take effect April 15, 1974 (8). The guidelines apply to beef feedlots with a one-time capacity of 1,000 or more head. EPA is in the process of assessing the probable economic impacts of pollution controls on small feedlots with the possibility of issuing guidelines for beef feedlots of less than 1,000-head capacity.

The best practicable technology currently available requires the control of all process-generated wastewater, plus the runoff from a 10-year, 24-hour rainfall event. The best available technology economically achievable requires the control of all runoff from a 25-year, 24-hour rainfall event, plus all process-generated wastewater. Newly constructed feedlots must employ a technology level with the capacity to control the runoff from a 25-year, 24-hour rainfall event, plus all process-generated wastewater. Process-generated wastewater is defined as water directly or indirectly used in the operation of a feedlot — spillage from watering systems, washing of feedlot facilities, etc. Process-generated wastewater is essentially zero for Michigan beef feedlots. The 10-year, 24-hour and 25-year, 24-hour rainfall events refer to rainfalls with probable recurrence intervals of once in 10 years or once in 25 years, as defined by the National Weather Service.

In addition to control of runoff and processed wastewaters specified through the use of the best practicable technology currently available and the best available technology economically achievable, other runoff that has been identified by either the regional EPA administrator or the state water pollution agency as a potential contributor to water pollution can be subject to control (5).

All point sources subject to the NPDES must obtain a permit from EPA or a federally approved state program. The permit recipient is issued a compliance schedule requiring a step-by-step reduction in pollutants over a specified time interval.

The authority to administer NPDES permit programs rests in the hands of the EPA or the appropriate state agency. In Michigan, responsibility for establishing pollution standards for the various surface and ground waters rests with the Water Resources Commission (6). The Water Resources Commission will be the issuing and monitoring body of the federal permit program for Michigan. Although it is possible for a state to have a more rigorous pollution abatement program than EPA guidelines require, Michigan's present stance is to proceed under these guidelines.

While the state permit issuing agency may supervise the NPDES permits and monitoring of polluting feedlots, it is not an autonomous unit. EPA maintains a supervisory role in deciding whether or not the best practicable technologies currently available and the best available technologies economically achievable are being used by point source dischargers. Thus, it is conceivable that abatement

[2]It has been hypothesized that a large proportion of assets tied up in durable assets leads to a tendency for an operator to be locked into a production pattern. This rigidity leads to losses in a competitive market structure when expectations are not fulfilled and the producer is locked into an unprofitable enterprise (4).

[3]Achievement of these two technology levels in the stated time periods is considered Rule A in the model analysis (see Table 1). Rule A is the only rule established to date under EPA rulemaking authority. Rule B is what some producers consider a plausible technical and economic alternative to the sequential adjustment required by Rule A. Rule C is what the authors have viewed as a suggested adjustment path by leading practitioners in humid states. Rule D incorporates both Rule C and one of several acceptable methods and practices for nonpoint source runoff control recently announced by EPA.

technology requirements for certain problem point sources could be more rigid than the guidelines established in the February 24, 1974, *Federal Register*.

Research Procedures

For the multiperiod analysis, a computerized simulation model was constructed to represent the production behavior of individual firms over a multiperiod time horizon. This multiperiod model simulates firm behavior under a variety of water pollution control rules.

The model was comprised of five components. The first component was a farm feedlot production component that represented an input-output relationship for the feedlot.[4] The component assumed a whole-farm approach to feedlot production by simulating feedlot design. This component simulated the production of crops, transportation of crops from field to storage facility, design of feed storage facilities, removal of waste to the fields and beef production (3). The objective of the component was to provide an accurate simulation of a wide range of Michigan feedlots. Available evidence indicated that the component was successful in accurately representing the performance of Michigan feedlots.[5]

Several assumptions were implicit in the farm feedlot production component. First, it assumed that inputs were combined in fixed proportions in the production of beef and waste materials. Given the amount of beef to be produced, type of ration fed, and type of feedlot technology to be employed on the farm feedlot, the component established the required inputs. The inputs included seed, fertilizer, herbicides, labor, fuel and machinery required to raise the feed; crop equipment, fuel and labor used to transport the crops to the farmstead; building, silo equipment, fuel and labor requirements for the feedlot; and equipment, fuel and labor requirements for waste disposal and runoff abatement.

The production component assumed that feedlots were one of five different types (five housing technologies) (Fig. 1):

1. Drylot paved feedlot. The feedlot structure consisted of a shelter with an open front allowing access to a paved outside lot. There were 25 ft² of shelter area and 35 ft² of paved lot per animal.
2. Drylot unpaved feedlot. Shelter area was 25 ft² per animal, with an unpaved lot area of 150 ft² per animal.
3. Open lot feedlot. No shelter was provided for the animals. The facility consisted of a dirt lot, with 200 ft² per animal.
4. Cold confinement with solid floor construction. Feeders were completely confined as in sheltered structure, with the floor being solid concrete. Each animal was alloted 30 ft.² Manure was scraped from the structure regularly and either spread immediately or stored to spread later.
5. Cold confinement with slotted floor construction. The structure confined the animals to 30 ft² of sheltered area per head. The floor was slotted with a pit providing storage for waste. The waste was distributed to fields several times a year by pumping it into wagons which spread it onto fields.

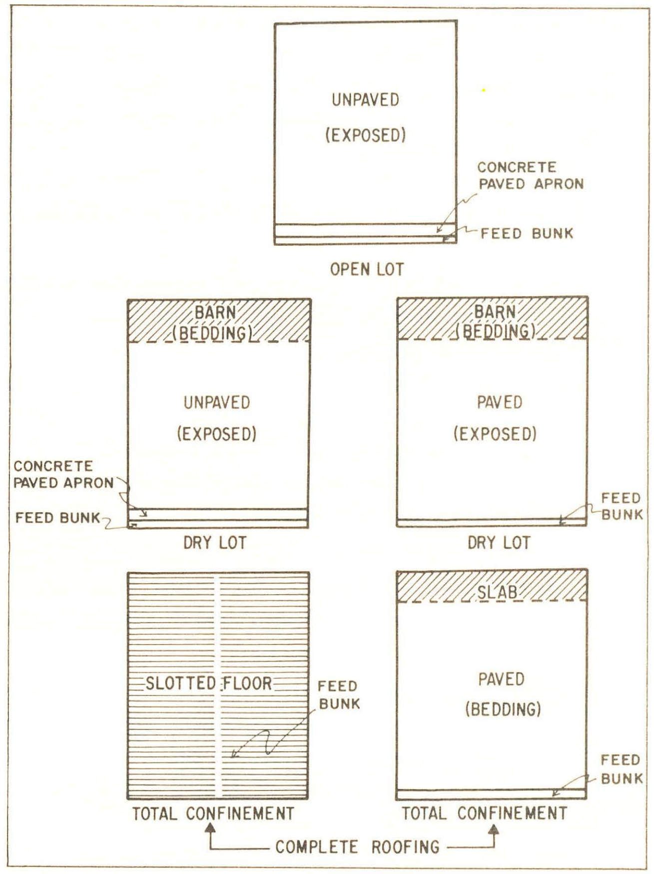


Fig. 1. Beef housing technologies used in simulation model.

The animals were assumed to be fed the same ration in each type of feedlot. This ration was a "1%

[4]This component was a modified product of a joint effort by personnel in the Electrical Engineering and Systems Science, Agricultural Economics, Crop and Soil Sciences, and Agricultural Engineering Departments at Michigan State University.

[5]Data from the Michigan State University farm records project for beef feedlots were used as a check on the accuracy of the production component (7).

concentrate" ration, consisting of moist corn and silage, with the volume of concentrate being equal to 1% of the total body weight of the animal (1). Moist corn storage was provided in each of the feedlot types. The size of the simulated feedlots was limited to less than 1,000-head capacity. Over 99% of Michigan feedlots were less than 1,000-head capacity in 1969.

Along with the feedlot production component described briefly above, the simulation model contained four other components:

1. Price expectation relationships, which computed feedlot operators' estimates of future input and output prices. This component provides information for determining the expected returns for various size and type of investments.[6]
2. A decision-making component that determined the output of beef and the inputs used in the production process.
3. Price realization relationships that provided estimates of actual prices paid and received, and were based on historic price cycles and trends. The purpose of these relationships was an attempt to represent reality by making the model prices paid and received reflect historic price movements. These relationships summarize the returns realized in the model for each investment type and size level shown.
4. An accounting process that combined the price realization component with the farm-feedlot component to compute annual net earnings, taxes, user cost of durables and the financial position of the firm.

In the multiperiod simulation, each firm was given certain initial financial and production characteristics. Each firm was then allowed to develop expectations concerning input and output prices and its production function. The firm's objective was to maximize profits. A linear programming decision-making model was employed, with the information used based on price and production function expectations. The model simulated the firm's operation; its price and production realization provided the price and production-related data needed to summarize the returns that would be actually realized by a firm in each time interval within the simulation period. The accounting component computed the financial measures of firm performance.

A water pollution control rule affected the firm's behavior by changing these production relationships. Upon the imposition of a selected rule, the levels of capital outlays and annual costs of the firm changed with the addition of pollution abatement controls. The firm made its decision concerning the resources to employ based on the expectations of how the pollution abatement control would affect the profitability of various types of feedlot investments. This decision determined inputs to be used and affected the firm's output relative to the output that would have been achieved with no pollution abatement requirement. Thus, the imposition of an alternative rule for water pollution control affected not only the investment level and annual cost structure of the feedlot, but also the amount of beef produced (i.e., effectively caused a shift in the feedlot's cost curves).[7]

The model simulated individual firms in each time period (Fig. 2). Twenty firms were simulated over the 1960-1985 period. The 1960-1971 simulation was used to find a set of acceptable parameter values for variables not observable from existing historical data and to test the accuracy of the simulation model.[8] The 1974-1985 period was used to test the behavior of the simulated firms under alternative rules for water pollution control.

For the static analysis, feedlots typical in physical and financial characteristics of those in Michigan were identified, and their capital requirements and production costs were estimated (3). Partial budgeting techniques were used to estimate the additional capital outlays and increases in annual production costs incurred as a result of complying with each of the pollution control rules. Several assumptions are implicit in the static cost estimates used in the analysis:

1. The ration fed is a "1% concentrate" ration. Each animal placed on feed goes from 450 lb to 1,050 lb in 300 days.
2. The feedlot is used at full capacity throughout the year.
3. The annual charges for durable assets are fixed percentages of replacement values. Buildings, silos, moist corn storage and runoff retention facility charges are 6.7% of initial value. Machinery and equipment charges are 10% of replacement value. (Essentially, these

[6]For a detailed description of this and other components, refer to Forster (2).

[7]In implementing a water pollution control rule, one standard technology was employed to limit runoff. This technology was a system of diversion terraces, settling basins, retention ponds, fencing and pump-irrigation equipment. While the size of the individual components of the control system varied with the amount of exposed feedlot surface, the basic structure of these components was the same for all feedlots. (An example of the capital outlays for feedlot runoff controls is presented in Appendix D.)

[8]Total feedlot capacity of the simulated firms was compared with cattle on feed data for the 1960-1971 period to test the ability of the model to duplicate past performance. An optimization procedure was used to determine an opportunity cost of funds, borrowing limit, user cost and net worth distribution determinant that best duplicated the actual 1960-1971 feedlot performance.

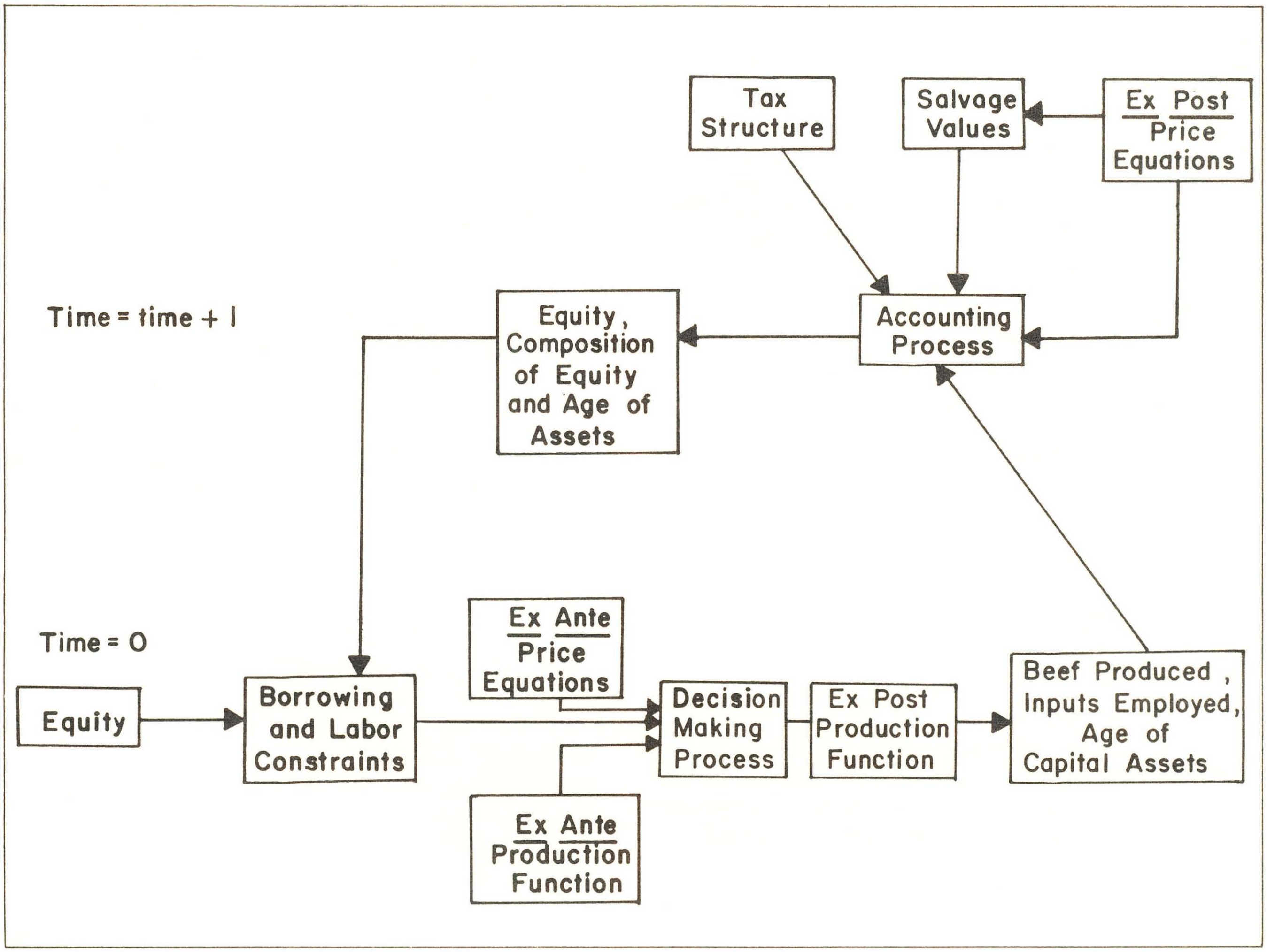


Fig. 2. Model of feedlot behavior over multiple-year horizon.

rates assume a 15-year life for structures and a 10-year life for machinery and equipment.)

4. All nondurable input purchases are financed with funds having an 8% opportunity cost. It is assumed that the purchase price of feeder calves is financed over the full production cycle. Other nondurable inputs are financed over one-half of the production cycle.
5. Total capital outlays in machinery, buildings and land are charged at 8% opportunity cost.
6. The incremental cost per head for each of the water pollution control rules is found by subtracting the total cost per head under continued operation in the absence of rule implementation from the total cost per head under each particular rule.
7. Prices in 1974 are used. In the static analysis, the price expectation equations were not used, but observed prices are reflected. (See Appendix E for an example of the total cost structure of selected feedlots.)

ALTERNATIVE WATER POLLUTION CONTROL RULES APPLICABLE TO FEEDLOTS

The alternative rules under investigation were those that might be employed by state or federal agencies in the control of runoff and process waters from feedlot production sites and in the control of runoff from farmland to which feedlot wastes are applied (Table 1).

Rules A through D were implemented on all Michigan feedlots of less than 1,000-head capacity by assuming that the runoff from a 10-year, 24-hour storm was equal to 5 in. of rainfall over the exposed feedlot surface; the runoff from a 25-year, 24-hour storm was equal to 6 in. of rainfall over the exposed feedlot surface; and runoff storage requirement for rainfall over a 6-month period was equal to 16 in. of rainfall over the exposed feedlot surface. Rule D's requirement that no winter spreading occur was implemented by assuming that solid waste storage, loading and spreading activities were to be

Table 1. Alternative water pollution control rules included in analyses

Rule	Provisions
A[a]	Current EPA effluent limitations guidelines would be expanded to all beef feedlots. Facilities must be constructed to control the runoff from a 10-year, 24-hour rainfall event by 1977, and the runoff from a 25-year, 24-hour rainfall event by 1983.
B	All feedlots must construct facilities to control all runoff from a 25-year, 24-hour rainfall event by 1977.
C	All feedlots must construct facilities to control all runoff from the rainfall occurring in any 6-month interval by 1977.
D	The same feedlot runoff abatement provisions as in C. Also, the feedlot may not spread wastes during winter months.

[a] This is the only rule established to date under EPA rulemaking authority. For an explanation of the plausibility of other rules, see footnote 3.

equipped to handle waste accumulation over a 180-day interval. (It was assumed that solid waste accumulated for 90 days under the other rules.)

It was assumed that all firms of less than 1,000-head capacity comply with rules by employing a standard feedlot runoff abatement technology consisting of four components — a diversion terrace, settling basin, retention pond and pump-irrigation equipment. Diversion terraces are used to control the extraneous water flow around feeding areas and/or to direct feedlot runoff through settling basins. Settling basins are used to collect solids carried in feedlot runoff. Retention ponds are designed to store process-generated wastewaters and storm runoff. Pump-irrigation equipment is used to periodically empty runoff from retention ponds onto farmland. Using a standard technology for feedlot (point source) runoff control assured that estimates of the economic effects of point source pollution control rules were upper-limit estimates. All feedlots may not be required to use the standard abatement technology used in the simulation model. Some firms may be able to satisfy the requirements by using less expensive runoff abatement technology.

One of several practices suggested to limit the potential of runoff from farmland to which feedlot wastes have been applied is to spread wastes only in periods when wastes can be incorporated immediately. In Michigan, this necessitates winter storage of solid and slurry wastes. For feedlots handling waste as a solid, this generally means the construction of a bunker silo-type waste holding area outside the feeding area; for systems handling waste as a slurry (such as slotted floor systems), this means the construction of additional pit storage outside the housing system.

In addition to expanding or constructing storage areas, the limiting of field spreading of wastes to only those periods when it can be incorporated may also necessitate the purchase of an additional manure spreader(s) and manure loading equipment. The level of additional investment is highly dependent on the particular firm's equipment complement prior to adjustment. (There may be other physical alternatives possible for limiting runoff from winter spreading; however, the above-described is the alternative considered in this model.)

ANALYSIS OF THE ECONOMIC IMPACTS OF ALTERNATIVE RULES

In several past studies of the economic impacts of water pollution control rules, the analyses were static in nature. In each analysis, an attempt was made to identify the cost per unit of output before and after the imposition of water pollution control rules (4). While the static analyses offer some perspective concerning the severity of alternative rules, many factors are not considered. Some of the questions not addressed by static analysis, but assimilated into the computerized simulation model, are: (1) Does the input mix used on feedlots change with the imposition of water pollution control rules? (2) Is the financial position of the feedlot severely restricted, resulting in a reduction in capital availability for beef production? (3) How many more durable assets does the firm require upon the imposition of water pollution control rules? (4) How is the firm's equity changed by the alternative rules?

The results are presented in two sections. First, the static analysis indicates the capital outlays required and average total cost increases incurred with the implementation of water pollution control rules. Second, the multiperiod analysis indicates the changes in production levels and reductions in equity growth incurred by firms adjusting to water pollution control rules and the effects a shift in aggregate beef supplies will have on consumer prices for beef.

Static Analysis

The average total costs per head sold in feedlots continuing production without the imposition of rules are shown (Table 2). The incremental costs per head sold of four alternative water pollution control rules are presented (Tables 3-6). The rules analyzed in the static analysis are derived from rules previously described (Table 1). After implementation of each of the rules, the feedlots of 100-head capacity under each of the housing types incur a larger average total cost increase than the feedlots of greater capacity.

Table 2. Average total cost per head sold for cattle fed on simulated Michigan feedlots, by housing technology and feedlot capacity, before imposing water pollution control rules, 1974 input prices [a]

Housing technology	Feedlot capacity (head) 100	500	900
Drylot paved	$503	$400	$390
Drylot unpaved	$502	$399	$389
Open lot	$527	$413	$402
Cold confinement, solid floor	$509	$406	$396
Cold confinement, slotted floor	$512	$407	$405

[a] Average total cost includes cost of feeder calves ($47/cwt), fertilizer, herbicide, supplement, seed, fuel, labor, machinery repair, insurance, property taxes, interest, and depreciation for silo, moist corn storage, feedlot and buildings, and machinery. These costs reflect the use of tower silos by all technology and capacity combinations considered. The use of bunker silos would not substantially alter these costs for the capacity levels analyzed.

Table 3. Incremental total cost per head sold of controlling a 10-year, 24-hour rainfall event for cattle fed on simulated Michigan feedlots, by housing technology and feedlot capacity, 1974 input prices [a]

Housing technology	Feedlot capacity (head) 100	500	900
Drylot paved	$4.65	$1.19	$ .73
Drylot unpaved	$5.09	$1.61	$1.13
Open lot	$5.88	$1.98	$1.45
Cold confinement, solid floor	— [b]	—	—
Cold confinement, slotted floor	— [b]	—	—

[a] Control of runoff from a 10-year, 24-hour rainfall event is the first provision of Rule A.

[b] Control of runoff from a 10-year, 24-hour rainfall event would not affect this housing type, since there is no exposed feedlot surface.

Table 4. Incremental total cost per head sold of controlling a 25-year, 24-hour rainfall event for cattle fed on simulated Michigan feedlots, by housing technology and feedlot capacity, 1974 input prices [a]

Housing technology	Feedlot capacity (head) 100	500	900
Drylot paved	$4.67	$1.20	$ .74
Drylot unpaved	$5.16	$1.66	$1.18
Open lot	$5.95	$2.05	$1.52
Cold confinement, solid floor	— [b]	—	—
Cold confinement, slotted floor	— [b]	—	—

[a] Control of runoff from a 25-year, 24-hour rainfall event is the second provision of Rule A and also comprises Rule B.

[b] Control of runoff from a 25-year, 24-hour rainfall event would not affect this housing type, since there is no exposed feedlot surface.

Table 5. Incremental total cost per head sold of controlling a 6-month rainfall event for cattle fed on simulated Michigan feedlots, by housing technology and feedlot capacity, 1974 input prices [a]

Housing technology	Feedlot capacity (head) 100	500	900
Drylot paved	$4.80	$1.31	$ .85
Drylot unpaved	$5.64	$2.09	$1.59
Open lot	$6.66	$2.68	$2.11
Cold confinement, solid floor	— [b]	—	—
Cold confinement, slotted floor	— [b]	—	—

[a] Control of runoff from a 6-month rainfall event comprises Rule C.

[b] Control of runoff from a 6-month rainfall event would not affect this housing type, since there is no exposed feedlot surface.

Table 6. Incremental total cost per head sold of prohibiting winter spreading for cattle fed on simulated Michigan feedlots, by housing technology and feedlot capacity, 1974 input prices [a]

Housing technology	Feedlot capacity (head) 100	500	900
Drylot paved	$.29	$.41	$.41
Drylot unpaved	$.32	$.41	$.42
Open lot	$.31	$.45	$.46
Cold confinement, solid floor	$.35	$.42	$.42
Cold confinement, slotted floor	$.57	$.54	$.42

[a] Prohibiting winter spreading is the second provision of Rule D. The provision concerning winter spreading is independent of provisions concerning runoff control. The effect of adding the prohibition against winter spreading to any of the runoff control rules can be determined by adding the incremental costs in Table 6 to those in Tables 3, 4 or 5.

As expected, the rule to control the runoff from a 10-year, 24-hour rainfall event (the first provision of Rule A) is the least expensive of the three feedlot runoff abatement rules. The 25-year, 24-hour rainfall event runoff control rule (Rule B and the second provision of Rule A) produces slightly greater costs per head than the 10-year, 24-hour rainfall runoff control rule. The 6-month rainfall runoff control rule (Rule C and the first provision of Rule D) increases the cost per head further. The increase in the average total cost per head ranges from $.85 for the 900-head capacity drylot paved facility to $6.66 per head for the open lot with 100-head capacity.

The rule of requiring only the storage of waste tends to favor the small producer over the larger producer, as seen in Table 6. All producers are assumed to have 56 hours of available field time to dispose of the waste in the spring. As the feedlot increases in capacity, the limited time available to spread solid waste forces the operator to acquire more and more spreading and loading equipment.[9] A longer waste retention time initially has the most effect on the slotted floor confinement feedlot since increased waste holding pit construction is required. However, the liquid waste storage system for this type of feedlot does not require the additional equipment needed by the other systems, and some economies of size are realized.

Multiperiod Analysis

Since the alternative rules for controlling water pollution require adjustment by feedlots by July 1, 1977, the simulated behavior of feedlots until 1976 reflects no mandatory adjustments through implementation of these rules.[10]

A random sample of 20 feedlots was drawn from the population of Michigan feedlots for the 1960 production year. These 20 firms were representative of the Michigan beef feedlot industry. Changes in these 20 firms prior to, during, and after the implementation of the alternative rules for water pollution control can be viewed as representative of those for the entire Michigan beef feedlot industry.[11]

In 1960 the average net worth of simulated Michigan feedlot firms was close to $79,000. In that year, the average simulated Michigan feedlot returned nearly 8.5% on operator equity (Table 7). For the period 1960 through 1973, the average capacity of Michigan feedlots increased. The simulation results indicate that the average feedlot had a capacity of 232 head in 1967, 246 head in 1969, and 278 head in 1972. Historical data from a separate source indicate the reported average feedlot capacity in Michigan for the same years was 189, 209 and 262 head (7). The same source indicated that returns to equity reported in past years closely parallel those simulated (Table 7).

If feedlots were allowed to continue operation without any mandatory adjustment to water pollution control rules, the capacity of the average Michigan feedlot in 1985 would be approximately 29% greater than in 1974, according to simulated results (Table 8). Most of this increase in average feedlot capacity would be expected to occur in the 1974-1979 period, reflecting the effects of cyclical increases in beef prices incorporated in the simulation model. Model results indicate that the equity of the average Michigan feedlot would expand from $220,000 in 1974 to nearly $750,000 in 1985 at an average annual growth rate of 11%.

Table 7. Average measures of performance for a simulated sample of Michigan feedlots for the 1960-1973 period prior to imposition of water pollution control rules.

Year	Average feedlot capacity	Weighted average return to equity[a]	Average annual equity per firm[b]	Mean annual equity change
	(Head)	(Ratio)	($)	($)
1960	207	.0847	78,541	—
1961	207	.0766	82,900	4,359
1962	206	.0702	87,354	4,454
1963	214	.0680	92,800	5,446
1964	215	.0550	97,412	4,612
1965	224	.0643	104,225	6,813
1966	225	.0656	111,724	7,499
1967	232	.0564	119,121	7,397
1968	239	.0533	127,416	8,295
1969	246	.0597	137,773	10,357
1970	257	.0570	149,321	11,548
1971	266	.0609	163,301	13,980
1972	278	.0692	180,488	17,187
1973	287	.0690	199,825	19,337

(a) Returns include income after taxes. Changes in the market value of assets are not included. The weighted average returns to equity for the random sample were calculated by summing the products of each firm's equity level times that particular firm's capacity and dividing the sum of these products by the sum of all 20 firms' capacities for the same period.

(b) Annual equity position is the market value of all assets (measured as salvage values) minus all debts.

Capacity and production would be expected to be slightly less with the imposition of the rule requiring control of runoff from a 10-year, 24-hour rainfall event by 1977, and from a 25-year, 24-hour rainfall event by 1983 (Rule A), as compared to performance if no water pollution control rules are imposed. Under the assumption that all firms adopt the required technology, production was seven head less for the average simulated firm, or an average of 0.167% less over the entire 1974-1985 period, compared to simulated production when no water pollution control rules are imposed.

The equity loss to Michigan beef feedlots that would be expected with the implementation of the rule requiring control of a 10-year, 24-hour storm by 1977 and a 25-year, 24-hour storm by 1983 (Rule A) can be determined by comparing the annual change in a firm's equity under a particular rule, and the annual change in a firm's equity when no water pollu-

[9]A recent study included the high opportunity cost for spring labor in the analysis of water pollution control rules (9).

[10]The assumption of no required additional investments in pollution abatement through the 1976 production year is made for analytical convenience. In actuality, some of the feedlots required to apply for NPDES permits may initiate needed remedial actions prior to July 1, 1977, when part 1 of Rule A must be met.

[11]The distribution of Michigan feedlots is skewed to the right along the capacity axis. Additionally, within any capacity stratum, drylot unpaved and drylot paved housing systems jointly accounted for 92% of all systems. Given these population characteristics, a small stratified random sample provides sufficient reliability for generalizing to the entire population of Michigan beef feedlots.

Table 8. Average measures of performance for a simulated sample of Michigan feedlots for the 1974-1985 period without the imposition of water pollution control rules

Year	Average feedlot capacity	Weighted average return to equity [a]	Average annual equity per firm [b]	Average annual equity change per firm
	(Head)	(Ratio)	($)	($)
1974	284	.0669	219,889	20,064
1975	319	.0724	245,904	26,015
1976	330	.0753	276,037	30,133
1977	344	.0730	309,790	33,753
1978	352	.0764	348,605	38,815
1979	362	.0730	391,224	42,619
1980	361	.0747	439,280	48,056
1981	367	.0728	492,332	53,052
1982	361	.0726	550,829	58,497
1983	367	.0713	615,093	64,264
1984	367	.0690	683,935	68,842
1985	368	.0679	758,687	74,752

(a) Returns include income after taxes. Changes in the market value of assets are not included. The weighted average returns to equity for the random sample were calculated by summing the products of each firm's equity level times that particular firm's capacity and dividing the sum of these products by the sum of all 20 firms' capacities for the same period.

(b) Annual equity position is the market value of all assets (measured as salvage values) minus all debts.

tion control is imposed.[12] Under Rule A, the present value of the equity loss is $3,724 over the 1974-1985 period for the average Michigan beef feedlot.

Rule B, the rule requiring the control of a 25-year, 24-hour rainfall event by 1977, had an equity loss effect similar to that incurred under Rule A. Beef production was 7.2 head less over the entire 1974-1985 period for the average Michigan feedlot, or a decrease of 0.17% compared to production when no pollution control rules are in force. The present value of equity losses to the average feedlot owner is $3,911 under Rule B.

Rule C, the requirement that all firms control runoff from a 6-month rainfall, has more severe effects. Production was 37.7 head less over the entire 1974-1985 period for the average feedlot, a decrease of 0.90% relative to production when no rules are imposed. The present value of the equity loss under Rule C is equal to $4,800 for the average feedlot.

Rule D, which prohibits winter spreading and requires control of runoff from a 6-month rainfall, results in production being 38.3 head less over the entire 1974-1985 period for the average feedlot, or a decrease of 0.91% relative to production when no rules are imposed. The present value of the equity loss incurred is $5,990 for the average feedlot.

The impacts of imposing each of the four water pollution control rules are quite varied when contrasted with performance in the absence of rule imposition (Table 9).

Table 9. The impacts of four alternative rules, measured in terms of lower production levels and the present value of the equity loss per firm, 1974-1985, relative to continued operation without imposition of water pollution control rules

Rule	Average feedlot production level difference over the 12-year period [a]	Present value of average equity loss per firm [c]
	(Head)	($)
A [b]	7.0	3,724
B	7.2	3,911
C	37.7	4,800
D	38.3	5,990

(a) Calculated as the average firm's production in the absence of the implementation of rules less the average production under each rule.

(b) Refer to Appendix A-3 for nominal values of equity, by rule, by year.

(c) Present value of average equity loss per firm consists of the discounted values for the relevant years of the difference between the average firm's equity under a particular rule and the average firm's equity in the absence of any pollution control rule.

All four water pollution control rules (Rules A, B, C or D) result in equity losses, and these losses become a larger proportion of equity as the amount of firm equity declines (Table 10). To identify the degree of regressiveness, the 20-firm sample was simulated with two levels of average net worth. Post-diction of the simulation model with actual Michigan beef feedlot performance for 1960-1971 indicated a mean average firm equity level of $220,000 in

[12] Equity loss is calculated by determining the present value of annual differences in the firm's equity under Rule A and when no rule is imposed. The discount rate used is 8%.

Table 10. Comparison of equity losses over the 1974-1985 period through the imposition of alternative water pollution control rules for the average simulated feedlot under alternative firm net worth levels

Rule	Average simulated firm equity in 1974 equals $220,000		Average simulated firm equity in 1974 equals $105,000	
	Equity loss over 1974-85 period	Equity loss/ 1974 equity	Equity loss over 1974-85 period	Equity loss/ 1974 equity
	($)	(Ratio)	($)	(Ratio)
A	3,724	.0169	3,281	.0313
B	3,911	.0178	3,479	.0331
C	4,800	.0218	4,983	.0474
D	5,990	.0272	5,746	.0546

1974; performance of the 20-firm sample of feedlot firms taken as representative of the Michigan feeding industry through the post-diction validation was compared with the performance of an alternate sample of 20 firms with a 1974 average equity of $105,000. Both samples of firms had the four alternative water pollution control rules imposed separately.

IMPLICATIONS

The focus of this study was to investigate some of the economic impacts involved under selected water pollution control rules with the potential for being directed at Michigan beef feedlots. Through the imposition of such rules, three groups might be affected: feedlot owners, consumers of fed beef, and users of the nation's water supplies. In its present regulatory role, EPA has the responsibility for assessing the economic impacts of rule implementation on beef producers, beef consumers and users of water supply. The adverse economic effects that could accrue to producers and consumers of beef are weighed against the beneficial effects that could be realized by users of water supplies.

The purpose of this study was to provide further clarification relative to the first two effects, producer and consumer losses. While important, the measurement of environmental improvements that might be realized by water users is outside the scope of the model analyses.

Feedlot operators will witness three measurable changes in their economic performance as a result of the imposition of these selected water pollution control rules. Changes will arise in the equity positions of feedlot firms and in their asset structures. In addition, distribution of wealth among feedlot owners will change.

Through the implementation of these alternative rules, total production for the average simulated firm over the 1974-1985 period will not be as large as that which would have been realized in the absence of water pollution controls. Most restrictive is Rule D, which requires winter storage of livestock wastes to limit the application of wastes to farmland in periods when runoff potential is great. However, these production reductions lead only to nominal reductions in the levels of equity growth achieved by the average simulated firm over the 12-year simulated period.

Second, the asset structure of the average simulated feedlot is not drastically affected through implementation of the alternative rules. The capital outlays required for compliance with the rules are not substantial in comparison to the existing capital structure of the average simulated beef feedlot. Furthermore, there is only a nominal reduction in the growth of the feedlot (measured in equity change) for the average simulated feedlot relative to its growth potential in the absence of controls.

Third, the distribution of wealth for feedlot owners will undergo some change through the imposition of pollution control rules. In the multiperiod analysis, it was shown that the average firm from a sample of feedlots with relatively low equities would incur higher equity losses per dollar of 1974 capital investment than the equity losses per dollar of 1974 equity incurred by the average firm taken from a representative sample of Michigan feedlots. This unequal incidence of adjustment is also apparent in the static analysis. Per-head capital outlays are much higher for the smaller, more land extensive feedlots (small, open lots). Lower per-head capital for larger-capacity feedlots reflect the size economies that arise because of the inherent internal economies of the abatement technologies under consideration.

Beef production over the 1974-1985 period is expected to be less by 1% under the most severe rule (Rule D) than production levels that would be achieved in the absence of water pollution control rule implementation. In the analysis of supply response and price effects, it was assumed that: (1) all beef feedlots of less than 1,000-head capacity in the nation would undergo adjustments subsequent to rule implementation that would parallel adjustments made by Michigan feedlots of similar capacity, and (2) feedlots of 1,000 and over capacity would not increase production in response to rule implementation on the smaller-capacity feedlots. With an estimated price flexibility for beef at farm level of 1.73, the expected price increase under the implementation of Rule D (where aggregate beef supplies decrease by 0.91%) would be approximately 1.5%. Price increases would be less under Rules A, B and C, where aggregate production would decrease by 0.167, 0.17 and 0.90%, respectively. If rule implementation became additive — for example Rule A and part 2, Rule D — the percent increase in beef prices would reflect the joint decreases in aggregate supplies. The relaxing of either of the above-specified assumptions would tend to lessen the consumer price effects expected.

The implications of this study for the U.S. Environmental Protection Agency are that the alternative water pollution rules considered (1) reduce the equity levels of feedlot owners, (2) have a regressive impact on smaller-capacity feedlots, and (3) have only a minimal impact on the quantities of beef available for consumption by consumers.

This study also has implications for any state agency given responsibility for implementing state water quality statutes and/or administering federal effluent guidelines. Rules more severe than extending the present EPA guidelines (Rule A) to feedlots of less than 1,000-head capacity could present major penalties to the state's feedlot industry. If Michigan feedlots were required to retain runoff from a 6-month rainfall (Rule C), the mean present value of the equity loss for the average simulated firm for the 12-year period would be approximately $1,000 more than the equity loss incurred through extending the implementation of EPA guidelines (Rule A) to feedlots of less than 1,000 head.

State actions taken to eliminate the pollution potential from wastes applied to cropland in winter months (Rule D, part 2) would be even more severe; equity losses for the average simulated Michigan feedlot for the 12-year period would be $2,200 greater than those incurred through the implementation of Rule A. Although not too severe in impact on the average simulated feedlot, the incidence of adjustment is not uniformly distributed. Small feedlots will incur higher per-head capital outlays and annual cost increases because of the economies of size inherent in the technologies required for compliance with the alternative rules.

The implications of this study to individual feedlot operators, the beef feeding industry, and consumers of beef are valid only for the data and assumptions of the model employed in the analyses. Readers will benefit most from interpreting the empirical estimates of the capital outlays required and increases in annual beef production costs in a relative vein. Also, changes in the aggregate supplies of fed beef and associated changes in the price of beef for consumers are most meaningful when interpreted on a relative basis.

REFERENCES

1. Black, J. Roy and Harlan D. Ritchie (1973). Average daily gain and daily dry matter intake of various kinds of cattle fed three different rations under several environmental situations. Staff Paper 1973-1, Department of Agricultural Economics, Michigan State University.
2. Forster, David L. (1974). The effects of selected water pollution control rules on the simulated behavior of beef feedlots, 1974-85. Unpublished Ph.D. Thesis, Michigan State University.
3. Hughes, Harold A. (1973). Energy consumption in beef production systems as influenced by technology and size. Unpublished Ph.D. Thesis, Michigan State University.
4. Johnson, Glenn L. (1972). Alternatives to the neoclassical theory of the firm. American Journal of Agricultural Economics.
5. Johnson, J. B. and G. A. Davis (1974). The economic impacts of imposing EPA effluent guidelines on the U.S. fed-beef industry. Cornell University Waste Management Conference.
6. Johnson, J. B., L. J. Connor and C. R. Hoglund (1972). Summary of state air and water quality statutes applicable to the management of livestock wastes. Agricultural Economics Report No. 231, Michigan State University.
7. Kyle, Leonard R. Business analysis summary for cattle feeding farms. Agricultural Economics Report, Michigan State University, selected annual issues.
8. Office of the Federal Register, *Federal Register*, Vol. 39, No. 2. National Archives and Records Service, General Services Administration, Washington, D.C.
9. Pherson, Carl L. (1974). Beef waste management economics for Minnesota farmers-feeders. Cornell University Waste Management Conference.
10. U.S. Congress (1972). Public Law 92-500. Ninety-Second Congress.

APPENDIX

Table A-1. Original capital investment per head capacity by housing technology and feedlot capacity without imposing water pollution control rules[a]

Housing technology	Feedlot capacity (head)		
	100	500	900
Drylot paved	$336.50	$255.23	$253.78
Drylot unpaved	$320.57	$238.74	$237.23
Open lot	$268.91	$186.00	$184.37
Cold confinement, solid floor	$346.72	$265.99	$264.58
Cold confinement, slotted floor	$436.83	$334.17	$328.15

[a] The investments in Tables A-1 and A-2 are on a per-head basis for a one-time feedlot capacity. To find the amount of capital investment per head of beef sold, the following calculation would be made:

$$\text{Investment per head sold} = \frac{\text{Investment per head capacity}}{\text{Turnover rate} \times \text{life of investment}}$$

For drylot paved and unpaved facilities, the turnover rate is approximately 1.22 for the ration used in this study. For open lot facilities it is approximately 1.10, and for the confined facilities the turnover rate is approximately 1.25.

Investment per head capacity includes the total capital outlay for feed storage facilities, lot and buildings, the feed handling system, and waste disposal equipment and facilities.

Table A-2. Additional capital investment per head capacity required to comply with alternative water pollution control rules by housing technology and feedlot capacity, 1974 prices[a]

Water pollution control rule and housing technology	Feedlot capacity (head)		
	100	500	900
1. Rule: control runoff from a 10-year, 24-hour rainfall event			
Technology:			
a. Drylot paved	$26.56	$ 6.86	$ 4.55
b. Drylot unpaved	$32.33	$12.17	$ 9.76
c. Open lot	$34.72	$14.42	$11.98
d. Cold confinement, solid floor[b]	—	—	—
e. Cold confinement, slotted floor[b]	—	—	—
2. Rule: control runoff from a 25-year, 24-hour rainfall event			
Technology:			
a. Drylot paved	$26.73	$ 6.99	$ 4.67
b. Drylot unpaved	$32.88	$12.64	$10.21
c. Open lot	$35.43	$15.04	$12.58
d. Cold confinement, solid floor[b]	—	—	—
e. Cold confinement, slotted floor[b]	—	—	—

(Continued)

Table A-2. (Continued)

Water pollution control rule and housing technology	Feedlot Capacity (head)		
	100	500	900
3. Rule: control runoff from a 6-month rainfall event			
Technology:			
a. Drylot paved	$28.20	$ 8.17	$ 5.78
b. Drylot unpaved	$38.01	$17.15	$14.60
c. Open lot	$42.07	$20.96	$18.35
d. Cold confinement, solid floor[b]	—	—	—
e. Cold confinement, slotted floor[b]	—	—	—
4. Rule: no winter spreading of wastes			
Technology:			
a. Drylot paved	$ .96	$ 3.45	$ 2.34
b. Drylot unpaved	$ .78	$ 3.27	$ 2.17
c. Open lot	$ .68	$ .68	$ 2.06
d. Cold confinement, solid floor	$ 2.27	$ 4.76	$ 3.44
e. Cold confinement, slotted floor	$ 6.81	$ 6.13	$ 4.03

[a] Additional capital investments include additional capital outlays for buildings and equipment needed to comply with a rule.

[b] These housing types are not affected by this particular water pollution control rule.

Table A-3. Average equity per firm for a simulated sample of Michigan feedlots over the 1974-1985 period under four alternative water pollution control rules[a]

Year	Average Equity Under			
	Rule A	Rule B	Rule C	Rule D
1974	$219,889	$219,889	$219,889	$219,889
1975	$245,904	$245,904	$245,904	$245,904
1976	$275,773	$275,764	$275,674	$275,569
1977	$308,978	$308,947	$308,173	$307,925
1978	$347,236	$347,180	$346,603	$346,204
1979	$389,104	$389,023	$387,965	$387,395
1980	$436,592	$436,478	$435,377	$434,615
1981	$488,872	$488,731	$487,412	$486,450
1982	$546,899	$546,728	$545,097	$543,913
1983	$610,307	$610,129	$608,750	$607,345
1984	$678,971	$678,784	$677,240	$675,558
1985	$752,931	$752,736	$751,544	$749,626

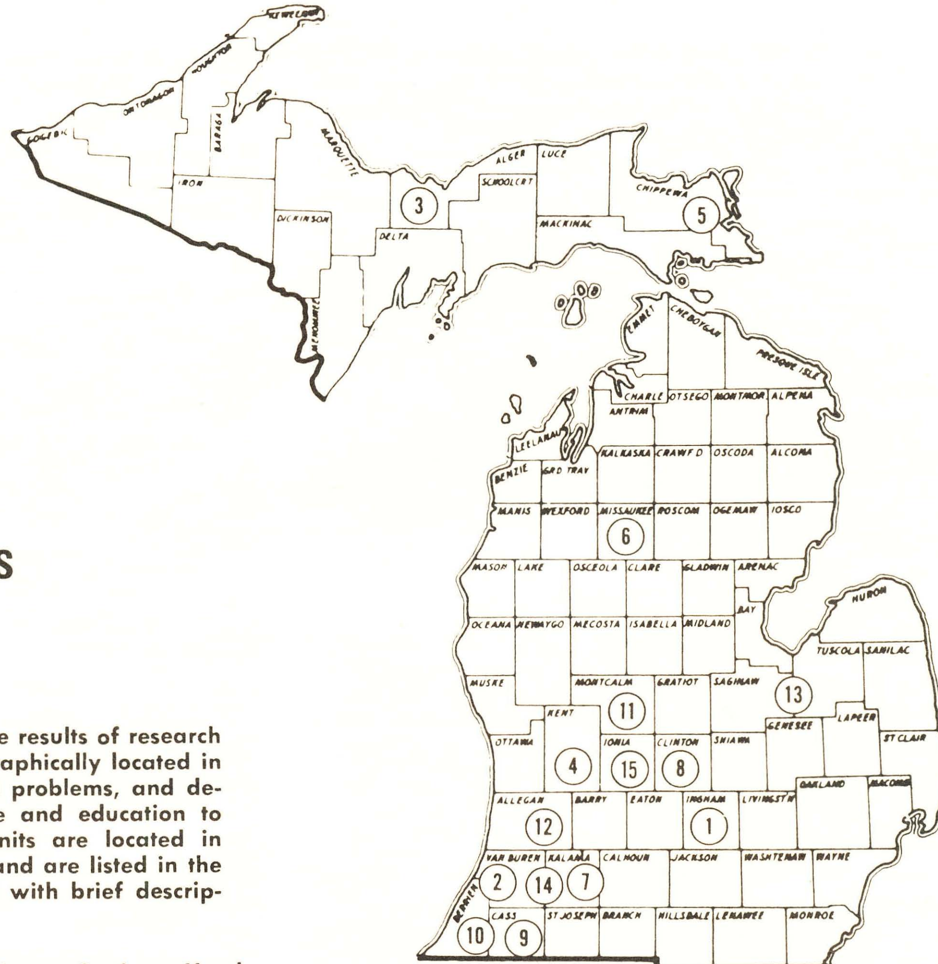
[a] These equity levels are used to compute the "equity loss" incurred by the simulated firms under the alternative water pollution control rules. The "equity loss" refers to the difference between the present value of annual equity changes when no rule is imposed and the present value of annual equity changes under particular water pollution control rule.

Table A-4. Examples of initial investment costs for two housing systems using the runoff retention system used in simulation model with the capacity to retain a 6-month rainfall

	100 head feedlot capacity	500 head feedlot capacity	900 head feedlot capacity
Drylot, unpaved housing system			
Diversion terrace	$ 140	$ 700	$1,260
Settling basin	$ 34	$ 172	$ 310
Holding pond and lining	$ 569	$2,578	$4,540
Cost of fence	$ 147	$ 328	$ 441
Cost of pump	$2,145	$2,219	$2,219
Total	$3,035	$5,997	$8,770
Drylot, paved housing system			
Diversion terrace	$ 33	$ 163	$ 294
Settling basin	$ 10	$ 41	$ 72
Holding pond and lining	$ 157	$ 656	$1,132
Cost of fence	$ 71	$ 158	$ 213
Cost of pump	$2,145	$2,219	$2,219
Total	$2,416	$3,237	$3,930

Table A-5. Annual costs and costs per pound of beef sold for three feedlot technologies, 500-head capacity

	Drylot, unpaved no runoff abatement		Drylot, unpaved runoff abatement for 25-year, 24-hour storm		Cold confinement solid floor	
Feeder calves		$128,662		$128,662		$131,736
Nondurable inputs:						
Fertilizer and herbicides	$12,126		$12,126		$12,126	
Supplement	$ 9,896		$ 9,896		$ 9,896	
Seed	$ 3,421		$ 3,421		$ 3,421	
Fuel	$ 1,005		$ 1,005		$ 829	
Labor	$10,855		$10,855		$11,239	
Repair	$ 3,079		$ 3,079		$ 3,194	
Insurance	$ 277		$ 289		$ 309	
Property tax	$ 5,370		$ 5,431		$ 5,512	
Interest on short term loan	$17,144		$17,147		$17,533	
Runoff abatement	$ 0		$ 452		$ 0	
Total		$ 63,173		$ 63,701		$ 64,059
Durable inputs:						
Silo	$ 3,528		$ 3,528		$ 3,528	
Moist corn storage	$ 1,895		$ 1,895		$ 1,895	
Lot and buildings	$ 2,556		$ 2,556		$ 3,469	
Transport	$ 1,363		$ 1,363		$ 1,549	
Runoff abatement	$ 0		$ 407		$ 0	
Crop machinery	$ 4,369		$ 4,369		$ 4,369	
Total		$ 13,713		$ 14,119		$ 14,813
Opportunity costs of land and durables		$ 34,128		$ 34,160		$ 34,215
Total annual cost		$239,676		$240,643		$244,821
Cost per pound sold		$ 0.375		$ 0.377		$ 0.374



Outlying Field Research Stations

These research units bring the results of research to the users. They are geographically located in Michigan to help solve local problems, and develop a closeness of science and education to the producers. These 15 units are located in important producing areas, and are listed in the order they were established with brief descriptions of their roles.

(1) Michigan Agricultural Experiment Station. Headquarters, 101 Agriculture Hall. Established 1888. Research work in all phases of Michigan agriculture and related fields.

(2) South Haven Experiment Station, South Haven. Established 1890. Breeding peaches, blueberries, apricots. Small fruit management.

(3) Upper Peninsula Experiment Station, Chatham. Established 1907. Beef, dairy, soils and crops. In addition to the station proper, there is the Jim Wells Forest.

(4) Graham Horticultural Experiment Station, Grand Rapids. Established 1919. Varieties, orchard soil management, spray methods.

(5) Dunbar Forest Experiment Station, Sault Ste. Marie. Established 1925. Forest management.

(6) Lake City Experiment Station, Lake City. Established 1928. Breeding, feeding and management of beef cattle and fish pond production studies.

(7) W. K. Kellogg Farm and Bird Sanctuary, Hickory Corners, and W. K. Kellogg Forest, Augusta. Established 1928. Forest management, wildlife studies, mink and dairy nutrition.

(8) Muck Experimental Farm, Laingsburg. Plots established 1941. Crop production practices on organic soils.

(9) Fred Russ Forest, Cassopolis. Established 1942. Hardwood forest management.

(10) Sodus Horticultural Experiment Station, Sodus. Established 1954. Production of small fruit and vegetable crops. (land leased)

(11) Montcalm Experimental Farm, Entrican. Established 1966. Research on crops for processing, with special emphasis on potatoes. (land leased)

(12) Trevor Nichols Experimental Farm, Fennville. Established 1967. Studies related to fruit crop production with emphasis on pesticides research.

(13) Saginaw Valley Beet and Bean Research Farm, Saginaw. Established 1971, the farm is owned by the beet and bean industries and leased to MSU. Studies related to production of sugar beets and dry edible beans in rotation programs.

(14) Kalamazoo Orchard, Kalamazoo. Established 1974. Research on integrated pest control of fruit crops.

(15) New Horticultural Field Station, Clarksville. Established 1974. Research on all types of tree fruits, vegetable crops, and ornamental plants. First research plots to be established during 1975.

4-75 — 5M