Determinants of Farm Size and Structure

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FARM GROWTH IN THE ONTARIO DAIRY INDUSTRY: A SKEPTICAL LOOK AT GIBRAT'S LAW

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> Economics consists of theoretical laws which nobody has verified and empirical laws which nobody can explain.
>
> Attributed to Michal Kalecki
> by Josef Steindl

I. Introduction

The dynamics of farm firm growth are important to farm operators, to farm policy and to rural communities. This importance is reflected in the considerable attention that agricultural economists have devoted to farm size and structure issues. In spite of this extensive and intensive professional scrutiny, there is much about the growth of farm firms that we do not understand. As a result, much of the agricultural economics literature on changing farm structure is descriptive.

Farm growth is a dynamic process in the sense that it is described by changes in measures of farm size over time. Farm structure is a static concept which relates to, among other things, the size distribution of farm firms within an agricultural industry at a point in time. Clearly, the size distribution dimension of farm structure is simply a cross sectional snapshot of the dynamic growth processes in operation within a population of farm firms.

II. Background

Two traditions have dominated economists' discussions of the size distribution of firms within an industry. What might be called the technological approach is usually traced to Viner (1931). Advocates of this approach emphasize the shape of the long run average cost function as a determinant of firm size. Industry structure is simply the reflection of the distribution of cost functions. Sylos-Labini's (1962) model of oligopoly is consistent with this tradition, as is the span of control literature (Williamson (1967), Beckmann (1977)), the model of industry structure proposed by Panzar and Willig (1978) and Walter

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Oi's (1983) explanation of the existence of different firm sizes within an industry. Oxley (1988) used a model strongly reminiscent of Viner's paper to study the impact of technological change on the structure of an agricultural industry.

In the present context, the hallmark of the technological approach is that it makes no general predictions about the size distribution of firms in a particular industry. In principle, any size distribution could be supported by the right distribution of shapes of long run average cost functions. That there might be empirical regularities observed in the size distribution of firms is neither predicted nor is it even anticipated.

The empiricist tradition, formalized by Gibrat (1931), begins with the observation that the size distribution of firms within most industries is approximately log normal. The apparent robustness of this phenomenon across industries and at different points in time has fueled speculation about types of growth patterns of firms which would be consistent with this outcome.

Gibrat's Law, or the Law of Proportionate Effect, asserts that the rate at which firms grow is independent of the size of the firm. The evolution of firm size over time is modelled as a stochastic process which obeys

$$X_t - X_{t-1} = \epsilon_t X_{t-1} \qquad (1)$$

where X is some measure of firm size, t denotes a specific time period and ϵ_t is the t-th element of $\{\epsilon_j\}$, a sequence of independently and identically distributed random variables. Rearranging (1) to obtain

$$X_t = (1 + \epsilon_t) X_{t-1} \qquad (2)$$

which through successive substitutions yields

$$X_t = X_0 \mathop{\pi}_{i=1}^{n} (1 + \epsilon_i) \qquad (3)$$

for a firm that is n time periods old. If the elements of $\{\epsilon_i\}$ are small relative to 1, then

$$\ln X_t = \ln X_0 + \mathop{\pi}_{i=1}^{n} \ln \epsilon_i \qquad (4)$$

Appealing to the central limit theorem, $\ln X_t$ is asymptotically normally distributed and hence X_t, our measure of firm size at a point in time, is lognormally distributed.

There has been a recent resurgence in the popularity of empiricist models of firm growth. Researchers have studied variations of the Law of Proportionate Effect in the non-farm sector (Singh and Wittington (1975), Clarke, (1979), Hall, (1987) and Evans (1987)) and in the farm sector (Shapiro <u>et al.</u> (1987). The results of these studies are mixed. The approximately lognormal distribution of firm sizes within industries persists, although most analysts find more very large firms than a lognormal distribution would predict. The problem of entry and exit of firms at different points in time have compounded empirical investigation. Strictly speaking, Gibrat's Law predicts that lognormality is the limiting distribution of firm sizes, that is that all firms would need to be "old".

This paper reports results of a test of the Law of Proportionate Effects using a longitudinal cross section sample of Ontario dairy farms. Although the size distribution of farms in our sample appears lognormal, (Figures 1 and 2), we estimate a version of equation (1) which admits the possibility that the random disturbance terms for specific farms may be serially correlated. We do not have good news. Like Shapiro et al. (1987), we find that the growth patterns in our sample of farms is not strictly consistent with Gibrat's Law.

III. Farm Size and Structure in the Ontario Dairy Industry 1981-1987

The past decade has witnessed the integration of fluid and industrial farms into a single class of farms in Ontario. All milk is now produced subject to the same quality standards and is separated according to end use at the processing stage. Total Ontario milk sales fell from 25.4 million hectolitres in 1982 to 24.8 million hectolitres in 1987. Dairy farm numbers has declined from over 15,000 in 1976 to about 10,000 in 1985. While nominal dollar measures of size indicate steady growth during the time period (Table 1), adjustment to constant dollars (Table 1a) shows little change in average farm size in recent years.

The value of milk quota has become an increasingly important component of the assets measure of farm size. As of January 1, 1987, the average estimated market value of milk quota holdings in Ontario was about $200,000.00. This represents the market value of the present value of rents accruing to an average farm from the formula price/production control instruments which constitute supply management.

It is the shape of the size distribution of farms which is of interest to advocates of the Law of Proportionate Effects. The frequency distribution of sizes of farms in 1987, whether measured in terms of assets or sales (Figures 1 and 2) is indeed skewed. As in many industries, the upper tail of the size distribution is somewhat fatter than would be the case with a strictly lognormal distribution.

IV. Putting Empiricism to the Test

If the stochastic process described in (1) is in fact driving the size evolution in a population of firms, then the size of the i-th firm in a cross section at t would follow

$$X_{it} = (1 + \epsilon_{it}) X_{it-1} \tag{5}$$

can be expressed as a linear estimating equation as

$$\ln X_{it} = \beta \ln X_{it-1} + \epsilon_{it} \qquad (6)$$

as long as ϵ_{it} is small relative to one.

A value of 1 for β has often been taken as confirmation of Gibrat's Law. Chesher (1979) and later Shapiro et al. (1987) have emphasized that OLS estimates of β are not consistent if the ϵ_{it} disturbance terms are serially correlated. The possibility of serial correlation for the ϵ_{it} should not be ignored. Intertemporal correlation of the rate of returns to assets and of net farm income (Tables 2 and 3) suggests that these two factors, which arguably are important determinants of farm growth rates, are not independently distributed between years.

Chesher has shown that if a first order autoregressive process drives ϵ_{it} over time, so that

$$\epsilon_{it} = \rho\, \epsilon_{it-1} + \delta_{it} \qquad (7)$$

then OLS estimates of β are inconsistent even when estimated with cross section data. If β and ρ are positive, OLS estimates of β will consistently over-state the size of the true β, which could lead to a false acceptance of Gibrat's Law. An alternative procedure which simultaneously estimates β and ρ uses OLS on longitudinal cross section data on firm sizes to estimate

$$X_{it} = \gamma_1 X_{it-1} + \gamma_2 X_{it-2} + \alpha_{it} \qquad (8)$$

Lower case X's represent firm size measured as the deviation of the logarithm of firm size from the mean of the logarithms of firm sizes at t. Parameter estimates for γ_1 and γ_2 are used to recover consistent estimates of β and ρ using

$$(\hat{\beta}, \hat{\rho}) = 1/2\ \{\hat{\gamma}_1 \pm (\hat{\gamma}_1^2 + 4\hat{\gamma}_2)\} \qquad (9)$$

The Law of Proportionate Effect requires that $\beta = 1$ and $\rho = 0$. In terms of the parameters of estimating equation (8), this suggests a null hypothesis that $\hat{\gamma}_1 = 1$ and $\hat{\gamma}_2 = 0$, which gives $(\beta, \rho) = (1, 0)$.

Equation (8) was estimated using a longitudinal cross section of data from farm accounts of 157 dairy farms participating in the Ontario Farm Management Analysis Project in the years 1984-1987. Equations with farm size in 1987 and in 1986 were estimated (Table 5). The hypothesis that $\hat{\gamma}_1 = 1$ and $\hat{\gamma}_2 = 0$ was rejected, suggesting that Gibrat's Law does not provide an appropriate explanation of firm growth for Ontario dairy farms. Chesher also rejected Gibrat's Law for a sample of commercial and industrial corporations in the U.K. (Table 6). His rejection, however, would appear to depend more on a finding that $\rho \neq 0$, that is that significant first order serial correlation was found in the stochastic process during firm growth. Our values for ρ are much smaller, but our estimates of β are much larger, suggesting that the growth of farm firms in this sample was an increasing function of farm size. This result is consistent with the observed increase in "concentration" in the industry.

Shapiro et al., however, reported that small farms grew faster than large farms in their sample. The rate of return to equity for all dairy farms participating in OFMAP in 1987 (Figure 3) is almost symmetrically distributed. Rate of return to assets, however, has been higher on smaller farms in our sample (Figure 4) which is consistent with Shapiro et al.

V. Conclusions

The economic world in which we live contains many empirical regularities which defy explanation. Factor shares stay remarkably constant over time, all the consumer demand curves that we have ever seen slope down to the right, the size distribution of firms in an industry looks approximately lognormal and neither parliament nor congress can balance a budget. In an attempt to explain the third of these regularities, the Law of Proportionate Effects has been recently revived by students of firm growth. The growing weight of evidence suggests that the "Law" is being broken in agriculture. This is, however, of little consolation to advocates of what we have called the technological view of industry structure, since this view offers no explanation of any particular firm size distribution. The lives of farm firms are often linked more closely to the lives of individuals than is the case in other sectors. Results of a recent Farm Credit corporation survey suggest that there may be a type of life-cycle effect in the growth of farm firms that contributes to the growth patterns of specific farms and may also influence industry structure. Perhaps this life cycle effect on the distribution of farm sizes at a point in time can be linked to the factor price explanation of average farm size due to Kislev and Peterson (1982) and the earlier related work of Heady and Ball (1962) to provide a starting point for a technological explanation of farm structure.

Endnotes

1 In the unlikely event that the reader is uninitiated, I recommend Robison (1988), OTA (1986), Brinkman and Warley (1983) and the Bergland report (USDA, 1979).

2 An important exception is a paper by Kislev and Peterson (1982).

3 If Markov chain models are considered as an agnostic version of Gibrat's Law, this resurgence resembles a stampede.

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Table 1

Change in the Average Size of Ontario Dairy Farms 1981-1987*

		Nominal Dollars	
	Sample Size	Gross Cash Income	Total Assets**
1981	119	114,000	553,431
1982	148	127,516	599,257
1983	139	123,142	651,615
1984	135	134,260	701,773
1985	131	141,200	730,847
1986	138	154,599	741,035
1987	129	157,068	702,164

* Source: Annual reports of the Ontario Dairy Farm Accounting Project

** Assessed market value as of December 31.

Table 1A

Change in the Average Size of Ontario Dairy Farms 1981-1987*

Constant 1981 Dollars

	Sample Size	Gross Cash Income	Total Assets**
1981	119	114,000	553,431
1982	148	115,083	540,829
1983	139	105,070	555,985
1984	135	109,779	573,812
1985	131	111,006	574,565
1986	138	116,767	559,694
1987	129	113,653	508,078

* Source: Annual Reports of the Ontario Dairy Farm Accounting Project

** Assessed market value as of December 31.

Table 2

Pearson Correlation Coefficients for Rate of Return to Assets,[1] 1984-87

157 Ontario Dairy Farms

	1985	1986	1987
1984	0.5768 (0.0001)[2]	0.5820 (0.0001)	0.4907 (0.0001)
1985		0.5747 (0.0001)	0.5603 (0.0001)
1986			0.5870 (0.0001)

[1] Rate of return to assets is net farm income, plus wages and salaries, less the opportunity cost of equity (at 5 percent), all divided by total assets.

[2] Probability values.

Table 3

Pearson Correlation Coefficients for Net Farm Income, 1984-87

157 Ontario Dairy Farms

	1985	1986	1987
1984	0.6255 (0.0001)[1]	0.5217 (0.0001)	0.5631 (0.0001)
1985		0.6531 (0.0001)	0.7007 (0.0001)
1986			0.6811 (0.0001)

[1] Probability values.

Table 4

Parameter Estimates for the Growth Model[1]

157 Ontario Dairy Farms

Year	$\hat{\gamma}_1$	$\hat{\gamma}_2$	$\hat{\beta}$	$\hat{\rho}$	F
1987	1.108 (0.7457)[2]	-0.1450 (0.07211)	1.170	-0.06200	8.59[3]
1986	1.056 (0.05203)	-0.09773 (0.04756)	1.142	-0.08550	8.53[3]

[1] Size is measured as the appraised market value of assets expressed in constant $.

[2] Values in parentheses are standard errors.

[3] The critical value for an F-test of the null hypothesis is about 4.75 at a 5% significance level.

Table 5

Parameter Estimates of $\hat{\gamma}_1$, $\hat{\gamma}_2$, $\hat{\beta}$ and $\hat{\rho}$

Reported by Chesher[1]

Year	$\hat{\gamma}_1$	$\hat{\gamma}_2$	$\hat{\beta}$	$\hat{\rho}$	X^2
1969	1.229 (0.064)[2]	-0.219 (0.065)	1.012	0.216	12.8[3]
1968	1.325 (0.073)	-0.320 (0.074)	1.007	0.318	21.5[3]
1966	1.233 (0.046)	-0.227 (0.046)	1.093	0.139	25.8[3]

[1] These results were obtained using a longitudinal cross section of 183 publicly held commercial and industrial corporations in the U.K. Size is measured as capital employed.

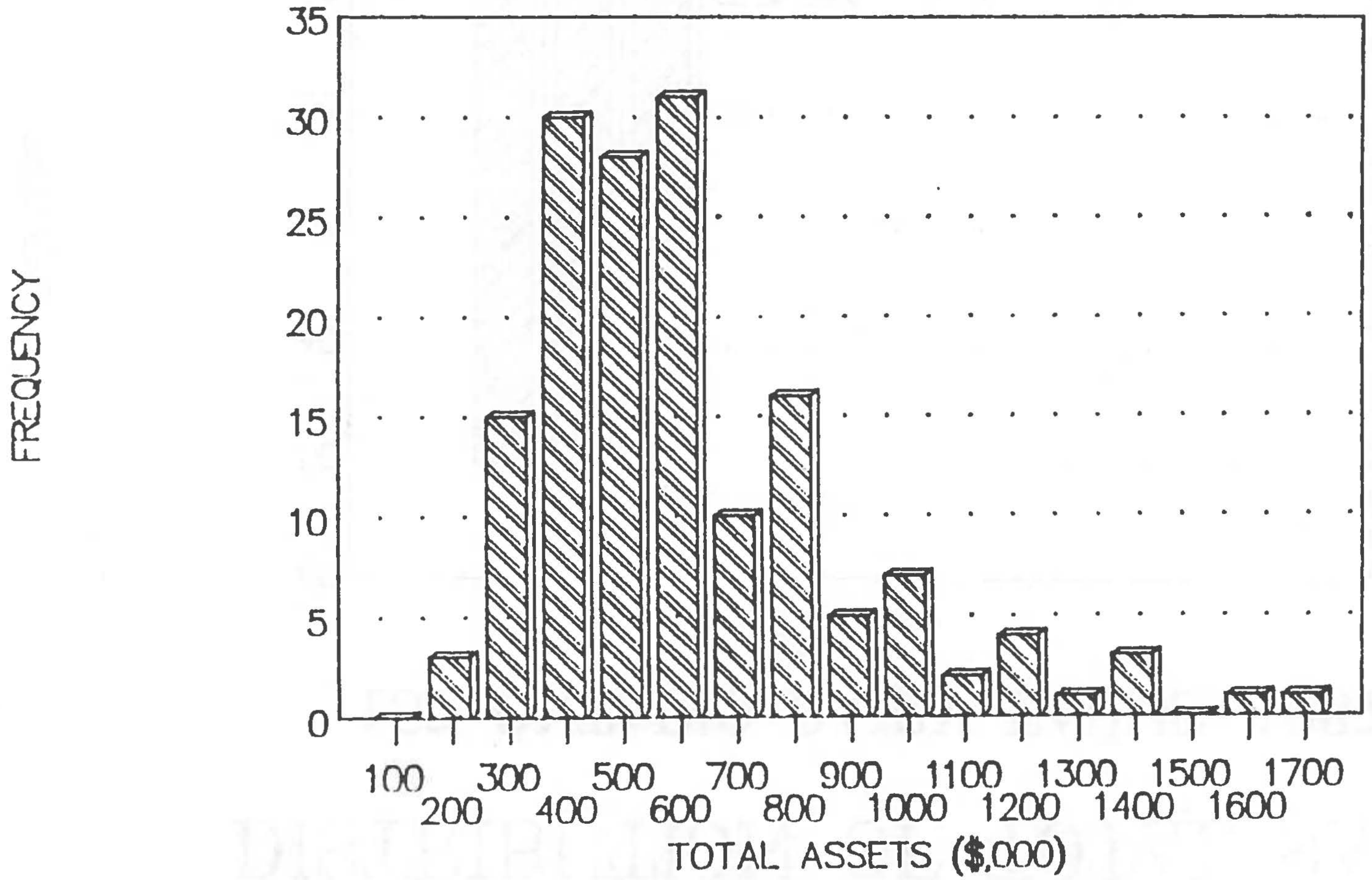
[2] Values in parentheses are standard errors.

[3] The critical X^2 value is 10.6.

FIGURE 1

DISTRIBUTION OF TOTAL ASSETS

157 ONTARIO DAIRY FARMS, 1987

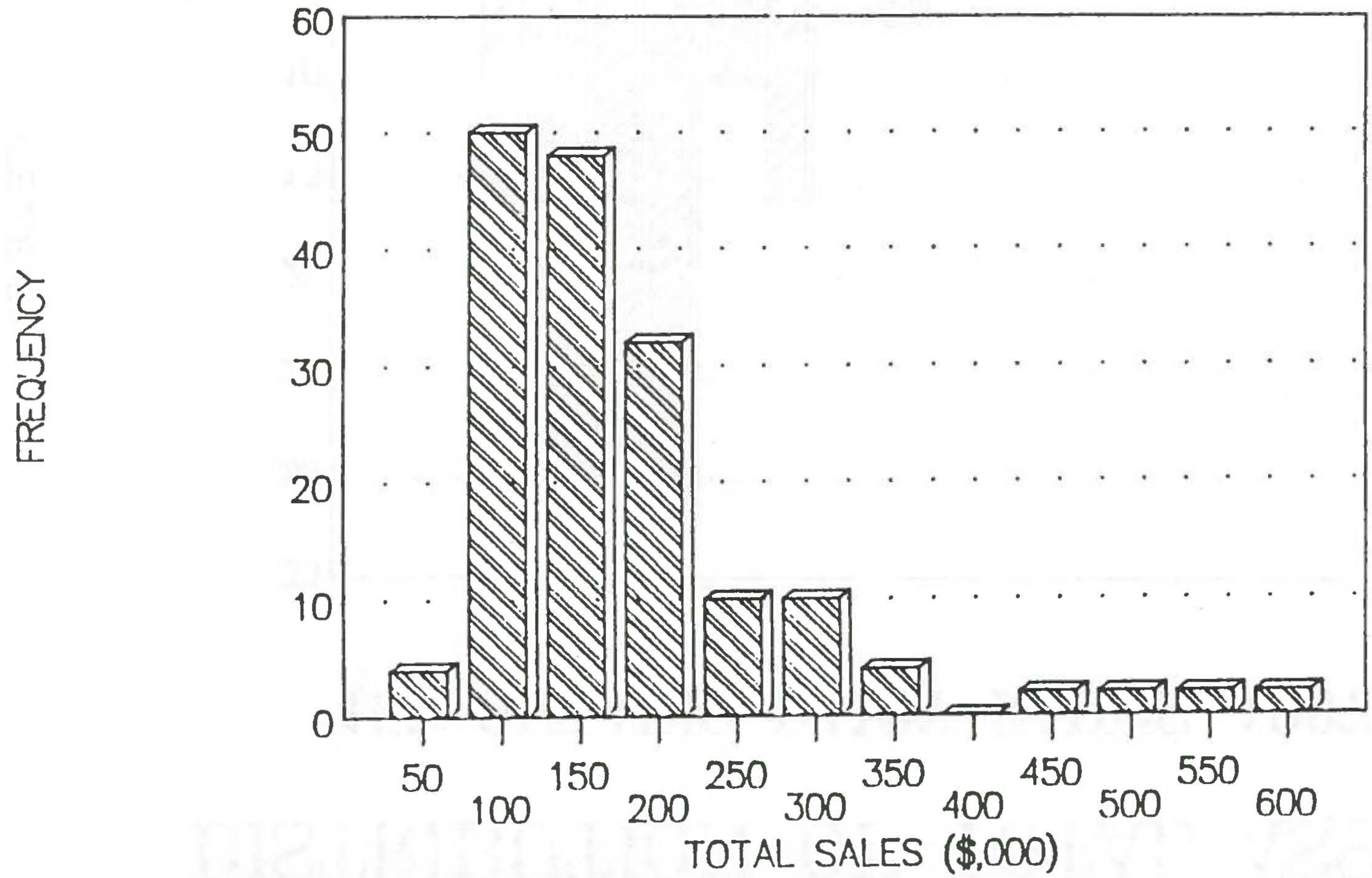


Source: Ontario Farm Management Analysis Project

FIGURE 2

DISTRIBUTION OF TOTAL SALES

157 ONTARIO DAIRY FARMS, 1987

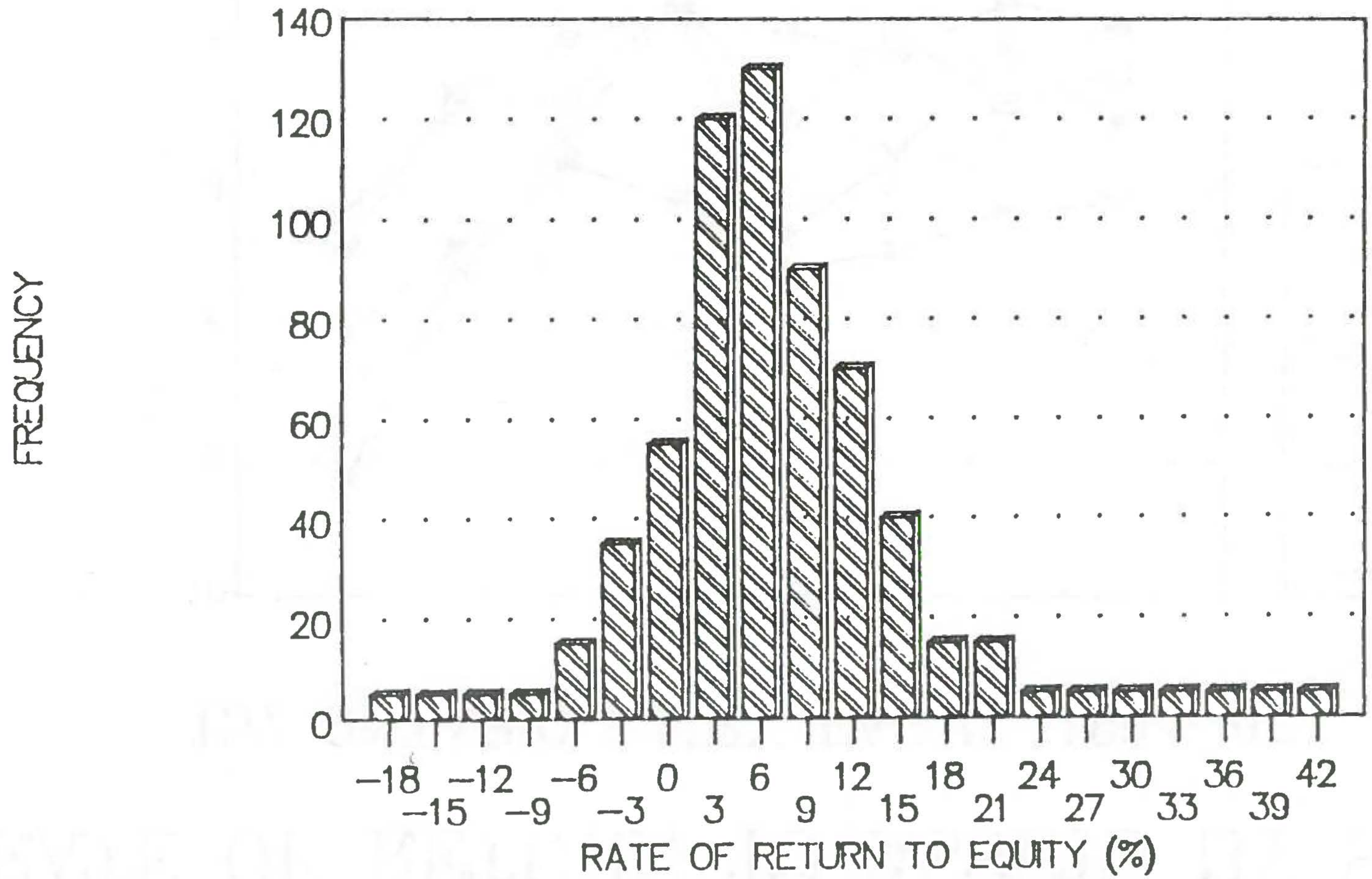


Source: Ontario Farm Management Analysis Project

FIGURE 3

RATE OF RETURN TO EQUITY

661 ONTARIO DAIRY FARMS, 1987

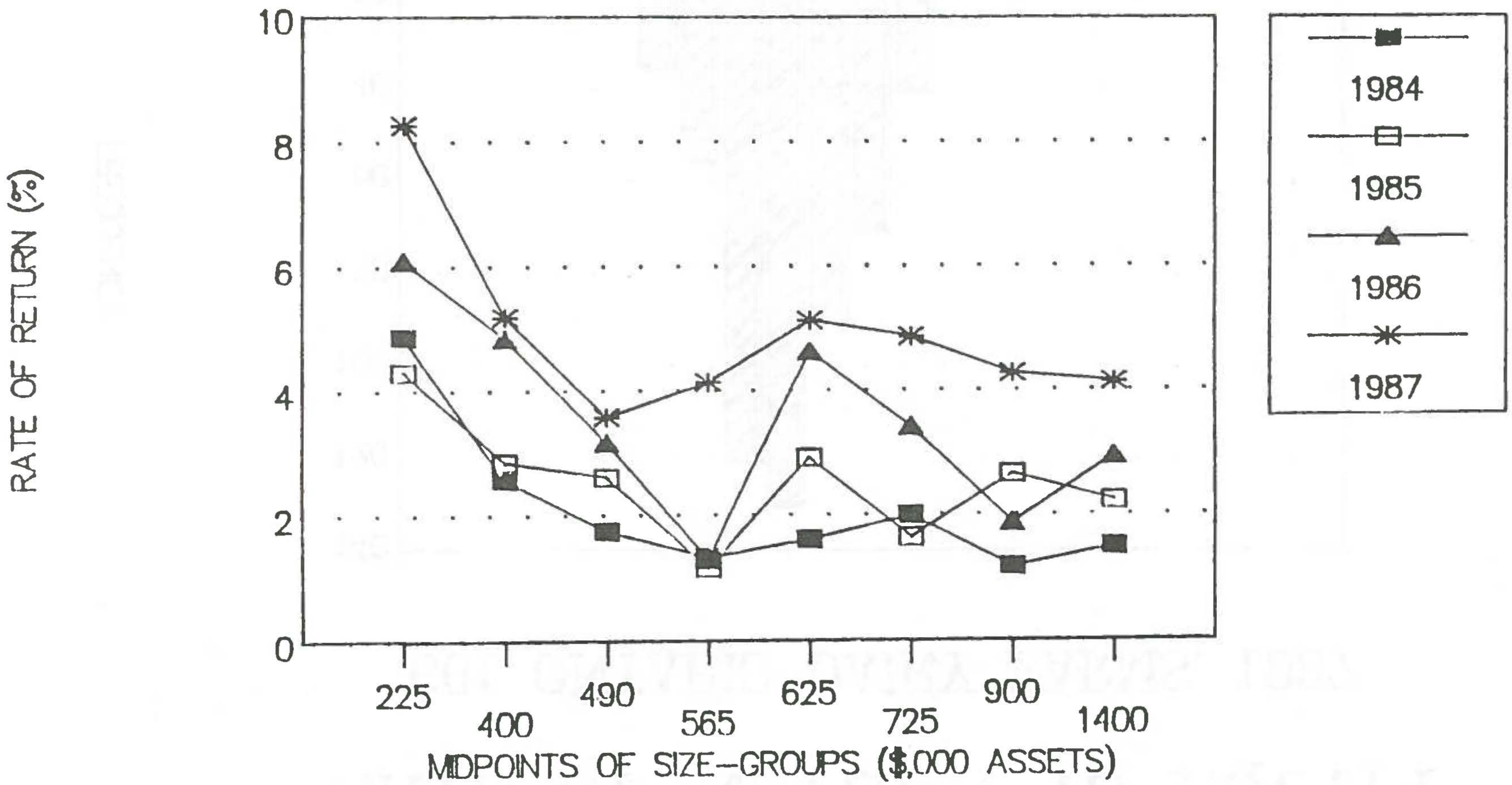


Source: Ontario Farm Management Analysis Project

FIGURE 4

RATE OF RETURN TO ASSETS BY SIZE

157 ONTARIO DAIRY FARMS, 1984–87



Source: Ontario Farm Management Analysis Project