Adjusting for Time

in

Computer Assisted Mass Appraisal

by

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I. Introduction

Appraisers have long recognized the need to adjust sales prices for time in the sales comparison approach and in sales ratio studies. Recently this subject has commanded special significance due to rapid appreciation of real estate values in some areas and substantial declines in others, along with requirements in many states that time trends be recognized in sales ratio studies. Unfortunately, except for [2], the treatment of time adjustment techniques in appraisal textbooks is largely confined to pairwise sales analysis. Such procedures are tedious, inconsistent, and impractical in mass appraisal.

This paper discusses alternative techniques for making time adjustments in a Computer Assisted Mass Appraisal (CAMA) system and demonstrates the application of one particularly flexible technique to a statewide sample of sales subject to various economic conditions. Section II of the paper evaluates alternative CAMA time adjustment techniques. Section III discusses the database and research design. Section IV presents the results and Section V summarizes the conclusions and recommendations. The paper suggests that assessors can effectively model time trends and demonstrates one simple, effective technique for doing so.

II. Time Adjustment Methods

The traditional method of adjusting sales prices for time involves paired sales analysis. The appraiser identifies similar properties that sold at different points in time and adjusts the older sale to the more recent for physical differences and location. Any remaining difference in price is then attributed to time. If the price of the more recent sale is greater than the adjusted price of the older sale, inflation is indicated. If the older sale has a greater adjusted price, deflation is indicated. The difference in price can be converted to a monthly rate of chance by (1) dividing by the older, adjusted sale price and (2) dividing by the number of months between the two sales. For example,

	$150,000	More recent sale (September, 1989)
-	145,000	Older, adjusted sale (January, 1989)
=	5,000	Difference

1. 5,000 ÷ 145,000 = .0345

2. .0345 ÷ 8 (months between sales) = .0045/month

By analyzing a large number of sales in this manner, an appraiser can extract a typical rate of change to use in adjusting sales to a common point in time, usually the appraisal date.

Paired sales analysis, however, is impractical in mass appraisal. Because it relies on manual analysis, it is prone to inconsistency and error, particularly when highly similar sales are not available in adequate numbers. An error in the adjustment for, say, an extra bedroom or a garage can greatly distort the residual adjustment attributed to time. More importantly, the technique is too tedious and time-consuming for use in mass appraisal. Three alternative to paired sales analysis are (1) analysis of resales, (2) inclusion of time variables in CAMA models, and (3) models using time and current appraised value.

1. Analysis of Resales. Property resales can be analyzed in a manner similar to paired sales. The appraiser computes the difference in price, divides by the older sale price, and then divides by the number of months between sales. If a large number of resales is available, a typical rate of change can be extracted. One must be careful, however, to ensure that the property has not been physically altered between sales. Often the seller will have improved the property, perhaps by curing deferred maintenance or adding new landscaping. In other cases, the resale may be prompted by distress circumstances. Also, the number of usable resales in the period of interest is generally quite limited. Hence, although helpful, resales require considerable analysis and alone are usually insufficient to establish market trends.

2. <u>CAMA Models</u>. Time of sale can be used as a variable in CAMA models. In linear multiple regression analysis (MRA), such models take the form:

$$SP = B_0 + B_1X_1 + B_2X_2 + \ldots + B_nX_n + B_tX_t$$

where SP is sale price; X_1, X_2, ... X_n are variables representing property characteristics; X_t is a variable for date of sale (for example, number of months prior to the most recent sale); and B_0, B_1, B_2 ... B_n and B_t are the regression coefficients. The coefficient, B_t, divided by the average sale price provides an estimate of the rate of change in property values over time. For example, if B_t is $320 and the average sale price is $80,000, property tends to appreciate at the rate of .4 percent per month ($320 divided by $80,000) or 4.8 percent per year. The standard error for B_t will indicate the confidence one can have in this figure. In stepwise MRA, the variable will not enter the model if it is not significant.

Nonlinear rates of change can be incorporated into the above model through appropriate transformations to the variable, X_t. If property values have been increasing but at a decreasing rate, for example, a square root or logarithmic transformation may be appropriate. Both inflation and deflation during the sale period can be accommodated through addition of a quadratic term:

$$SP = B_0 + B_1X_1 + B_2X_2 + \ldots + B_nX_n + B_tX_t + B_{t+1}X_t^2$$

Stepwise MRA will allow one to test various nonlinear terms in the model. Again, variables found significant can be divided by the average sale price to compute a rate of change.

Multiplicative models will yield percentage adjustments directly. In this case, the models take the form:

$$SP = B_0 * B_1X_1 * B_2X_2 * \ldots * B_nX_n * B_tX_t$$

which can be solved using loglinear MRA. As with linear MRA, nonlinear terms can be tested in the model using stepwise regression. The following model would accommodate both inflation and deflation over the sale period:

$$SP = B_0 * B_1X_1 * B_2X_2 * \ldots * B_nX_n * B_tX_t * B_{t+1}X_t^2$$

Finally, if adaptive estimation procedure (AEP) or "feedback" is being used for value estimation, one can incorporate time in the model as a general qualitative variable or variables. Unlike MRA, stepwise analyses and standard errors of the coefficients are not available. However, one can use stepwise MRA beforehand to test whether time trends are significant and, if so, what variables best reflect the trend.

3. <u>Models Using Current Appraised Value</u>. The primary problem in modeling for time is to hold constant the effect of other variables that impact sale price. In CAMA models this is accomplished by including variables for size, age, location, and other characteristics related to price. An alternative is to use current appraised value as a proxy for market value. This avoids the need to formulate full value estimation models. It works particularly well when properties have been recently reappraised and appraisals are uniform as measured by the coefficient of dispersion (COD) or other measures of appraisal uniformity.

There are two versions of this approach. In the first and simpler version, sales prices are divided by appraised values and regressed on time variables. The simplest form of this model is:

$$S/A = B_0 + B_t X_t$$

where S/A is the ratio of sale price to appraised value. Since the appraisals reflect a common point in time, in a stable market S/A ratios will show no trend. If, however, the ratios are increasing over time (Figure 1 below), inflation is indicated. Conversely, if the ratios are decreasing (Figure 2 below), deflation is indicated. The rate of change in values is computed by dividing B_t by B_0. For example, if B_t is .0058 and B_0 is .904, indicating that S/A ratios have been increasing by .0058 per month from a base of .904, the indicated rate of inflation is .0064 per month (.0058 ÷ .904).

Figure 1

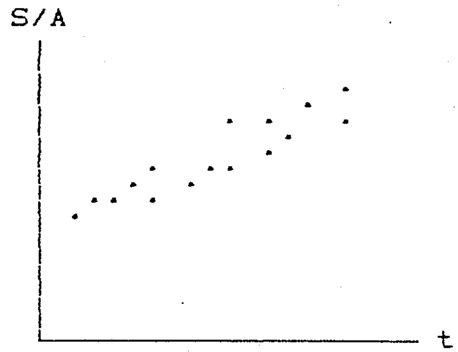
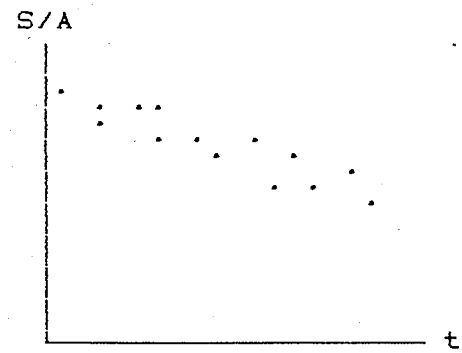


Figure 2



Plotting S/A ratios against time in this manner is highly useful in suggesting the pattern of time trends. If the pattern is nonlinear, appropriate transformations can be used.

The second approach to time analysis utilizing current appraisals to control for market value is the multiplicative model:

$$SP = B_0 * AV^{B_1} * B_2^{\,t}$$

where AV is appraised value. The model is readily solved with loglinear MRA. A value for B_2 greater than 1.00 indicates inflation; a value less than 1.00 indicates deflation. Assuming that t represents months prior to the most recent sale, a value for B_2 of 1.005, for example, would indicate inflation at the rate of .5 percent per month. Nonlinear terms can be easily incorporated in the model and stepwise MRA used to select the variable(s) providing the best fit.

This model has several advantages. First, being multiplicative, it will handle wide dispersion in sales prices and is not overly affected by occasional extreme values. Second, it yields a direct estimate of the rate of changes in values; there is no need to divide the coefficient by the constant. Third, it tends to produce acceptable goodness-of-fit statistics. If current appraisals are reasonable accurate, R^2 will usually approach or exceed .90, with the increase in R^2 associated with the time variable(s) indicating the percentage of the variation in sales prices accounted for by time alone.

Both methods of adjusting for time based on use of current appraised values share another advantage. The models are generalized and simple. In contrast to CAMA models, the appraiser need not specify a full valuation model and need not be concerned about deleting cases with minimal observations for any given variable, say an occasional swimming pool or three car garage. The paucity in the number of independent variables also reduces the number of required sales. Moreover, the models can be used for all types of property, including vacant land and commercial property, for which CAMA models may be difficult or inappropriate. When used in conjunction with stepwise MRA, a generic model can be specified and used for most any type of property or neighborhood. Finally, plots of S/A ratios on time can be incorporated into the procedure and used to illustrate time trends.

The primary shortcoming of these techniques is the requirement that current appraised values be reasonably accurate. In general, the less equitable the appraisals, as measured, for example, by the coefficient of dispersion, the larger the number of sales required to discern significant time trends. It must be emphasized, however, that the techniques make no assumption about the level of appraisal, as measured, for example, by the median sale ratio. Lower appraisal levels will be reflected in higher values of the constant, B_0, but, by themselves, will not distort indicated time trends.

III. Data Base and Study Design

The State of Colorado annually contracts for a sales ratio study covering all major classes of property in all 63 counties in the State. Sales from a recent 18 month period are preferred in the study; however, older sales, not to exceed a period of 60 months, can be used to meet sample requirements, provided that they are adjusted for time as necessary. The most recent study was conducted for the 1989 tax year, for which the valuation date was June, 1988. Hence, sales used in the study ranged from July, 1983 through June, 1988. Sales periods exceeding 18 months were used in approximately half of the counties for residential properties and vacant land and in almost all counties for commercial property.

The time adjustment method chosen was that which uses current appraised value as a proxy for market value. Both a simple linear model and a multiplicative model were run. The first, which served as a "control" model, took the form:

$$S/A = B_0 + B_1 MONTHS$$

where MONTHS represents month of sale and is coded 0 for sales from June, 1988, -1 for sales from May, 1988, -2 for sales from April, 1988, and so forth with sales from July, 1983 coded -60. Nonlinear terms were not employed. The relationship between S/A and MONTHS was graphed and fit using linear MRA.

The second model took the form:

$$SP = B_0 * AV^{B_1} * B_2^{MONTHS} * B_3^{MOSQRT} * B_4^{MOSQ} * B_5^{MOHALF}$$

where MOSQRT is the square root of months, MOSQ is months squared, and MOHALF is months raised to the 1.5 power. Like MONTHS, these variables were converted to negative values so that coefficients above 1.00 would represent inflation and vice versa. For a sale occuring in February, 1988, for example, MONTHS = -4, MOSQRT = -2, MOSQ = -16, and MOHALF = -8. The model was designed to reflect any significant nonlinear trends. Figure 3(a) shows the general form of each variable in an inflationary environment (coefficients greater than 1.00). Figure 3 (b) illustrates their form in a deflationary environment (coefficients less than 1.00).

The model was converted to loglinear format by taking natural logarithms of both sides:

$$LN(SP) = LN(B_0) + B_1*LN(AV) + LN(B_2)*MONTHS + LN(B_3)*MOSQRT$$

$$+ LN(B_4)*MOSQ + LN(B_5)*MOHALF$$

and calibrated using stepwise MRA with the significance level set at .10. This served to keep the result as simple as possible while still capturing any meaningful patterns in the data. The entry of two or more variables in the model would indicate a change in the trend line over the sale period. Note that the coefficients in the model indicate directly the rate of change in property values. For example, a value of B_1 of .008 indicates a rate of change of .008 per month, since the antilog of .008 is 1.008. Similarly, a coefficient of -.008 indicates deflation at the rate of -.008 per month, since its antilog is .992. Hence, it is not necessary to convert the model back to its original units to measure the indicated trends.

Modeling was accomplished using SPSS/PC+ V2.0 on IBM-compatible 286 and 386 personal computers. In an effort to ensure that appraised values were reasonably representative of market values, extreme sales ratios were eliminated prior to modeling. (Extreme ratios were generally defined as being less than .50 or greater than 1.50 if the sale occurred in the last 18 months, with the range extended for older sales). Also, two runs were conducted; the second excluded cases with standardized errors from the first run (as indicated by studentized deleted residuals) of less than -2.00 or greater than 2.00, which tends to exclude those 5 percent or so of cases that most adversely effect the model.

The following questions are of interest:

1. How effective were the models in detecting value trends?
2. How many sales are required? Do longer time horizons require more or fewer sales?
3. How important are nonlinear terms in the model? How often are multiple terms required?
4. In practice, how easy is the technique to apply? What are the pitfalls? How defensible are the results?

IV. Results

Colorado requires ratio studies whenever a class or subclass of property constitutes 20 percent or more of total assessed value. Such classes and subclasses include single family residential and commercial property in all counties, vacant land in 16 counties, condominiums in 18 counties, and multi family residential property in 8 counties. Because of small sample sizes in many counties, commercial sales were often combined for certain statistical purposes, including time analysis. Such combined results are reported here; of the 35 analyses reported for commercial property, 25 are for individual counties and 10 are for grouped counties.

Table 1 summarizes results obtained for the primary model,

$$SP = B_0 * AV^{B_1} * B_2^{MONTHS} * B_3^{MOSQRT} * B_4^{MOSQ} * B_5^{MOHALF}$$

In all, 140 analyses were run. Time trends were found significant at the 90 percent confidence level in 50 cases (36 percent), at the 95 percent confidence level in 37 cases (26 percent) and at the 99 percent confidence level in 23 cases (16 percent). At the 90 percent confidence level, time trends were significant in about one-half of cases for commercial, condominium, and multi family properties, but in only about one-fourth of cases for single family properties and vacant land. Of the 37 cases significant at the 95 percent confidence level, time trends were nonlinear in 29 (78 percent), although two or more variables were significant in only three cases (8 percent). Time trends were usually negative, reflecting difficult economic conditions in much of Colorado. Most of the exceptions occurred in mountain counties that have tourist and recreational influences.

Table 2 summarizes the results for the control model,

$$S/A = B_0 + B_1 MONTHS$$

At the 95 percent confidence level, the control model detected significant time trends in 39 cases, versus 50 for the primary model. The difference is solely attributable to the ability of the latter to detect nonlinear tends. Whenever the primary model detected a significant linear trend at the 95 percent confidence level or better, the control model was able to do the same. However, of the 29 cases where the primary model detected a nonlinear trend at the 95 percent confidence level or better, the control model was unable to detect a trend at the 95 percent confidence level in 7 of them (24 percent). Further, in the other 22 cases in which the control model was able to detect a trend, the primary model gave a better fit.

To evaluate the ability of the primary model to discern time trends for various time periods and sample sizes, the 140 data sets were grouped by time period (18 months or less, 19 - 36 months, and 37 - 60 months) and number of sales (less than 30, 30 - 99, and 100 or more). Table 3 shows the number and percent of cases in which time trends were found significant at the 90 percent confidence level in each group. The results suggest that the technique is quite capable of determining significant trends for small samples. In all, significant trends were noted in 16 of 35 samples (46 percent) with 29 or fewer sales, versus 22 of 83 samples (27 percent) with 30 to 99 sales and 12 of 22 samples (55 percent) with 100 or more sales.

Interestingly, the significance of the trends appears to be related more to the length of the sale period than to the number of sales per se. Significant trends were found for only 33 percent of samples from sales periods of 18 months or less (usually 18 months) versus 59 percent from sales periods of 37 to 60 months, even though the former usually had larger sample sizes. For the latter group, even when the number of sales was 29 or less, significant trends were noted in 13 of 20 cases (65 percent). Statistically, the significance of the independent variables in MRA is a function of sample size, the ability of the variables to explain the dependent variable, and the variance of the independent variables. All else equal, the larger the variance of an independent variable, the greater its statistical significance, that is, the easier it is for MRA to discern the impact of the independent variable upon the dependent variable. Hence, a longer time span tends to enhance the statistical significance of the time variables.

Figures 4 through 9 are examples of time plots and related statistics produced by the control model,

$$S/A = B_0 + B_1 MONTHS$$

for commercial property in selected counties. Figures 4 and 5 are examples of data that exhibit no time trend, the former for a relatively small sample (31 sales) over a 30 month period and the latter for a relatively large sample (111 sales) over an 18 month period. Figure 6 shows a linear time trend for a group of four small counties with a total of 63 sales over a 60 month period. The rate of value change is -.0057 per month or -.0684 per year.

Figures 7 through 9 show nonlinear trends. In Figures 7 and 8 values are declining at a decreasing rate as one moves from the older to the more recent sales. In both cases, the variable, MOSQ, was significant in the primary model (see Section III above) at the 99 percent confidence level. The time trend analysis at the bottom of the exhibits shows the loss in value from selected points in time over the sale period. In contrast, Figure 9 show an example of inflation. In this case, values are increasing at an increasing rate as one moves from the older to the more recent sales; the variable, MOSQRT, was significant in the primary model at the 99 percent confidence level. In all three cases, the technique was able to discern easily nonlinear patterns based on samples of less than 30 sales.

V. Conclusions

Adjusting for time in mass appraisal is an important issue that can be either time consuming and difficult or reasonably straightforward. This paper has evaluated various time adjustment techniques and demonstrated one simple technique that proved highly effective on 140 samples representative of various property types and economic conditions in the State of Colorado. Some specific conclusions follow.

First, the techniques presented were highly effective in detecting value trends. They have the advantages of being simple, generalized, and flexible. The appraiser need not develop a full value estimation model to isolate the effects of time. The primary limitation is that current values must be reasonably uniform and consistent as measured, for example, by the coefficient of dispersion.

Second, plots of S/A ratios on time can be very effective in depicting time trends. A simple linear regression of S/A ratios on time, however, will often not adequately capture nonlinear trends, which are common over longer time periods. To capture such trends, one should use a multiplicative model that incorporates nonlinear terms (the "primary" model presented here). Time plots will visually confirm and support the statistical results.

Third, large samples do <u>not</u> appear to be required, particularly over longer time periods (more than 18 months). Many significant trends were determined at the 95 percent confidence level or better based on 30 sales or less.

Fourth, the techniques presented here can be incorporated into a generalized template and run for various property groups with little modification. However, the data must be edited and the appraiser must understand proper interpretation and application of the results. Good appraisal judgment is essential in establishing the final set of adjustment factors.

References

1. Gloudemans, Robert J. and Thimgan, Garth. "A Statewide Ratio Study Using Microcomputers and Generic Software." Paper presented at the Conference on New Developments in Hardware and Software Options to Support CAMA sponsored by IAAO and the Lincoln Institute of Land policy, Boston, Massachusetts, Nov. 10-11, 1987.

2. Improving Real Property Assessment. Chicago: IAAO, 1978.

3. Mendenhall, William and McClave, James T. A Second Course in Business Statistics: Regression Analysis. San Francisco: Dellen Publishing Co., 1981.

4. Neter, John; Wasserman, William; and Whitmore, G.A. Applied Statistics. Boston: Allyn and Bacon, Inc., 1978.

5. SPSS/PC+ V2.0 Base Manual. Chicago: SPSS Inc., 1988.

6. SPSS/PC+ Advanced Statistics V2.0. Chicago: SPSS Inc., 1988.

7. Standard on Assessment-Ratio Studies. Chicago: IAAO, 1980.

Table 1
Primary Model Results

	Single Family	Commer'l	Vacant Land	Condo-miniums	Multi Family	Total
Cases	63	35	16	18	8	140
Significant at .90	17	16	4	9	4	50
Significant at .95	13	12	3	7	2	37
Significant at .99	8	8	1	4	2	23
Nonlinear Terms Significant at .95	9	9	2	7	2	29
Two or More Variables Significant at .95	0	1	0	2	0	3
Inflation at .95	2	2	1	0	0	5
Median Months	18	51	22	18	21	22
Median Sample Size	48	38	43	50	40	44
Median R^2	.933	.983	.935	.949	.955	.949

Table 2
Control Model Results

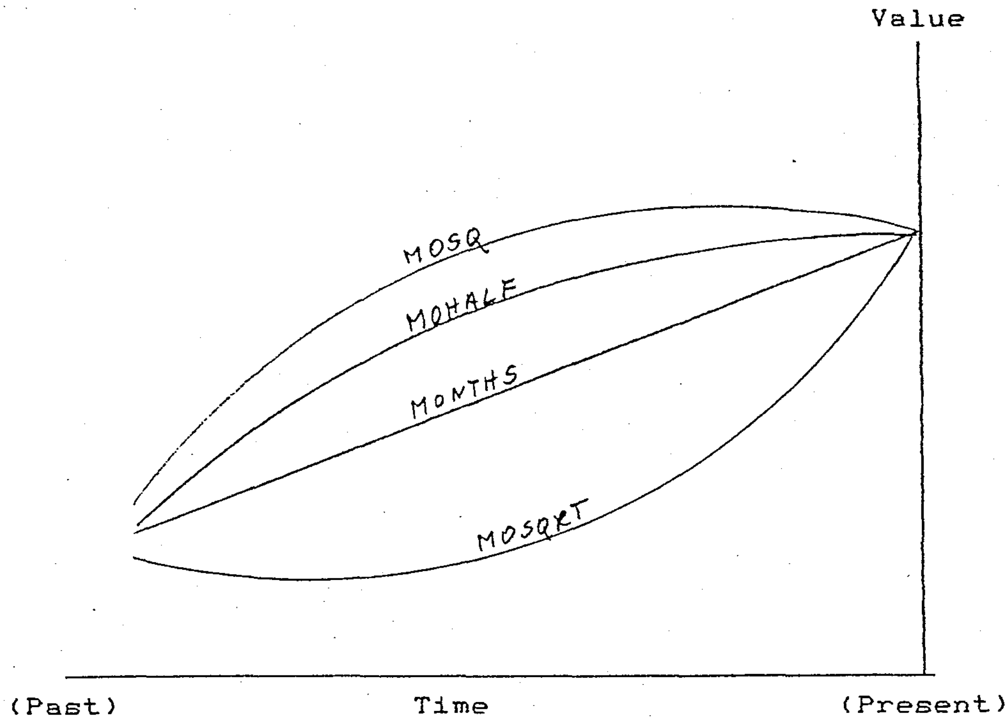
	Single Family	Commer'l	Vacant Land	Condo-miniums	Multi Family	Total
Cases	63	35	16	18	8	140
Significant at .90	15	12	4	6	2	39
Significant at .95	10	9	3	4	2	28
Significant at .99	6	7	1	4	2	20
Inflation at .95	0	2	1	0	0	3
Median Months	18	51	22	18	21	22
Median Sample Size	48	38	43	50	40	44

Table 3
Time Trends by Sale Period and Sample Size

Months	Sales	Cases	Cases Significant at 90% Conf. Level	% Significant (4) ÷ (3)
0 - 18	11 - 29	7	2	.29
	30 - 99	43	10	.23
	100 or More	17	10	.59
	Total	67	22	.33
19 - 36	11 - 29	8	1	.13
	30 - 99	22	3	.14
	100 or More	4	1	.25
	Total	34	5	.15
37 - 60	11 - 29	20	13	.65
	30 - 99	18	9	.50
	100 or More	1	1	...
	Total	39	23	.59
All Cases	11 - 29	35	16	.46
	30 - 99	83	22	.27
	100 or More	22	12	.55
	Total	140	50	.36

Figure 3
Time Trends

(a) Inflation



(b) Deflation

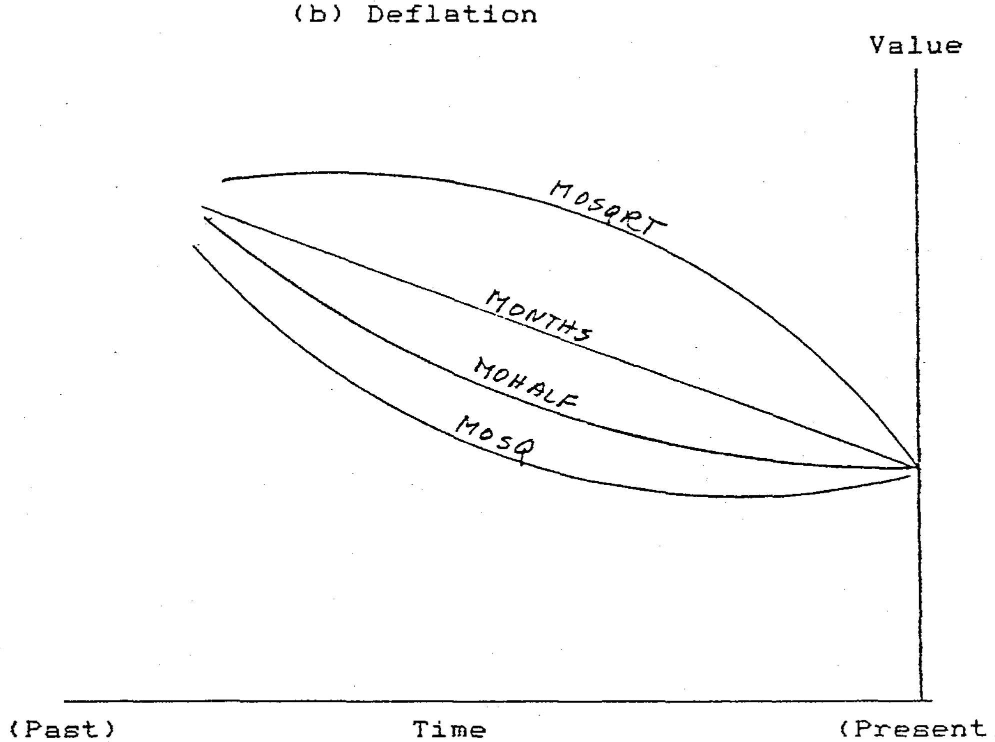
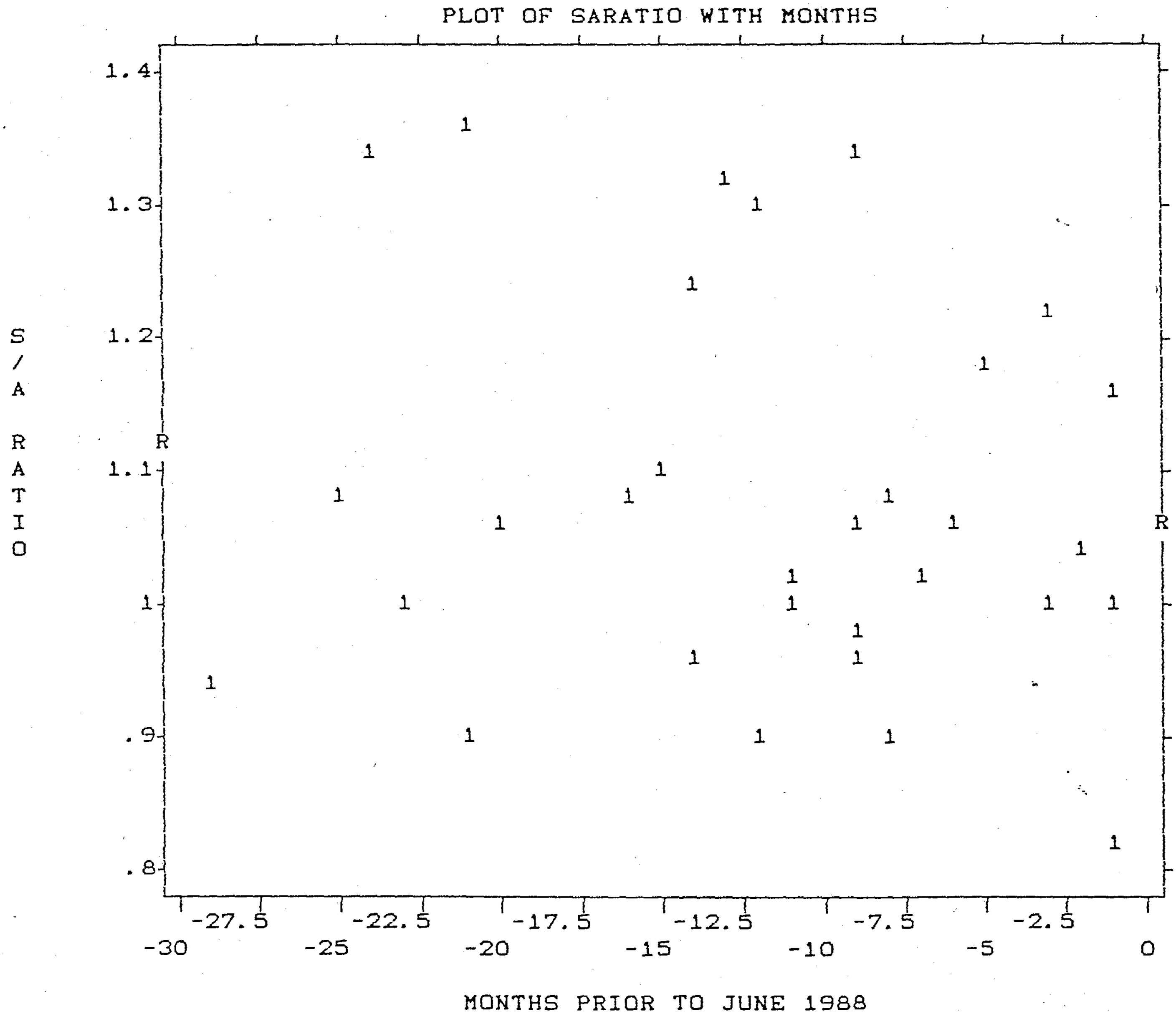
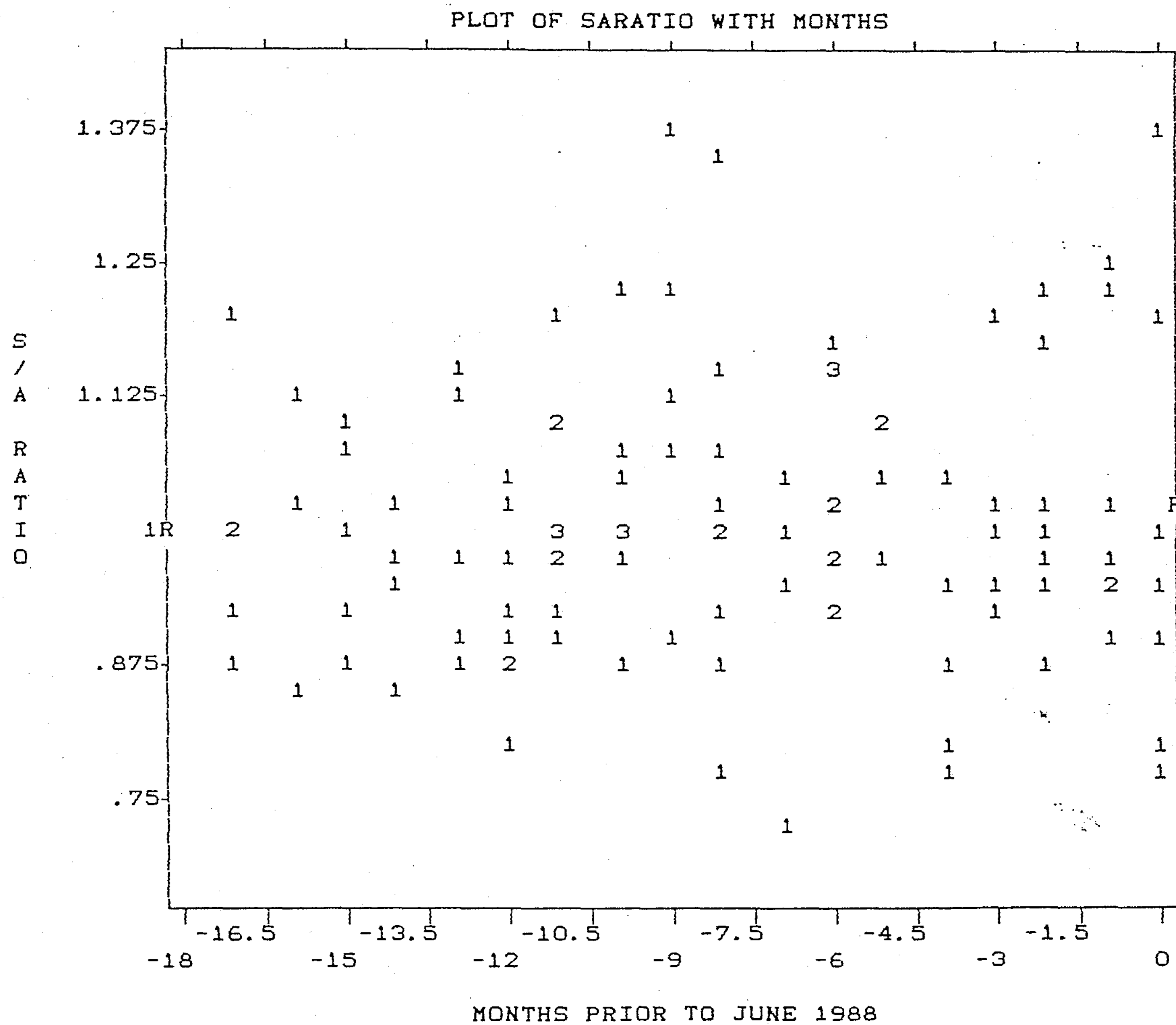


Figure 4
Example of No Time Trend: Small Sample Size



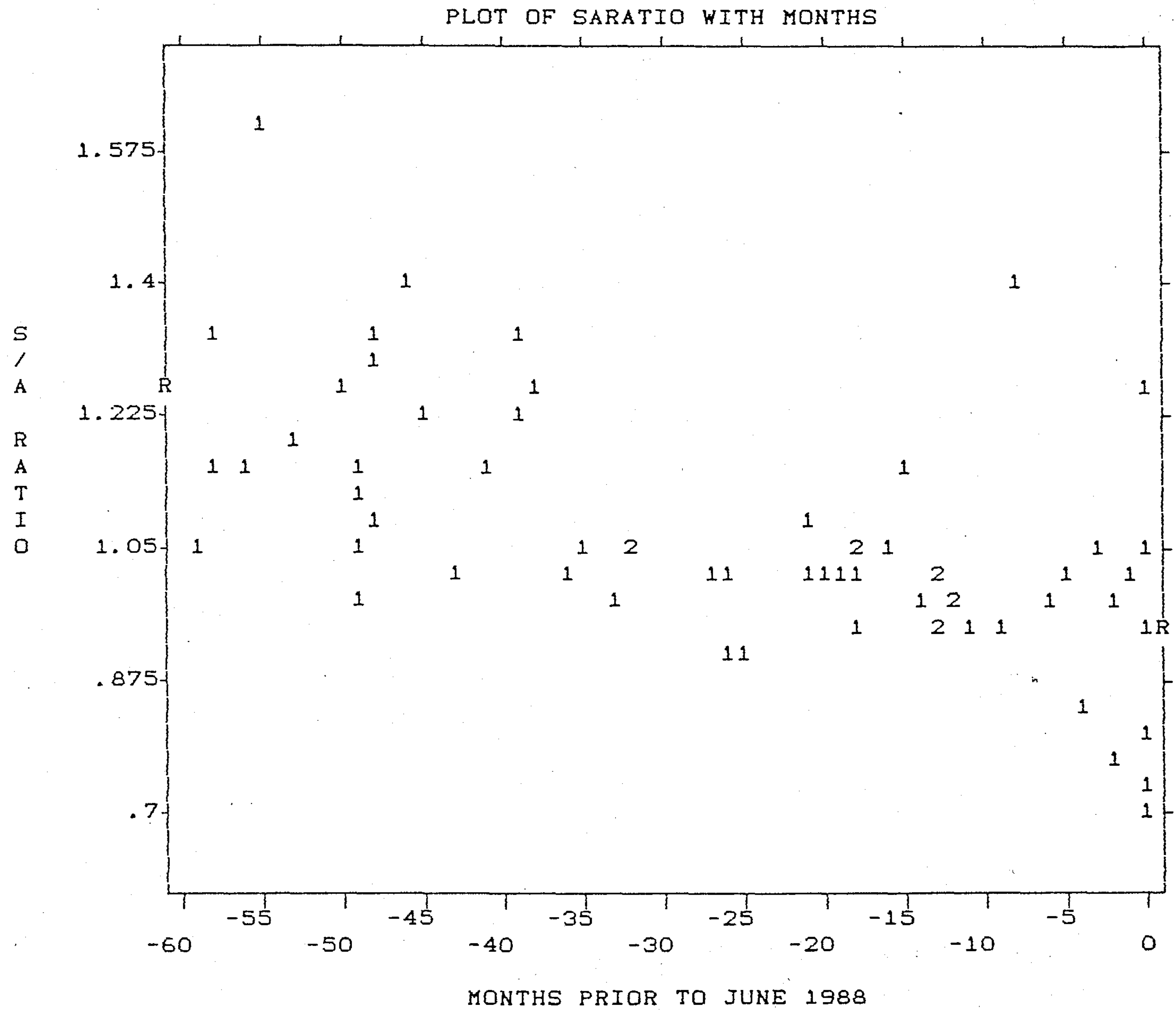
31 cases plotted. Regression statistics of SARATIO on MONTHS: Correlation -.12622 R Squared .01593 S.E. of Est .14744 Sig. .4987
Intercept(S.E.) 1.05201(.04860) Slope(S.E.) -.00239(.00349)

Figure 5
Example of No Time Trend: Large Sample Size



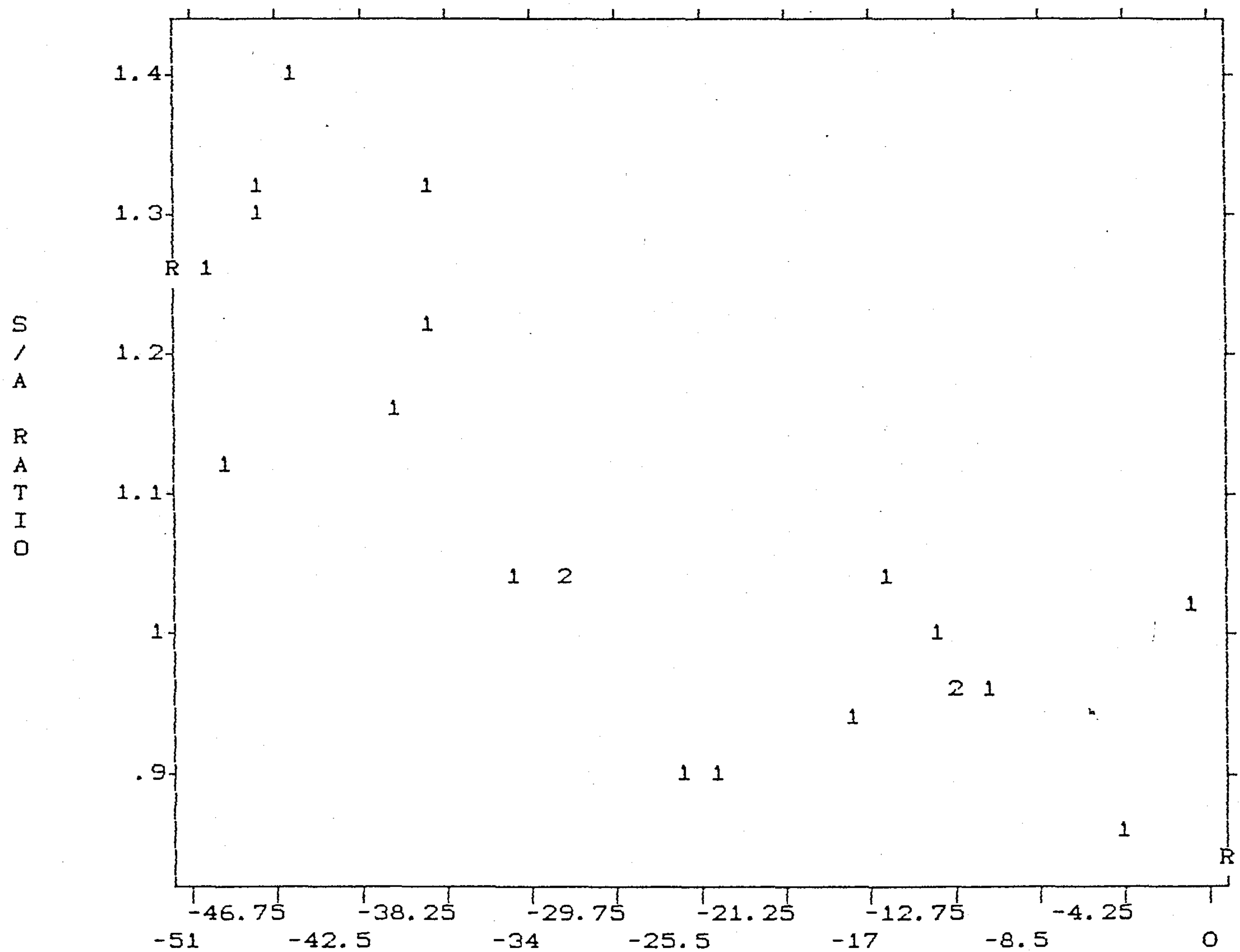
111 cases plotted. Regression statistics of SARATIO on MONTHS: Correlation .07229 R Squared .00523 S.E. of Est .12643 Sig. .4508
Intercept(S.E.) 1.02222(.02304) Slope(S.E.) .00184(.00244)

Figure 6
Example of Linear Time Trend: Deflation
Value Change = -.0057 per Month



63 cases plotted. Regression statistics of SARATIO on MONTHS: Correlation -.60170 R Squared .36204 S.E. of Est .13275 Sig. .0000
Intercept(S.E.) .92802(.02835) Slope(S.E.) -.00525(.00089)

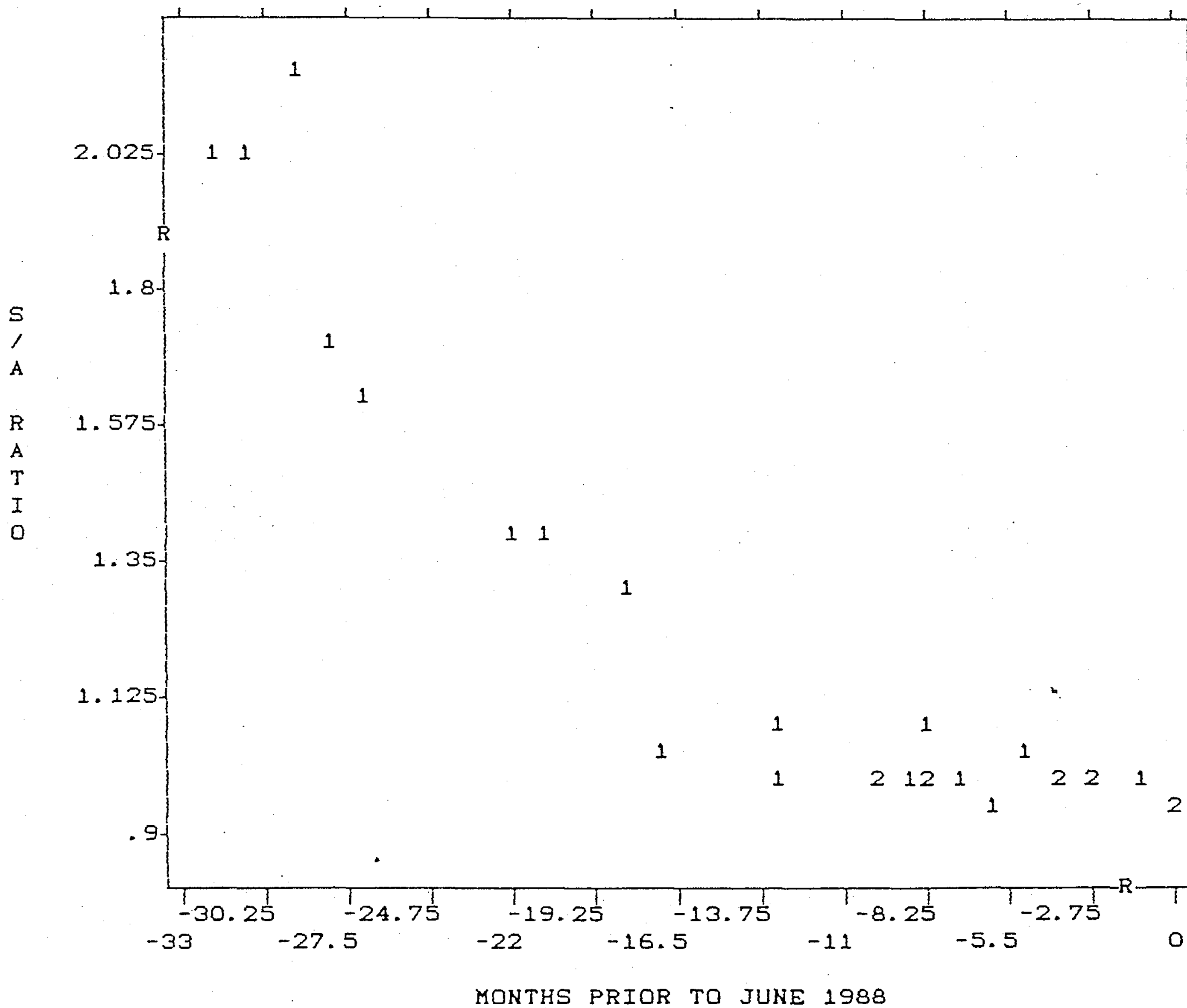
Figure 7
Example of Nonlinear Time Trend: Deflation
Time Coefficient = -.00014 per Month Squared



21 cases plotted. Regression statistics of SARATIO on MONTHS: Correlation -.80509 R Squared .64818 S.E. of Est .09823 Sig. .0000
Intercept(S.E.) .84914(.04500) Slope(S.E.) -.00819(.00138)

Months	Sale Date	Time Factor	Value Change
12	June 87	$.99986^{**12^2} = .99986^{**144} = .980$	-.020
24	June 86	$.99986^{**24^2} = .99986^{**576} = .923$	-.077
36	June 85	$.99986^{**30^2} = .99986^{**900} = .834$	-.166
48	June 84	$.99986^{**48^2} = .99986^{**2304} = .724$	-.276

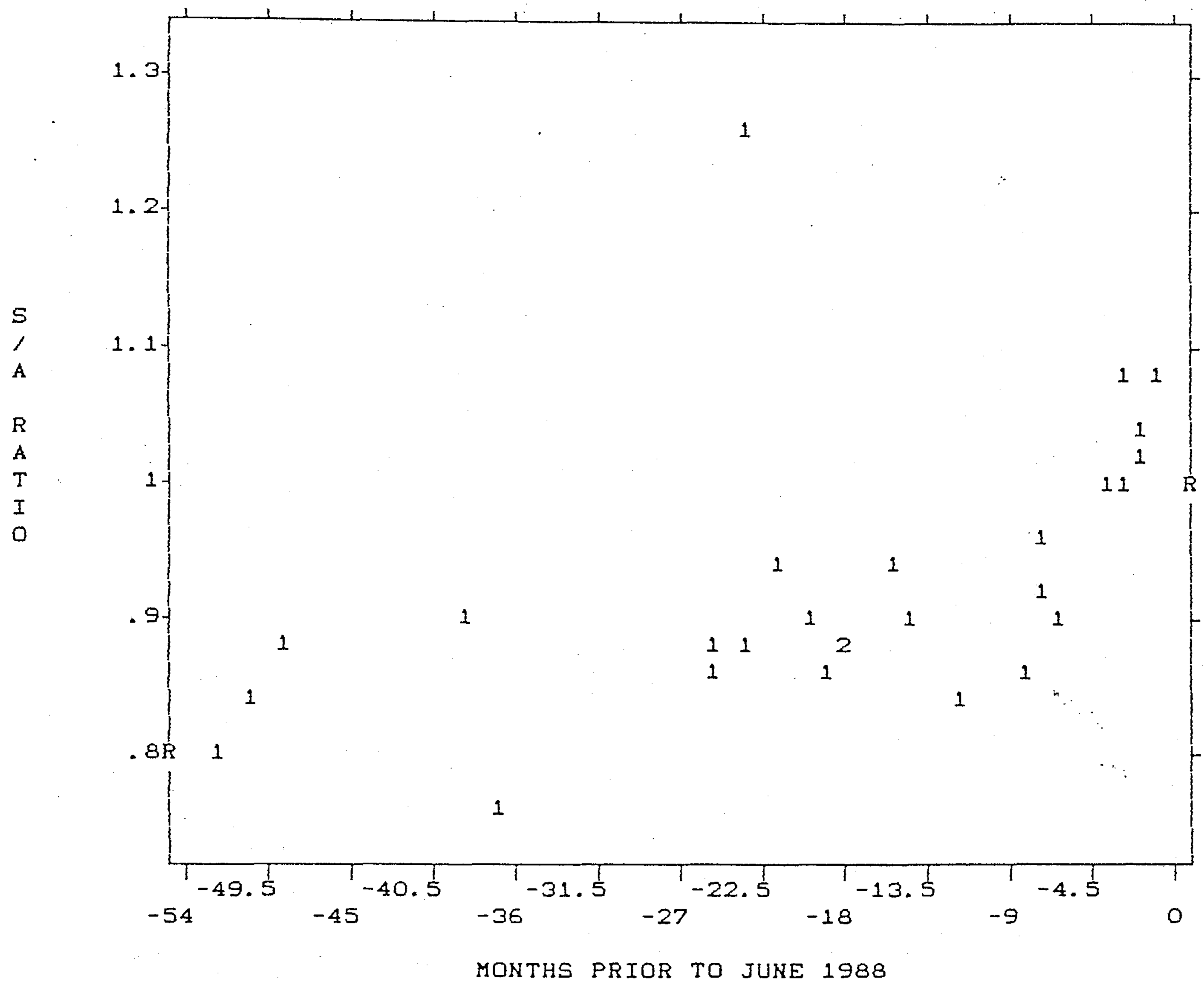
Figure 8
Example of Nonlinear Time Trend: Deflation
Time Coefficient = -.00076 per Month Squared



27 cases plotted. Regression statistics of SARATIO on MONTHS: Correlation -.91027 R Squared .82859 S.E. of Est .15613 Sig. .0000
Intercept(S.E.) .79445(.04837) Slope(S.E.) -.03339(.00304)

Months	Sale Date	Time Factor	Value Change
12	June 87	$.99924^{12^2} = .99924^{144} = .896$	-.104
24	June 86	$.99924^{24^2} = .99924^{576} = .865$	-.135
30	June 85	$.99924^{30^2} = .99924^{900} = .505$	-.495

Figure 9
Example of Nonlinear Time Trend: Inflation
Time Coefficient = .0348 per SQRT(Months)



27 cases plotted. Regression statistics of SARATIO on MONTHS: Correlation .51688 R Squared .26716 S.E. of Est .08963 Sig. .0058
Intercept(S.E.) .99455(.02751) Slope(S.E.) .00347(.00115)

Months	Sale Date	Time Factor	Value Change
12	June 87	1.0348**12$^{1/2}$ = 1.0348**3.46 = 1.126	.126
24	June 86	1.0348**24$^{1/2}$ = 1.0348**4.90 = 1.183	.183
36	June 85	1.0348**36$^{1/2}$ = 1.0348**6.00 = 1.228	.228
48	June 84	1.0348**48$^{1/2}$ = 1.0348**6.93 = 1.268	.268