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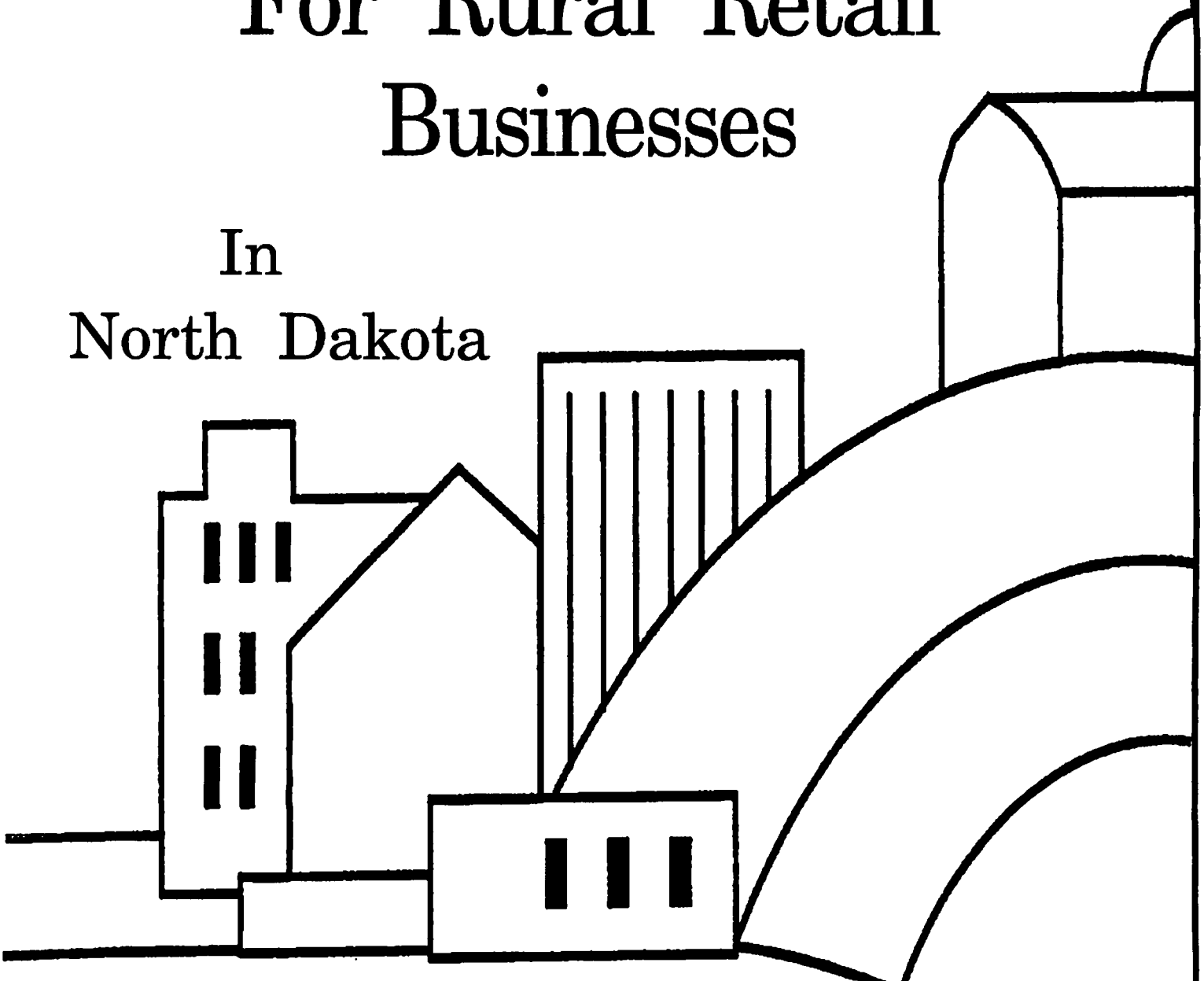
Threshold Population Levels For Rural Retail Businesses In North Dakota



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The authors accept sole responsibility for any remaining errors or omissions.

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THRESHOLD POPULATION LEVELS FOR RURAL RETAIL BUSINESSES IN NORTH DAKOTA

Alan V. Schuler and F. Larry Leistritz[‡]

Substantial demands for adjustment to changing socioeconomic conditions have characterized many nonmetropolitan communities during the past decade. For areas where agriculture or mining was the primary economic base, the 1980s were typically a period of decreasing primary industry employment and income (Henry et al. 1987). Decline in these areas' basic industries, in turn, often led to outmigration and decreased population and retail sales. These changes posed major adjustment problems for business persons and community leaders (Doeksen 1987, Murdock et al. 1987, Stone 1987).

Changes in the shopping patterns of rural residents often exacerbated these adjustment problems. Reports indicate an increasing tendency for rural residents to bypass nearby small towns for shopping centers and discount stores in larger trade centers (Johnson and Young 1987, Stone 1987, Mortensen and Leistritz 1988). As a result, main street merchants in smaller communities often discover that they are receiving a decreasing share of a declining retail sales volume. For example, in North Dakota, total taxable sales and purchases, adjusted for inflation, decreased by almost 18 percent from 1980 to 1989, and the share accounted for by towns with populations less than 10,000 fell from 35 percent to 26 percent during the same period (Leistritz et al. 1990).

Explanations for these changes in shopping patterns include improved transportation, changing tastes and preferences of rural residents, and the necessity to travel to larger centers to obtain specialized services, such as medical care (Leistritz et al. 1989, Ayres et al. 1989). Whatever the causes, however, the effects of recent changes in rural retail trade patterns pose major challenges for rural business operators and community leaders. Throughout North Dakota and other rural areas of the Midwest, nonmetropolitan communities are placing a very high priority on local economic development, as evidenced by activities such as creating local loan pools and hiring paid development coordinators (Leistritz et al. 1989, Ayres et al. 1989). While many development efforts were geared toward recruiting or developing new basic sector businesses, local development groups also attempt to enhance their local retail sectors. Some towns emphasized re-establishing a business type previously lost, such as a farm machinery dealership or a furniture store, while other local leaders perceived new market opportunities for particular business types.

Whatever the initial stimulus for attempts to revitalize or diversify the local retail sector, a major question that must be addressed relates to the adequacy of a community's population base to support a given type of business. *Population thresholds*, the minimum number of consumers necessary to provide an adequate sales volume for a particular type of retail business, have long been a key concept in central place theory (Berry and Garrison 1958,

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Shaffer 1989). As community leaders evaluate their local retail sector, the threshold concept is particularly useful. This study examines the population levels associated with specified numbers of businesses of various types in nonmetropolitan communities in North Dakota.

Objectives

The purpose of this study is to determine population levels associated with the presence of specified types of businesses in North Dakota communities. The 16 business types examined represent retail establishments frequently found in nonmetropolitan trade centers. The communities included in the analysis were the North Dakota towns having populations between 200 and 10,000 in 1980.

Procedures

The data used to identify the presence of particular types of businesses in a given community were records of sales and use tax permit holders from the North Dakota State Tax Department. The number of permit holders by Standard Industrial Classification (SIC) group were identified for all incorporated towns with populations between 200 and 10,000 in 1980. Sixteen business types that are relatively common in the state's nonmetropolitan trade centers were used as the basis for the analysis. These are SIC 3-digit industries except for two 4-digit industries (SIC 5812 Eating Places and SIC 5813 Drinking Places -- Alcoholic Beverages). A detailed description of the 16 business types is found in Appendix Table 1. The communities included in the study are North Dakota towns with populations between 200 and 10,000 in 1980, a total of 181 communities. The number of towns by population group is summarized in Table 1, and the number of towns having different numbers of establishments of each type is shown in Table 2.

Although the data set consists of the entire population of permit holders for the 16 business types in North Dakota cities with populations between 200 and 10,000, this data set may be regarded as a sample of two

TABLE 1. NUMBER OF NORTH DAKOTA CITIES BY POPULATION GROUP

Range in Population, 1980	Number of Cities
2,501 - 10,000	8
1,501 - 2,500	19
1,001 - 1,500	25
501 - 1,000	44
200 - 500	85
	181

TABLE 2. NUMBER OF TOWNS IN NORTH DAKOTA WITH INDICATED NUMBER OF ESTABLISHMENTS, 1988

SIC Code Number and Industry Description		Number of Establishments															
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15 or more
508	Farm and Garden Machinery and Equipment Stores	42	48	23	27	12	11	6	5	1	1	0	3	1	1		
519	Farm Supply Stores	63	48	24	11	18	7	4	4	1	1						
521	Lumber and Other Building Materials	77	69	24	6	2	3										
525	Hardware Stores	77	57	28	12	4	2	0	0	1							
531	Department Stores	146	28	7													
533	Variety Stores	145	30	5	1												
541	Grocery Stores	21	100	46	11	2	1										
544	Gasoline Service Stations	13	37	43	38	14	8	11	4	6	1	1	1	1	1		
565	Family Clothing Stores	131	27	13	5	2	0	1	0	1	1						
571	Home Furniture and Furnishings Stores	126	31	16	2	1	4	1									
573	Radio, Television, and Electronics Stores	106	32	17	12	3	7	2	2								
591	Drug Stores	102	58	16	2	3											
594	Sporting Goods Stores and Bicycle Shops	89	53	19	5	4	4	0	2	1	1	0	0	1	0	0	2
599	Florists	115	32	22	5	1	2	2	0	0	1	0	0	0	1		
5812	Eating Places	2	66	35	17	1	15	13	7	9	4	3	1	1	1	1	5
5813	Drinking Places (Alcoholic Beverages)	2	37	67	20	15	13	8	6	3	3	0	3	1	0	0	3

different populations. It could be considered as a sample (North Dakota) of a larger geographic area (several states) having similar trade and service activities of rural communities or as a sample of one year (1988) from a population of a number of years. In either case, the data set may be considered as a sample whose statistics could be used to make inferences regarding the values of parameters of the population that the sample represents. The inferences could involve either hypothesis tests or estimation (either point estimates or confidence interval estimates).

Definition of Threshold Population

A threshold population is generally defined as the minimum level of population required to support a business establishment at an acceptable level of return or profit (Shaffer 1989). A portion of the entrepreneur's return is a "normal" profit, i.e., the minimum return or payment necessary to retain the entrepreneur in this specific business. If this minimum or normal return is not realized, the entrepreneur will withdraw his/her efforts from this specific business and reallocate the resources to another business -- or change from an entrepreneur to a wage or salary earner.

Although the traditional definition of threshold population implies a level of population that is barely sufficient for one business of a given type to be successful in a community, estimates derived in this study are more likely to be the "expected" city population associated with a given number of businesses of that type in a community. However, the existing number of businesses in most rural communities in North Dakota is probably larger than the long-run equilibrium number because of population declines in those communities over time.

Economic theory indicates that firms will remain in operation as long as their revenues exceed their variable costs, even though they may not recover all their fixed costs. A substantial number of North Dakota businesses may be in that situation. They may be owned and operated by people who are too old to seek alternative employment, and the business may not be an attractive investment for others. The present owners' best option may be to operate their businesses until they retire, but the businesses will likely not continue to operate after the retirement of the owner. For these reasons, the "expected" city population estimates obtained in this analysis may indeed be reasonable estimates of the threshold population for selected business types in rural communities in North Dakota.

Empirical Model

Previous empirical studies typically have employed models in which population is the dependent variable and the number of establishments is the independent variable. These models were often of the form:

$$P_i = B_0 \, B_i^{N_{ij}}$$

where:

P_i = estimated 1988 population of city i (U.S. Bureau of the Census 1990)

N_{ij} = number of permit holders of SIC group j in city i, and B_0 and B_i are parameters of the equation.

While it can be argued that an alternative specification with population as the independent variable and the number of establishments as the dependent would be more consistent with economic theory, the population-dependent model

is used in this analysis. (For the results of the model in which number of establishments is a function of population, estimated using the same data set, see Schuler [1990].)

Four different functional forms of the population-dependent model were estimated:

Exponential

The exponential model can be expressed as follows:

$$P_i = B_0 B_1^{N_{ij}}$$

which can be transformed into a form that is linear in the logarithms of P and B:

$$\text{Log}_e P_i = \text{Log}_e B_0 + N_{ij} \text{ Log}_e B_1$$

where P_i, N_{ij}, B_0, and B_1 are as previously defined.

Some towns included in the sample have no businesses of a given type (i.e., $N_{ij} = 0$). Because the logarithm of zero is not defined, a value of 0.0001 was entered in the data set for those towns that had no businesses of type j.

Linear

The linear model was of the form:

$$P_i = B_0 + B_1 N_{ij}$$

Quadratic

The quadratic model used in this study was of the form:

$$P_i = B_0 + B_1 N_{ij} + B_2 N_{ij}^2$$

Double Log

The double log model was of the form:

$$\text{Log}_e P_i = B_0 + B_1 \text{Log}_e N_{ij}$$

The four models were estimated using the permit holder data set. The relative performance of the models was evaluated on the basis of the frequency with which the mean value of population for cities with N permit holders was observed in the 95 percent confidence interval of each model. Figure 1

presents the results for cities having 1, 2, 3, or 4 permit holders of SIC Group 508 (Farm and Garden Machinery and Equipment). The mean value of the actual population (denoted by A) for cities with N number of permit holders is observed twice (N = 1 and N = 4) in the 95 percent confidence interval estimate for threshold population for the quadratic model (Figure 1). The mean value of the actual population is also enclosed in the linear confidence interval estimates for cities having one and those with two permit holders. The range of the confidence interval estimate for each model is indicated by the length of the respective line.

The evaluation of the models' performance indicated that the quadratic model yielded the most reliable estimates (Table 3). Therefore, the quadratic model was employed to develop estimates of threshold populations for the sixteen business types.

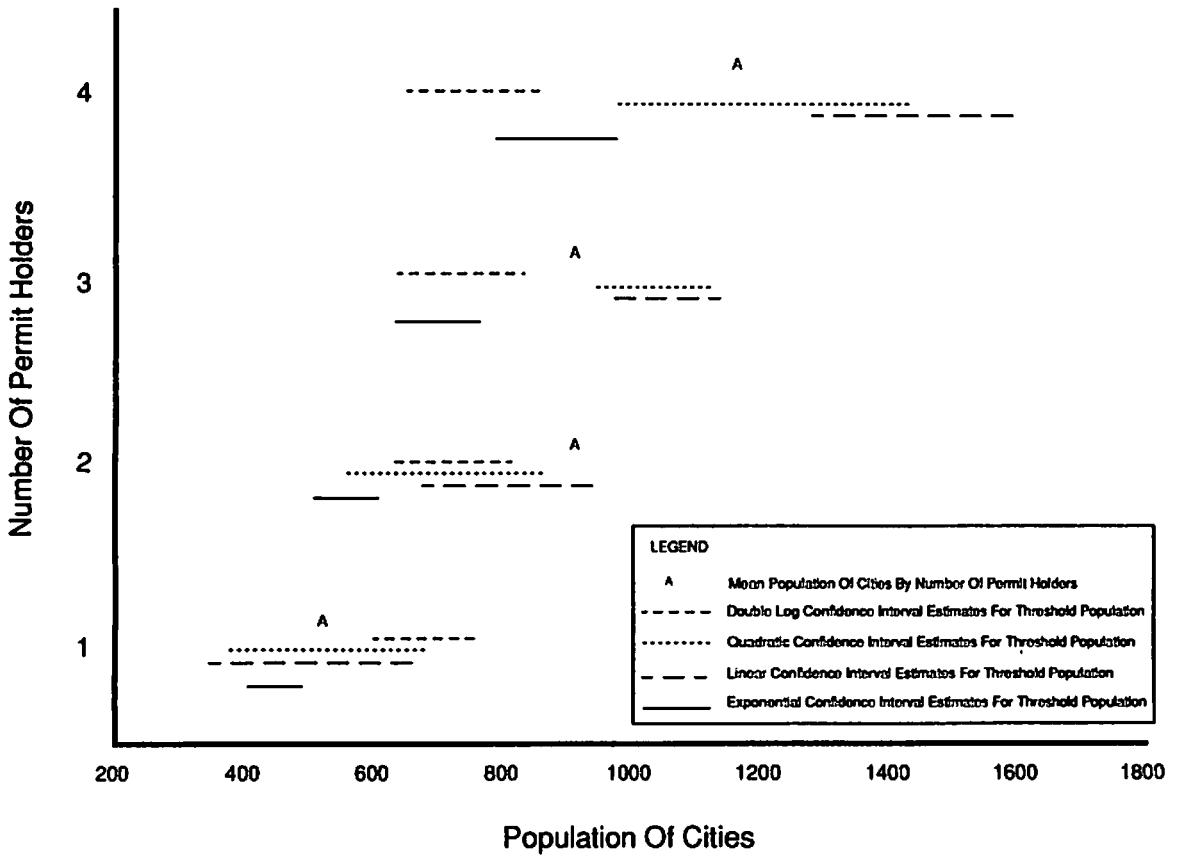

Figure 1. Mean Population and Confidence Interval Estimates for Cities With 1, 2, 3, or 4 Firms, Farm and Garden Machinery, and Equipment.

TABLE 3. PERCENT OF CONFIDENCE INTERVALS THAT INCLUDE THE MEAN POPULATION OF NORTH DAKOTA CITIES WITH 1, 2, 3, OR 4 PERMIT HOLDERS IN THE 16 TYPES OF BUSINESSES, 1988, BY MODEL

Model	Percent
$P = B_0 B_1^N$	26.2
$P = B_0 + B_1 N$	32.8
$P = B_0 + B_1 N + B_2 N^2$	55.7
$LnP = B_0 + B_1 LnN$	18.0

Results

Point estimates of the city population required to support indicated numbers of firms in the 16 SIC categories are shown in Table 4. For example, a town of 530 people could support one farm and garden machinery establishment, while a population level of 712 would be required to support two establishments. The boundaries of 95 percent confidence intervals for each business type are shown in Appendix Table 2. The point estimates indicate that the population required to support various business types varies substantially. Business types with relatively low population requirements include eating and drinking places and gasoline stations (Table 4). On the other hand, variety stores and department stores have the highest levels of required population among the business types studied.

The confidence intervals for the various business types (Appendix Table 2) indicate the relative variability of the required population levels. For instance, the estimated lower limit for drinking places (108) is only 43 percent of the point estimate (249) whereas the lower limit estimates for family clothing stores, florists, and drugstores, respectively, are 87, 87, and 85 percent of the corresponding point estimate values.

Conclusions and Implications

Business and community leaders frequently question the population level necessary to provide adequate sales volume for a particular type of business. Further, these relationships may have changed in recent years as a result of changing tastes, preferences, and shopping patterns of rural residents. This study examines population levels associated with specified numbers of 16 business types in North Dakota towns with populations between 200 and 10,000 in 1988.

TABLE 4. ESTIMATES OF CITY POPULATION REQUIRED TO SUPPORT AN INDICATED NUMBER OF ESTABLISHMENTS OF SELECTED BUSINESS TYPES, NORTH DAKOTA, 1988

Business Type	Number of Establishments			
	1	2	3	4
Farm and Garden Machinery and Equipment	530	712	938	1,207
Farm Supply Stores	663	927	1,235	1,587
Lumber and Other Building Material Stores	793	1,480	2,532	3,947
Hardware Stores	763	1,333	2,107	3,085
Department Stores	1,651	3,373	a	a
Variety Stores	1,806	4,614	a	a
Grocery Stores	528	1,285	2,676	4,702
Gasoline Service Stations	455	485	625	876
Family Clothing Stores	1,135	1,804	2,553	3,381
Home Furniture and Furnishings Stores	1,007	1,765	2,805	4,127
Radio, Television, and Consumer Electronics Stores	1,044	1,574	2,017	2,372
Drug Stores	1,103	2,305	3,990	6,159
Sporting Good Stores and Bicycle Shops	782	1,122	1,490	1,885
Florists	1,093	1,698	2,280	2,838
Eating Places	340	504	678	863
Drinking Places (Alcoholic Beverages)	249	506	775	1,057

[a]Not estimated because the data set contained insufficient numbers to support reliable estimates in these categories.

SOURCE: Appendix Table 2

The estimates developed in this study must be interpreted with caution for several reasons. First, this analysis, like most other analyses of threshold population levels (Shaffer 1989), is based on the number of firms offering a particular good or service in towns of different sizes. It does not necessarily follow that these population levels will yield sufficient sales volume to allow the business to be financially successful. (The ultimate criteria of financial success, of course, is the ability of the business to meet its proprietor's profit expectations, and these expectations can vary.) Second, the analysis is based on city population, whereas the population of the trade area (i.e., the city plus the surrounding rural area) should be considered in assessing the prospects for a new business. Finally, the relationships reported here represent averages across the state. The situation for an individual community may differ greatly from state norms based on differences in population composition (e.g., age and gender distribution), in per capita income, and in the strength of competing trade centers. With these limitations in mind, however, it is hoped that the information provided will be useful to decision makers in both private and public sectors.

References

Ayres, Janet, Larry Leistritz, and Kenneth Stone. 1989. "Issues, Strategies, and Policy Options for Rural Retail Business Survival." Paper presented at Rural Sociological Society Meeting, August 5-8, Seattle, Washington. West Lafayette, Indiana: Purdue University, Department of Agricultural Economics.

Berry, Brian J.L., and William C. Garrison. 1958. "A Note on Central Place Theory and the Range of a Good." Economic Geography 34:304-311.

Doeksen, Gerald A. 1987. "The Agricultural Crisis as it Affects Rural Communities." Journal of the Community Development Society 18(No.1):78-88.

Henry, Mark, Mark Drabenstott, and Lynn Gibson. 1987. "Rural Growth Slows Down." Rural Development Perspectives 3(No.3):25-30.

Johnson, Bruce, and Joel Young. 1987. Trends in Retail Sales Activity Across Nebraska's Counties and Communities. Lincoln: University of Nebraska, Department of Agricultural Economics.

Leistritz, F. Larry, Janet Wanzek, and Rita R. Hamm. 1990. North Dakota 1990: Patterns and Trends in Economic Activity and Population. Agr. Econ. Stat. Series No. 46. Fargo: NDSU, North Dakota Agricultural Experiment Station.

Leistritz, F. Larry, Tim L. Mortensen, Holly Bastow-Shoop, Joan Braaten-Grabanski, Alan Schuler, and Julie Fedorenko. 1989. Revitalizing the Retail Trade Sector in Rural Communities: Experiences of 13 North Dakota Towns. Ag. Econ. Rpt. No. 250. Fargo: NDSU, North Dakota Agricultural Experiment Station.

Mortensen, Timothy L., and F. Larry Leistritz. 1988. Changes in Selected County, City, and Trade Area Characteristics Between 1980 and 1986: Retail Sales, Population, and Pull Factors. Agr. Econ. Stat. Series No. 42. Fargo: North Dakota State University, Department of Agricultural Economics.

Murdock, Steve H., F. Larry Leistritz, Rita R. Hamm, Don A. Albrecht, and Arlen G. Leholm. 1987. "Impacts of the Farm Crisis on a Rural Community." Journal of the Community Development Society 18(No. 1):30-47.

Schuler, Alan V. 1990. "Factors Affecting the Viability of Rural Retail Centers." Unpublished M.S. thesis. Fargo: North Dakota State University: Department of Agricultural Economics.

Shaffer, Ron. 1989. Community Economics. Ames: Iowa State University Press.

Stone, Kenneth E. 1987. "Impact of the Farm Financial Crisis on the Retail and Service Sector of Rural Communities." Agricultural Finance Review 47:40-47.

U.S. Bureau of the Census, Current Population Report. Various Issues. Population and Per Capita Income Estimates for Counties and Incorporated Places. West North Central Series P-26, No. 84-WNC-SC. Washington, DC: U.S. Government Printing Office.

APPENDIX

APPENDIX TABLE 1. DEFINITION OF RETAIL ACTIVITY OF SELECTED BUSINESS TYPES

SIC Code	Business Type
508	FARM AND GARDEN MACHINERY AND EQUIPMENT Establishments primarily engaged in selling agricultural machinery and equipment for use in preparation, maintenance, planting, harvesting, and other operations pertaining to work on the farm or the lawn or garden, including dairy and other livestock equipment.
519	FARM SUPPLY STORES Establishments primarily engaged in selling animal feeds, agricultural fertilizers, chemicals, pesticides, seeds, and other farm production supplies.
521	LUMBER AND OTHER BUILDING MATERIALS DEALERS Establishments primarily engaged in selling lumber and a general line of building materials to the general public. However, even though these establishments may sell primarily to construction contractors, they are considered as retailers in the retail trade.
525	HARDWARE STORES Establishments primarily engaged in selling the basic hardware lines, such as tools (power and hand), builders' hardware, paint and glass, and plumbing and heating equipment.
531	DEPARTMENT STORES Establishments primarily engaged in selling a general line of apparel including suits, coats, dresses, and home furnishings. Establishments included in this group may have merchandise arranged in separate sections or departments with the accounting on a departmentalized basis.
533	VARIETY STORES Establishments primarily engaged in the retail sale of a variety of merchandise in the low and popular price ranges. Sales are usually made on a cash-and-carry basis, with the open-selling method of display and customer selection of merchandise.

- CONTINUED -

APPENDIX TABLE 1. DEFINITION OF RETAIL ACTIVITY OF SELECTED BUSINESS TYPES (CONTINUED)

SIC Code	Business Type
541	GROCERY STORES Establishments, commonly known as supermarkets, food stores, and grocery stores, primarily engaged in the retail sales of canned foods, dry goods, fruits, vegetables, and prepared meats, fish, and poultry.
554	GASOLINE SERVICE STATIONS Establishments primarily engaged in selling gasoline and lubricating oils. These establishments frequently sell other merchandise such as tires, batteries, and other automotive parts, and perform minor repair work. Included in this group are establishments that sell bulk fuel to individual customers.
565	FAMILY CLOTHING STORES Establishments primarily engaged in selling new clothing, shoes, hats, underwear, and related articles for personal wear and adornment for men, women, and children. Included in this group are establishments primarily engaged in the retail sale of men's, boy's, and women's ready-to-wear clothing and accessories.
571	HOME FURNITURE AND FURNISHINGS STORES Establishments primarily engaged in the retail sale of household furniture for the home, such as furniture, floor coverings, and draperies.
573	RADIO, TELEVISION, AND CONSUMER ELECTRONICS STORES Establishments primarily engaged in the retail sale of radios, television sets, stereo equipment, consumer audio, video electronics, computers, and computer peripheral equipment and software. Included in this group are establishments that sell a substantial amount of home appliances.

- CONTINUED -

APPENDIX TABLE 1. DEFINITION OF RETAIL ACTIVITY OF SELECTED BUSINESS TYPES (CONTINUED)

SIC Code	Business Type
591	DRUG STORES Establishments engaged in the retail sale of prescription drugs, proprietary drugs, and nonprescription medicines, and which may also carry related lines of goods such as cosmetics, toiletries, tobacco, and novelty merchandise.
594	SPORTING GOODS STORES AND BICYCLE SHOPS Establishments primarily engaged in the retail sale of sporting goods, sporting equipment, and bicycles, bicycle parts, and accessories.
599	FLORISTS Establishments primarily engaged in the retail sale of cut flowers and growing plants.
5812	EATING AND DRINKING PLACES Establishments primarily engaged in the retail sale of prepared food and beverages for on-premise or immediate consumption.
5813	DRINKING PLACES (ALCOHOLIC BEVERAGES) Establishments primarily engaged in the retail sale of alcoholic drinks such as beer, wine, and liquor, for consumption on the premises. Included in this group are also establishments primarily engaged in the retail sale of packaged alcoholic beverages for consumption off the premises.

SOURCE: Standard Industrial Classification Manual, 1987.

APPENDIX TABLE 2. QUADRATIC MODEL THRESHOLD POPULATION POINT ESTIMATES AND CONFIDENCE INTERVALS REQUIRED TO SUPPORT INDICATED NUMBER OF ESTABLISHMENTS OF SELECTED BUSINESS TYPES IN NORTH DAKOTA, 1988

Business Type	Number of Establishments											
	1			2			3			4		
	Lower Limit	Point Estimate	Upper Limit	Lower Limit	Point Estimate	Upper Limit	Lower Limit	Point Estimate	Upper Limit	Lower Limit	Point Estimate	Upper Limit
Farm and Garden Machinery and Equipment	376	530	684	563	712	862	756	938	1,120	990	1,207	1,423
Farm Supply Stores	493	663	833	713	927	1,142	977	1,235	1,494	1,307	1,587	1,867
Lumber and Other Building Material Stores	631	793	954	1,248	1,480	1,712	2,228	2,532	2,835	3,447	3,947	4,448
Hardware Stores	630	763	896	1,144	1,333	1,522	1,863	2,107	2,350	2,767	3,085	3,403
Department Stores	1,253	1,651	2,050	2,576	3,373	4,170	a	a	a	a	a	a
Variety Stores	1,557	1,806	2,055	4,198	4,614	5,030	a	a	a	a	a	a
Grocery Stores	385	528	671	1,097	1,285	1,472	2,374	2,676	2,978	4,076	4,702	5,329
Gasoline Service Stations	318	455	592	382	485	588	512	625	738	739	876	1,013
Family Clothing Stores	987	1,135	1,283	1,564	1,804	2,043	2,245	2,553	2,860	3,028	3,381	3,735
Home Furniture and Furnishings Stores	846	1,007	1,168	1,525	1,765	2,005	2,526	2,805	3,083	3,786	4,127	4,467
Radio, Television, and Consumer Electronics Stores	853	1,044	1,235	1,298	1,574	1,851	1,698	2,017	2,336	2,032	2,372	2,712
Drug Stores	934	1,103	1,272	2,070	2,305	2,539	3,596	3,990	4,383	5,362	6,159	6,956
Sporting Good Stores and Bicycle Shops	695	782	869	1,003	1,122	1,241	1,327	1,490	1,653	1,682	1,885	2,088
Florists	946	1,093	1,240	1,470	1,698	1,925	1,972	2,280	2,587	2,465	2,838	3,212
Eating Places	230	340	450	413	504	595	593	678	763	771	863	956
Drinking Places (Alcoholic Beverages)	108	249	390	401	506	611	675	775	875	939	1,057	1,176

[a]Not estimated because the data set contained insufficient numbers to support reliable estimates in these categories.