AN ANALYSIS OF THE RELATIONSHIP BETWEEN THE VOLUME OF TRADING AND THE PRICE OF EQUITIES AS EXHIBITED ON THE NEW YORK STOCK EXCHANGE

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Scope and Method of Study: This report is an analysis of the purported relationship between the volume of trading and the price of equities as observed on the New York Stock Exchange. Technical analysts have generally considered that volume of trading for an individual stock, as exhibited in a generally rising or "bullish" market, is an indication of the future price movements of that stock. It is the purpose of this report to make an objective and thorough investigation of the possible relationship between volume and price in the stock market at the individual security level.

In order to accomplish this project, weekly price and volume data were collected on some fifty randomly selected stocks from Standard and Poor's 500 composite index over a five-year period (1963 through 1967). These observations were then subjected to correlation analysis under various statistical transformations and time period relationships.

Findings and Conclusions: The results, although mixed, do provide definite insights into the problem at hand. A general, widely appliable relationship does not appear to exist in a normally rising market. However, in regards to those stocks which were volatile in nature, whose price fluctuated greatly at varying levels of trading volume, a higher degree of correlation does appear to be in evidence. Thus, although volume of trading cannot be used as a general indicator or predictor of prices, it can possibly be used as a profitable means of forecasting price under tightly specified and limited conditions.

ADVISOR'S APPROVAL George E. Pinches

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PREFACE

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I would like to take this opportunity to express my appreciation for the patience, guidance, and great assistance given me by my advisor, Dr. George E. Pinches, without whose help this report would not have been possible. Also for their personal counsel, assistance, and interest, I would like to thank Professor Fred J. McDonald, Dr. James Jackson, Dr. Wayne A. Meinhart, Mr. N. S. Horner, and Mr. John Benefiel.

In addition, I would like to express my sincerest gratitude to my wife, Drenda, for her perseverance, encouragement and great sacrifice in aiding me in preparing this project.

TABLE OF CONTENTS

LISTS OF TABLES

CHAPTER I

INTRODUCTION

In recent years the general interest in the subject of investment analysis and in the behavior of the stock market as a "hedge against inflation" has expanded greatly both in depth and field. Cognizant of this fact and as a result of the author's interest in the area, an empirical statistical analysis of one of the technical methods of stock price forecasting was chosen as the subject of this report.

Numerous theories abound today regarding the behavior of the stock market in general and any individual stock in particular. Basically these may be broken down into three distinct categories:

(1) "Fundamentalism" (Intrinsic Value Analysis) relies on analysis of objective data (income statements, balance sheets, management policies, dividend records, etc.) to determine the true value of any specific company.

(2) The "Random Walk" hypothesis states that since the stock exchange is an efficient market composed of a large number of rational, profit maximizers, the market price of any security at a specific point in time is a close approximation of the true or intrinsic value of that security. The past history of stock prices and trading volumes should have no effect on the future

prices of any equities. Successive price changes are independent and random.

(3) "Technical Analysis" views the market as controlled by supply and demand which is governed by many and varied factors. This supply and demand exhibits itself in distinct trends which last for an appreciable length of time and which tend to repeat themselves. Thus, the past patterns of price and volume activity in the market can be used for predictive purposes with the proper interpretations. It is an example of this theory that is herein investigated.

Many technical analysts believe that if the volume of trading in a stock rises on the days when its price rises during the course of the normally observed zigzag movement of the market, and then falls off when price recedes temporarily, the overall pattern is "bullish". On the other hand, if volume rises when price falls, and falls when price rises, the overall pattern is said to have "bearish" connotations. The basis behind this application of volume data to analysis of individual stocks is that volume of trading varies directly with the intensity of emotion on the part of stock buyers and sellers. When eager buyers outnumber eager sellers, they bid aggressively and prices rise on heavy volume (i.e., demand is greater than supply). When concerned sellers dominate the market action, they offer stock in increasing volume at markdowns in price. Volume therefore becomes a clue to shifts in the supply and demand schedules for a stock (5).

This theory has not been subject to many definitive and formal analyses. It is the intent here, therefore, to investigate whether the volume of trading for an individual stock (as exhibited in the rising or bullish market of 1963 through 1967) is an indication of the future, present, or past price movements of that stock. Previous studies lead one to believe that the relationship is a valid one which is statistically demonstratable.

Data collected on some fifty stocks, a selected random distribution from Standard and Poor's 500 composite stock average, covering five years of trading on a weekly basis (1963 through 1967 inclusive) was utilized in this study. By employing a statistical correlation analysis of the straight and/or lagged time series, it is possible to test whether the volume-price analysis is a valid forecast technique or is simply another means of technical analysis which should be disregarded. The exact definitions and limits of variables to be utilized are set forth below.

Overall, this study should be of significance in the current controversy over the usefulness of technical analysis versus the random walk or fundamentalist's approaches. It will assist in determining whether market analysis of past data has any bearing on the future fluctuations of the market.

Hypothesis

The proposition to be tested in this paper is that given a rising or bullish market on the New York Stock Exchange as exhibited in the 1963 through 1967 time period, the weekly volume of trading in an individual stock is a general indication of the present or future price movements of that stock. Therefore, the null hypothesis to be tested is that no relationship of a predictive nature does exist between the weekly volume and the weekly price movements of a particular stock. The alternate hypothesis is, of course, that some relationship of a general and reliable nature is in evidence.

Purpose and Significance

The purpose of this report is to make an objective and thorough investigation of the purported and possible direct and indirect general relationships between volume and price in the stock market at the individual security level. Whereas much of the previous work and effort in this area was directed toward special relationships at specific times as dictated by tightly specified criteria, it is the intended purpose here to show whether any widely applicable, volume-price relationship exists over a representative time period for a random sample of general interest common stocks.

The conclusions of this research should prove the validity, or at least eliminate much of the uncertainty as to the validity, of the above relationship and further strengthen or weaken the random walk theory itself. For only by intensive and accurate testing can the random walk - technical analysis controversy (as outlined below) be resolved. This work should make a meaningful contribution in this area.

Methodology

The price and volume data from the randomly selected companies used in this study was first analyzed graphically to determine what, if any, relationships existed between the variables. Application of the insights and implications from this initial inspection of the assembled data led to a use of correlation analysis as contained in two multiple regression programs. These final analyses rendered the conclusions regarding the validity of the stated hypothesis acceptable within the confines of the limitations which follow.

Limitations

Although sufficient precautions, as specified below, were incorporated into this research design and adequate care was taken in the gathering and analysis of the following data, definite limitations exist never the less. Beyond the possibility of unaccountable human error, it is believed the following items could prejudice the results.

(1) The data base for this study incorporated observations from the years 1963 through 1967. One cannot realistically claim that any conclusions drawn from these observations would necessarily hold for other years either preceding or following those chosen for the study. Indeed, the specific years considered were ones of prosperity and generally rising prices in the market. These conditions are certainly not always in evidence. However,

due to the amount of data considered, any general relationships should still hold true especially in regard to ascending market conditions.

(2) The selected stocks were randomly chosen from the Standard and Poor's composite stock index for the New York Stock Exchange. They are necessarily composed of stronger and larger companies as are found on the Big Board. Again this does not represent average companies, yet any results should prove valid for those companies in which the largest number of investors are particularly interested.

(3) The companies were analyzed on the basis of weekly data reflecting volume and prices. It is altogether possible that many relationships of concern to this study were smoothed or not considered by the utilization of aggregate data covering five trading days for each observation. It is felt, however, again due to the volume of data and observations, that if any relationships did exist they would make themselves apparent.

(4) All conclusions drawn from this study must be interpreted with the understanding that autocorrelation between price and volume is a definite possibility throughout the varied analyses. No statistical adjustments were made to combat this occurrence.

Overall, therefore, caution must be exercised in applying the results of this study given the above limitations. These limitations should not, however, negate the value of the analysis.

CHAPTER II

BACKGROUND AND LITERATURE REVIEW

Methods of Market Analysis

In order to place this study into its proper context, this paper will now discuss in brief and general terms, the three approaches to "predicting" stock prices and viewing the stock market in general which are commonly espoused by market professionals. These are (1) the "Fundamentalist" or "Intrinsic Value" approach; (2) the "Random Walk Hypothesis"; and, (3) the "Technical Analysis" or "Chartist" approach.

Intrinsic Value Analysis

Fundamentalists rely upon economic, financial, and other objective data to determine the true value of the securities of any specific company. In essence, the analyst investigates corporate income statements, balance sheets, dividend records, management policies, sales growth, managerial ability, plant capacity, competitive forces, industry attributes, etc. He scrutinizes press reports, bank studies, statistical compilations of government data, and other outside sources. In the final analysis, all applicable data is utilized and a projection of corporate earnings is made into the future. He then applies a satisfactory earnings multiplier (price-earnings ratio or capitalization rate--discounted value of a stream of future income from the stock) to arrive at the intrinsic value of the security in question (29).

This intrinsic value is then compared to the present market price which, under the normal conditions implied by market imperfections (lack of complete information, over-reaction to information, outside events, and so on), will be somewhat different. If the market price is either too high or too low as compared to the intrinsic value, the analyst, with his superior knowledge, may then place a sell or buy order if applicable and if the relative difference is great enough (19).

This approach to stock valuation, as well as the two methods outlined below, is fraught with many areas of debate and possible inconsistencies (e.g., timeliness and availability of information, accuracy, mutual sharing of beliefs among analysts and investors, expense, problems in projecting earnings and future prices, etc.). It is the intent here, however, to simply present the methods as applicable to this study and not critique them.

Random Walk Hypothesis

Random walk theorists base their hypothesis upon the concept that the major security exchanges (e.g., New York Stock Exchange) are good examples of "efficient" or nearly efficient markets. An efficient market is one in which there are a large number of rational, profit maximizers (fundamental analysts), with all important current knowledge freely available, who are trying to predict future market values of individual securities and capitalize on these predictions.

In this market, competition among the many well-informed participants utilizing past data and expected future occurrences leads to a situation where the price of a security, at any specific point in time, reflects its intrinsic value. In such a market all changes in prices should be independent of any past history of price changes (and, in some interpretations--all past public information). In other words, if successive price changes for a given security are independent, there is no problem in timing purchases and sales of that security. A simple "buy and hold" strategy will yield the same results, monetarily, as any other more involved and complicated form of technical or intrinsic analysis for timing purchases and sales.

Now in a world of imperfections and irrationalities, the intrinsic value can never be determined exactly. Thus, room exists for disagreement among analysts regarding the real underlying value of a stock. Such dispute will give rise to discrepancies between actual prices and intrinsic values. In the supposed efficient market, this disagreement will cause the actual price of any security to wander randomly about its intrinsic value (13). If the deviations are in the form of systematic tendencies or statistical dependencies rather than random in nature, then that knowledge should help the investor to better predict the future course of any equity. However, if these tendencies (e.g., those outlined by Smidt (33): demand for liquidity, lags in response to new information, and inappropriate response to new information) are great enough that increased profits are made possible as a result of utilizing them, then the random walk theory would be, de facto, invalid.

Random walk theorists state that the instantaneous adjustment property of an efficient market implies that successive price changes in individual securities will be independent. A market in which the above occurs is by definition a random walk market. As Fama states (13, p. 56):

> Most simply the theory of random walks implies that a series of stock price changes has no memory--the past history of the series cannot be used to predict the future in any meaningful way. The future path of the price level of a security is no more predictable than the path of a series of cumulated random numbers.

This theory has been tested both statistically and empirically against various technical trading rules. Although the results are not totally positive, the random walk hypothesis has been generally upheld (reference studies by Cootner (7 & 8), Fama and Blume (12), Kendall (18), Moore (24), Mayor (21), Zakon and Pennypacker (41), Smith (34), Seelenfreund, Parker, and Van Horne (32), and others in the bibliography).

No serious inner discrepancies exist between the random walk theory and intrinsic analysis. For, if there are many well-informed analysts who are proficient at estimating the true value of a stock, and if they have considerable resources at their disposal, they help in the long run to narrow discrepancies between actual prices and intrinsic values. They aid in causing market prices, on the average, to adjust instantaneously to changes in intrinsic values. As Fama relates (13, p. 58):

> ...the existence of many sophisticated analysts helps make the market more efficient which in turn implies a market which conforms more closely to the random walk model. Although the returns to these sophisticated analysts may be quite high, they establish a market in which fundamental analysis is a fairly useless procedure both for the average analyst and the average investor. That is, in a random walk - efficient market, on the average, a security chosen by a mediocre analyst will produce a return no better than that obtained from a randomly selected security of the same general riskiness.

Technical Analysis

Technical analysis refers to the study of the effect of price, volume, and other supply and demand factors on the market itself, as opposed to external factors (e.g., price-earnings ratios, sales, debt-equity ratios, etc.) which affect or are reflected in the market. It is in essence the recording of the actual history of trading as exhibited through time of both price movements and the volume of transactions for one stock or a group of equities. From this historical data is deduced the future trend. Technical analysts have no use for the data employed by the intrinsic analyst. The appropriate and relevant consequential information is already and more reliably reflected in the various movements of price and volume in the market.

Technical theory can be summarized as follows:

(1) Market value is determined solely by the interaction of supply and demand.

(2) Supply and demand are governed by numerous factors, both rational and irrational. Included in these factors

are those that are relied upon by the fundamentalists, as well as opinions, moods, guesses and blind necessities. The market weighs all of these factors continually and automatically.

(3) Disregarding minor fluctuations in the market, stock prices tend to move in trends which persist for an appreciable length of time [something less than the long run].

(4) Changes in trend are caused by the shifts in supply and demand relationships. These shifts, no matter why they occur, can be detected sooner or later in the action of the market itself (19, p. 83).

The basic assumption of technical theorists is that history tends to repeat itself. The past patterns of stock price and market behavior will or may recur in the future and can thus be used for predictive purposes. In other words, the technician relies upon the dependence of successive price changes, in a statistical sense (11).

Robert D. Edwards and John Magee eloquently express the argument for technical analysis (11, pp. 5-6):

It is futile to assign an intrinsic value to a stock certificate. One share of United States Steel, for example, was worth $261 in the early Fall of 1929, but you could buy it for only $22 in June of 1932! By March, 1937, it was selling for $126 and just one year later for $38.... This sort of thing, this wide divergence between presumed value and actual value, is not the exception; it is the rule; it is going on all the time. The fact is that the real value of a share of U. S. Steel common is determined at any given time solely, definitely and inexorably by supply and demand, which are accurately reflected in the transactions consummated on the floor of the New York Stock Exchange.

Of course, the statistics which the fundamentalists study play a part in the supply-demand equation--that is freely admitted. But there are many other factors affecting it. The market price reflects not only the differing value opinions of many orthodox security appraisers but also all the hopes and fears and guesses and moods, rational and irrational, of hundreds of potential buyers

> and sellers, as well as their needs and their resources --in total, factors which defy analysis and for which no statistics are obtainable, but which are nevertheless all synthesized, weighed and finally expressed in the one precise figure at which a buyer and seller get together and make a deal (through their agents, their respective brokers). This is the only figure that counts.
>
> ...In brief, the going price as established by the market itself comprehends all the fundamental information which the statistical analyst can hope to learn (plus some which is perhaps secret from him, known only to a few insiders) and much else besides of equal or even greater importance.
>
> All of which, admitting its truth, would be of little significance were it not for the fact, which no one of experience doubts, that prices move in trends and trends tend to continue until something happens to change the supply-demand balance.

The methods used by technical analysts to assess the strength of supply and demand are many and varied. Among these are: "Breadth of Market", volume-price, short sales ratios, odd-lot statistics, cumulation of new highs and lows, trend lines, point and figure charting, brokerage balances, the "Dow Theory", and many others (5); each of these can be individually and differently interpreted by the technician. Indeed, in many cases, combinations of these methods are utilized together with specific levels of influence to obtain meaningful pictures of potential supply and demand factors.

The divergence between technical analysis and fundamental analysis is noted above. The dichotomy between the random walk theory and the technician's approach is total. Further assessment of the value of technical analysis requires statistically sound studies that measure and evaluate what are propounded as technical relationships. Once these tests are rigorously applied, a more adequate value ordering of the three approaches to market evaluation can be made.

Levy (19, pp. 88-89) sums up the problem at hand:

> ...there is conceptual justification for contending that, except for the most sophisticated of the professional analysts, technical stock analysis may be as satisfactory, or perhaps more satisfactory, than fundamental analysis. Moreover, there is conceptual support for recommending technical analysis as a supplement to fundamental analysis for even the top professionals.
>
> However, conceptual reasoning is not enough. There is a vast amount of empirical evidence which supports the random walk model of stock market behavior and thus denies the value of technical analysis. In order to attain recognition from serious students of the stock market, technicians must combine existing conceptual support with empirical evidence which has heretofore been lacking.

Conclusion

The present study is based on one of the technical analysis theories. If the independence assumption of the random walk theory is valid and knowledge of the past behavior of a series of price changes cannot be used to predict future prices, then this endeavor should so indicate. However, if the results show a significant and consistent correlation between historical or past data and future prices, one can then surmise a real flaw in the basic random walk theory. This will show the validity of at least one form of technical analysis. It will only be through rigorous testing of the many and varied technical theories that an accurate assessment of the two diametrically opposed concepts can be finally and firmly evaluated.

Literature Review

The present case dealing with the possible correlation between volume and price as an indication of future price movements in a given specific security has not been thoroughly analyzed or adequately and formally tested in the past. Several studies are, however, of pertinence. Indeed, they were the catalyst to the inception of this study.

Mr. M. F. M. Osborne did the initial known and published work on volume-price relationships. In his studies on the "Brownian Motion" (26, p. 360) (physicists term for random motion) of stock prices, he first noted the relationship in his conclusions:

> These relationships [volume versus price] have the quite plausible and obvious interpretation that volume represents interest or attention to stocks, and that prices tend to move under the impact of this interest.

In a later study (28), Osborne defined definite criteria in analyzing delayed coincidences of volume events (volume of any day, week, month, etc. which is larger than the two preceding simple maxima in the volume series) with certain I (inferior) and S (superior) events. A ten percent S event was a simple maximum in a sequence of high prices for which there were preceding and following trades in the market at ten percent less than the price at S and none greater than S of closer proximity. A ten percent I event was similiarly defined from a minimum in the sequence of lows. All definitions were arbitrarily chosen to rule out excessive observations.

The effects were small but tended to give evidence that volume events appeared to precede I and S events (primarily S events) and avoid following the same events:

> The slight evidence that volume events tend to precede and avoid following I and S events is an imperfect expression of the complicated and esoteric rules for volume trading signals (28, p. 338).

A second serious attempt to relate price and volume in the stock market was initiated by Granger and Morgenstern (17, p. 16). They applied spectral analysis to both weekly and monthly price and volume data from the New York Stock Exchange. They concluded there was no connection between the price and corresponding volume series

> ...at least in the short run, and for the normal day-to-day or week-to-week workings of the stock exchange the movements in the amount of stock sold are unconnected with movements in price.

In a subsequent paper by Godfrey, Granger and Morgenstern (16), they extended their previous investigation by employing spectral analysis on daily data for a number of equity issues. Although they found that the volume series tended to be a quarter cycle out of phase with the series of lows, the corresponding relationship was too low to attach any significance. The only recognizable correlation was between volume and the differences between the high and low price for the day. While they had anticipated a significant correlation between absolute values of first differences in prices and volume, the results did not substantiate their expectations.

The final and most current study in this area was one conducted by Charles Ying (40). He utilized adjusted data consisting of Standard and Poor's 500 composite stock's daily closing price indices and daily volumes of stock sales on the New York Stock Exchange from January, 1957, to December, 1962. By employing both analyses for variance and spectral analysis as applied to logarithmic values of prices and volumes and their respective first differences, Ying (40) made the following significant conclusions:

(1) A large increase in volume is usually accompanied by either a large rise in price or a large fall in price.

(2) A small volume is usually accompanied by a fall in price.

(3) A large volume is usually accompanied by a rise in price.

(4) A large volume is usually followed by a rise in price.

(5) A small volume is usually followed by a fall in price.

Thus, although the previous works are sketchy and far from large in number, they do lead one to believe that a possible relation does exist between volume and price in the stock market. The most promising study by Ying unfortunately utilized a stock average rather than individual stocks from which to draw a conclusion. However, tentative beliefs may be formulated that a relationship, as stated in the hypothesis above, does exist. It is the intent of this paper to further explore and hopefully ascertain the limits of this relationship. The methodology used to test the volume-price theory is related in the chapter which follows.

CHAPTER III

DATA COLLECTION AND METHODOLOGY

The fifty companies analyzed in this study were chosen from Standard and Poor's 500 composite stock average using a systematic random sampling selection process. Every eighth company listed alphabetically in the composite list was selected. Certain of the companies originally adopted for the study had to be eliminated due to a lack of continuous and contiguous data. Replacements were similiarly chosen. Adjustments in price and volume were made if stock splits and/or stock dividends had taken place during the considered interval. A list of these stocks is presented in Table I.

The Standard and Poor Composite Index was chosen as the data source base due to its high acceptance in the stock market, its past history of valid reflections of the market as a whole, and its unquestioned quality. The weekly data for prices and volume were taken from Barron's weekly magazine, checked by a second individual, and compared to the same data as printed in the Commercial and Financial Chronicle. Adjustments for stock dividends and stock splits were made and based on data from the Standard and Poor's Security Owners Stock Guide and Moody's Handbook of Common Stocks.

TABLE I

FIRMS INCLUDED IN THE STUDY

1. Allied Chemical Corp.
2. American Airlines, Inc.
3. American Export Industries, Inc.
4. American Ship Building Co.
5. Archer Daniels-Midland Co.
6. Atlantic Richfield Co. (Atlantic Refining Co.)
7. Bath Industries, Inc. (Bath Iron, Inc.)
8. Blaw-Knox Co.
9. C.F. & I. Steel Co. (Colorado Fuel & Iron Corp.)
10. Caterpillar Tractor Co.
11. Chemetron Corp.
12. Coco-Cola Bottling Co. of N.Y., Inc.
13. Container Corp. of America (now Morcar Corp.)
14. Corn Products Co.
15. Crucible Steel Co. of America
16. Divco-Wayne Corp. (Divco Corp.)
17. Eastern Air Lines, Inc.
18. Federal Paper Board Co., Inc.
19. General Finance Corp.
20. General Foods Corp.
21. Goodrich (B.F.) Co.
22. Gulf Oil Corp.
23. Hercules, Inc. (Hercules Powder, Inc.)
24. Hudson Bay Mining & Smelting Co., Ltd.
25. Inland Steel Co.

TABLE I (continued)

26. Island Creek Coal Co.
27. Joy Manufacturing Co.
28. Kimberly-Clark Corp.
29. Lehigh Portland Cement Co.
30. Magnavox Co.
31. Maytag Co.
32. Mercantile Stores Co., Inc.
33. Mohasco Industries, Inc.
34. National Acme Co.
35. National Lead Co.
36. Penn-Dixie Cement Corp.
37. Raytheon Co.
38. Reynolds (R.J.) Tobacco Co.
39. Safeway Stores, Inc.
40. Scott Paper Co.
41. Shell Oil Co.
42. Standard Brands Inc.
43. Sunbeam Corp.
44. Texaco, Inc.
45. Trans World Airways, Inc.
46. Union Carbide Corp.
47. United Shoe Machinery Corp.
48. Ward Foods, Inc.
49. White Motor Corp.
50. Zenith Radio Corp.

Upon completion of the data collection and tabulation phase, a preliminary study was initiated to determine which relationship or relationships between volume and price, and which statistical method of analysis was most appropriate for the assembled information.

To best determine whether any significant relationship did exist between volume and price, the data was programmed through the IBM 360 computer using the sub-plot routine for the printout. This versatile subprogram allowed families of curves of the form $Y = f(x)$ to be plotted using as many as ten different characters. It was believed the graphical analysis of the various relationships between volume and price would best exhibit the most advantageous one upon which to accomplish the final correlation analyses.

The following relationships were plotted, using representative companies of the total sample (e.g., Trans World Airlines, General Foods, American Export, Raytheon, Champion Spark Plugs, and others):

(1) Volume at time (t) versus price at time (t), with no lead or lag relationships.

(2) Volume at time (t-1) versus price at time (t).

(3) Volume at time (t) versus time; and price at time (t) versus time (to determine if any periodicity existed in the relationships of volume and price).

(4) The first difference of volume at time (t) versus the first difference of price at time (t); and the second difference of volume at time (t) versus the second difference of price at time (t) - (to determine if any relationship existed between the changes in price and volume over time).

(5) The first difference of volume at time (t-1) versus the first difference of price at time (t).

(6) The second difference of volume at time (t-1) versus the second difference of price at time (t).

Examples of a selection of these printouts to show the methodology are contained in Appendix A accompanied by their respective fortran programs.

Although the graphical analysis provided a straight forward presentation, it was very time consuming and could not specifically be used to determine the degree of relationship or lack thereof between the variables. A discussion of this graphical analysis is presented in the following chapter. Therefore, a multiple regression program developed by Lawrence Salzman (31) was incorporated into this research design.

This program (reference Appendix B) provided the ability to test many transformations on the volume-price data with the independent variable (volume) in a straight, lead, or lag relation with the dependent variable (price). For this portion of the analysis, the five years of data for Trans World Airlines, as a representative stock, was used and divided into half (each half with two and one-half years of observations). The first group consisting of the time period January, 1963, through June, 1965, was relatively calm for this particular stock and demonstrated the volume-price relationship for a typical non-fluctuating stock. The last half of observations covering the period from July, 1965, to December, 1967, involved a large number of erratic, volatile movements, highs and lows of both price and volume, which were representative of a cyclical or non-stable equity.

Type I data as specified by this particular program was used with a single independent and dependent variable, which allowed one to efficiently determine what the "best" transformation was, before injecting all of the data into the final correlation analysis.

The five transformations employed over a negative two week lag for volume, a negative one week lag for volume, no lead or lag for volume, a positive one week lead for volume, and a positive two week lead for volume, were:

(1) Linear: This approach evaluated the data in the identical way in which it was entered into the computer. It gave a "picture" of the relationship between variables in the simplest conceptual manner.

(2) Square: Each observation was multiplied by itself thereby amplifying the amplitudes of the movements in the series.

(3) Square Root: The opposite of (2), this dampened the magnitude of movements.

(4) Logarithmic: The natural log to the base *e* afforded an exponential relationship.

(5) First Difference: Each observation minus the previous observation developed a new series which showed the rate of change of the original series.

After each of these transformations was accomplished by the program, it yielded the simple correlation coefficients, the regression equation and coefficients, the standard error, and a t-test.

The dependent variable (price) and the independent variable (volume) were given the following respective transformations and analyzed by the program as explained above:

(1) Linear vs. Linear.

(2) Square vs. Square.

(3) First Difference vs. First Difference.

(4) Logarithmic vs. Logarithmic.

(5) Square Root vs. Square Root.

(6) First Difference vs. Logarithmic (as suggested by Ying (40) in his earlier study).

(7) Linear vs. Logarithmic (as suggested in a formula used by a commercial stock advisory service).

The final portion of this paper utilized a multiple linear regression program developed by the OSU Computer Center (ref. Appendix C) from a similar program included by I. B. M. in their "Scientific Subroutines Package". This program yielded the correlation coefficients, a t-test for significance, and the standard deviation as applicable to this study. As a consequence of the analysis of the previous results, it was determined that only linear and logarithmic transformations with no lead or lag relationships would be undertaken. Also from the results garnered above, the fifty sample companies were divided into the following categories of price behavior to facilitate the final analyses:

(1) Stable: week to week fluctuations in price less than or equal to ten percent; no general rising or falling trend.

(2) Stable-Fluctuating: week to week fluctuations in price greater than ten percent; no general rising or falling trend.

(3) Rising: general rising trend with fluctuations in price less than or equal to ten percent.

(4) Volatile: definite rising and falling trends accompanied by fluctuations greater than ten percent.

(5) Falling: general decline in price over the five-year period.

From the above stated categories, the results were analyzed and the ultimate conclusions as to the validity of the stated hypothesis were formulated.

CHAPTER IV

ANALYSIS OF RESULTS

The results from the study accomplished here are not as concrete or open to definite conclusions as was originally desired. However, an attempt will be made to objectively relate these findings and their implications as they appear to the author.

The graphical analyses utilizing the subplot routine for the IBM 360 computer were far from specific enough to draw definite conclusions (reference Appendix A which includes examples of these graphical printouts accompanied by their respective programs). Yet, they afforded the opportunity to ascertain visually if any significant relationship did exist between the variables, price and volume, through several transformations over time.

Upon examination it was evident that possible correlation existed between the linear relationships of (1) volume at time (t) and price at time (t) and, (2) volume at time (t-1) and price at time (t). The relationship was most evident when one scrutinized that portion of the graph which included the higher volumes. As volume increased, price tended to increase. No significant difference was apparent between the straight relationship of volume and price and the lagged volume--price relationship.

The graphical tests used to determine if any periodic fluctuations in price or volume occurred substantiated the belief that the time period, per sé, had no noticeable effect on volume of trading or price of equities.

The graphs accomplished on the first and second differences at time (t) for price and volume showed no correlation. Likewise, the results drawn from the first and second differences with the volume figure plotted at time (t-1) and price at time (t) disclosed no relationships.

As was noted above, this form of analysis was not concrete enough or statistically verifiable; yet it did yield direction for further study. Therefore, the regression program developed by Lawrence Salzman (31) (Appendix B) was utilized. The transformations and lead-lag relationships as specified in the previous chapter were employed. Tables II and III show the results of this analysis of Trans World Airlines Data. The simple correlation coefficient (annotated if the t-test showed significance) is recorded for all observations.

The linear, square, square root, and logarithmic transformations for both variables, and the linear transformation for price versus the logarithmic transformation for volume, showed approximately equal degrees of correlation. The first difference for both variables and the first difference of price versus the logarithmic value for volume transformations showed the least significance as a group. No significant differences were readily apparent which would indicate that any particular one of the five above noted transformations would better explain the relationship

TABLE II

CORRELATION COEFFICIENTS FOR T.W.A. DATA OF JANUARY, 1963, THROUGH JUNE, 1965, OVER SEVEN TRANSFORMATIONS AND FIVE TIME RELATIONSHIPS

Time Period	Linear	Square	Square Root	Logarithmic	1st Difference	1st Diff-Price Log-Volume	Linear-Price Log-Volume
Vol. (t+2) Price (t)	.05246	-.08662	.10325	.15863 x	-.04800	.07628	.09138
Vol. (t+1) Price (t)	.04869	.08870	.13858	.18337 x	-.05393	.01583	.12061
Vol. (t) Price (t)	.11503	.07972	.18925 xx	.22474 xxx	.28318 xxxx	.15438 x	.16080 x
Vol. (t-1) Price (t)	.08408	.08645	.16025 x	.19344 xx	-.07520	-.15998 x	.12684
Vol. (t-2) Price (t)	.07628	.08826	.15454 x	.18585 xx	-.08845	-.00560	.11472

T-Table Significance Test: x - .05, xx - .02, xxx - .01, xxxx - .001

TABLE III

CORRELATION COEFFICIENTS FOR T.W.A. DATA OF JULY, 1965, THROUGH DECEMBER, 1967, OVER SEVEN TRANSFORMATIONS AND FIVE TIME RELATIONSHIPS

Time Period	Linear	Square	Square Root	Logarithmic	1st Difference	1st Diff-Price Log-Volume	Linear-Price Log-Volume
Vol. (t+2) Price (t)	xxxx .51588	xxxx .45847	xxxx .53765	xxxx .54234	.08771	-.02367	xxxx .54032
Vol. (t+1) Price (t)	xxxx .49712	xxxx .44738	xxxx .51951	xxxx .52826	.08015	-.05478	xxxx .52796
Vol. (t) Price (t)	xxxx .46722	xxxx .40875	xxxx .49666	xxxx .51407	.08236	-.03921	xxxx .51344
Vol. (t-1) Price (t)	xxxx .43806	xxxx .38578	xxxx .46411	xxxx .47861	-.08237	x -.17628	xxxx .47689
Vol. (t-2) Price (t)	xxxx .41289	xxxx .36217	xxxx .43657	xxxx .44857	-.08528	-.14653	xxxx .44614

T-Table Significance Test: x - .05, xx - .02, xxx - .01, xxxx - .001

between volume and price as compared with the others.

The same general approach should be taken in regards to viewing the lead-lag relationships. Although, the general tendency was toward a higher degree of correlation on the July, 1965, through December, 1967, data when volume lagged price by two and one units of time. The observations for January, 1963, through June, 1965, portrayed a greater correlation when no lead or lag relationships were introduced.

The regression coefficients and equations were not reliable enough to be of predictive significance as can be deduced from the correlation coefficients noted in Tables II and III.

The important finding from this part of the study is the great difference exhibited between the two periods in which the TWA data was analyzed. The correlation coefficients for the five transformations on the 1965-1967 data ranged from approximately .36 to .55. While the same coefficients for the 1963-1965 data ranged from .04 to .28. In addition all correlations in the 1965-1967 time period were significant at the .001 level.

It should be remembered that this data was separated into the two periods by the degree of volatility observed. The first half of the data was generally stable with a slowly rising price level, while the latter half exhibited very erratic and volatile movements.

Thus, it appeared the most significant correlation between price and volume existed when the individual equity was in a state of volatile price movements on increasing levels of trading volume.

The final part of this paper utilized all fifty of the randomly selected stocks chosen for this study. The stocks were analyzed by a simple correlation analysis, with no lead or lag relationship between variables, and again a t-test for significance. The differences produced above in the correlation coefficients of the TWA data by the varied transformations and multiple time period relationships were not great enough to suggest the efficacy of one over the other. However, the logarithmic transformation did produce overall better results. The correlation coefficients for both periods were the highest recorded for any transformation and were all significant at least at the .05 level. However, its reliability in application over the linear approach, for example, would be debatable. The coefficients of determination for volume in the logarithmic transformation (correlation coefficients squared) explained a maximum of 30 percent of the recorded changes in price. The same coefficient in the linear transformation explained 27 percent of the change in price. These differences were not great enough to indicate a justification for relying on one approach as opposed to the other.

Therefore, two of these straight forward analyses (the linear and logarithmic) were chosen as representative transformations of the several it would be possible to use. The data was separated into categories as noted in the previous chapter to facilitate the handling of the final conclusions. The results from this last portion of the study are summarized in Tables IV, V, VI, VII, and VIII which follow.

As can be readily deduced from these tables, the results are thoroughly mixed. Very generally speaking, the stocks listed as volatile (Table VII) had the highest correlation coefficients with two stocks exceeding .70. However, this table also included one of the lowest coefficients, .065, as exhibited by the logarithmic transformation of Mercantile Stores. The other categories, reflecting various degrees of stability and volatility, displayed an almost equal range of degrees of correlation between the variables, price and volume. Overall, the classification of these equities into categories reflecting volatility appears to be ill adapted to the study at hand. The relationship between price and volume is not primarily determined by stock price instability.

The t-test for significance suggested that the price-volume relationship was more consistent in volatile stocks, with only one stock out of eighteen not significant at the .001 level in the logarithmic transformations. The other categories displayed lesser significance values and consistencies in all cases.

The logarithmic transformation produced the highest degree of correlation in thirty-three out of the fifty cases. However, the differences in coefficients of correlation and determination were not great enough to concretely state it would be the best transformation in all cases.

In regards now to the stated hypothesis of this study, in certain limited cases a high degree of correlation does exist between price and volume, as can be deduced from certain of the

TABLE IV

CORRELATION COEFFICIENTS (R) AND COEFFICIENTS OF DETERMINATION (R^2)

FOR LINEAR AND LOGARITHMIC TRANSFORMATIONS OF EQUITIES

EXHIBITING A STABLE BEHAVIOR

(week to week fluctuation in price ≤ 10%;

no general rising or falling trend)

	Linear		Logarithmic	
	R	R^2	R	R^2
Allied Chemical Corp.	.51565	.275	.49982	.249
Coca Cola Bottling Co.	.41352 xxxx	.170	.39864 xxxx	.168
General Finance	.08216	.006	.16476 xxx	.025
Standard Brands	.23532 xxxx	.055	.26662 xxxx	.071
Union Carbide	.35420 xxxx	.125	.34779 xxxx	.120
United Shoe Machinery	.01913	.001	.09404	.008

T-Table Significance Test: x - .05, xx - .02, xxx - .01, xxxx - .001

TABLE V

CORRELATION COEFFICIENTS (R) AND COEFFICIENTS OF DETERMINATION (R^2) FOR LINEAR AND LOGARITHMIC TRANSFORMATIONS OF EQUITIES EXHIBITING A STABLE-FLUCTUATING BEHAVIOR

(week to week fluctuation in price $>$ 10%; no general rising or falling trend)

	Linear		Logarithmic	
	R	R^2	R	R^2
Bath Industries Inc.	.09337	.008	.07321	.005
Blaw-Knox Co.	xxxx .63335	.400	xxxx .56900	.320
Container Corp. of America	.03117	.001	.07364	.005
Corn Products Co.	xxxx .47684	.225	xxxx .51213	.263
Hercules, Inc.	.09182	.008	.07411	.005
Kimberly-Clark Corp.	xxx .20019	.040	xxxx .23271	.054
Maytag Co.	.01759	.003	.08042	.006
Reynolds (R. J.) Tobacco Co.	.11484	.013	.11998	.014
Scott Paper Co.	xxxx .44088	.195	xxxx .56574	.320

TABLE V (continued)

	Linear		Logarithmic	
	R	R^2	R	R^2
Texaco, Inc.	.06754	.004	.07806	.006

T-Table Significance Test: x - .05, xx - .02, xxx - .01, xxxx - .001

TABLE VI

CORRELATION COEFFICIENTS (R) AND COEFFICIENTS OF DETERMINATION (R^2)
FOR LINEAR AND LOGARITHMIC TRANSFORMATIONS OF EQUITIES
EXHIBITING A RISING BEHAVIOR

(general rising trend with fluctuations in price ≤ 10%)

	Linear		Logarithmic	
	R	R^2	R	R^2
American Export	xxx .14898	.022	.11139	.012
Archer-Daniels-Midland	xxxx .30164	.090	xxxx .30728	.090
Atlantic Richfield	x .13005	.017	xxxx .25354	.064
Caterpillar Tractor Co.	.04947	.002	.06796	.004
Crucible Steel Co. of America	xxxx .39830	.159	xxxx .44441	.196
Divco Wayne Corp.	.11827	.014	.09027	.008
Goodrich Co.	.00142	----	.04271	.001
Gulf Oil	xxx .18248	.033	xxxx .22433	.050
National Acme Co.	.01538	.002	.02507	.005
Shell Oil Co.	xxxx .31365	.098	xxxx .37874	.144

TABLE VI (continued)

	Linear		Logarithmic	
	R	R^2	R	R^2
Sunbeam Corp.	xxxx .23728	.056	xxxx .27549	.076
White Motor Corp.	.01562	.001	.04173	.002

T-Table Significance Test: x - .05, xx - .02, xxx - .01, xxxx - .001

TABLE VII

CORRELATION COEFFICIENTS (R) AND COEFFICIENTS OF DETERMINATION (R^2)
FOR LINEAR AND LOGARITHMIC TRANSFORMATIONS OF EQUITIES
EXHIBITING A VOLATILE BEHAVIOR

(definite rising and falling trends
accompanied by fluctuations > 10%)

	Linear		Logarithmic	
	R	R^2	R	R^2
American Airlines	xxxx .32865	.107	xxxx .33138	.110
American Ship Bldg.	xxxx .50308	.251	xxxx .71068	.505
C. F. & I. Steel Co.	xxxx .39807	.159	xxxx .52557	.275
Chemetron Corp.	xxxx .52245	.272	xxxx .61694	.379
Eastern Air Lines, Inc.	xxxx .51754	.266	xxxx .64484	.415
Hudson Bay Mining	xxxx .25006	.062	xxxx .25497	.064
Inland Steel Co.	xxxx .47535	.225	xxxx .56676	.320
Island Creek Coal	xxxx .58759	.340	xxxx .55839	.311
Joy Mfg. Co.	.10693	.011	xxxx .24028	.058

TABLE VII (continued)

	Linear		Logarithmic	
	R	R^2	R	R^2
Magnavox Co.	xxxx .46279	.213	xxxx .62980	.392
Mercantile Stores	.06925	.005	.06596	.005
Mohasco Industries	xxxx .24240	.058	xxxx .30841	.094
Penn-Dixie Cement	xxxx .50011	.250	xxxx .38826	.151
Raytheon Co.	xxxx .21512	.045	xxxx .54580	.296
Safeway Stores, Inc.	xxxx .43292	.186	xxxx .49228	.242
Trans World Airways, Inc.	xxxx .60449	.365	xxxx .60295	.365
Ward Foods, Inc.	xxxx .63139	.399	xxxx .78142	.610
Zenith Radio Corp.	.10553	.001	xxx .17061	.029

T-Table Significance Test: x - .05, xx - .02, xxx - .01, xxxx - .001

TABLE VIII

CORRELATION COEFFICIENTS (R) AND COEFFICIENTS OF DETERMINATION (R^2)
FOR LINEAR AND LOGARITHMIC TRANSFORMATIONS OF EQUITIES
EXHIBITING A FALLING BEHAVIOR
(general decline in price over five-year period)

	Linear		Logarithmic	
	R	R^2	R	R^2
Federal Paper Board	.02334	.054	.21926	.047
General Foods Corp.	xxxx .36588	.134	xxxx .37513	.141
Lehigh Portland Cement Co.	xxx .20397	.041	xxxx .28136	.079
National Lead Co.	xxxx .39095	.153	xxxx .39639	.157

T-Table Significance Test: x - .05, xx - .02, xxx - .01, xxxx - .001

selected stocks listed on the preceding pages. Likewise, in a similar number of instances, little or almost no correlation exists between the variables of other equities of similar price stability. Even those listed companies in the same industry and price-fluctuation category (e.g., airlines, mining, and food industries) have highly divergent coefficients of correlation.

It must be concluded, therefore, from this analysis that a generally reliable relationship between price and volume does not exist for any randomly selected stock from the New York Stock Exchange. At times, the relationship may be significant with high correlation, but in the average case this cannot be presumed without extensive background investigation.

CHAPTER V

CONCLUSIONS AND IMPLICATIONS

The objectives and significance of the study presented here, as well as the principal findings, have been dwelt upon at length and need no further clarification. A few brief summary remarks might well be offered at this point, however.

Overall from the results garnered from this study, one would have to conclude that no explanatory or predictive relationship, specified in widely applicable general terms, does exist between volume and price within any of the time parameters as specified in the research design. It is, however, quite noticeable that a general slight correlation is in evidence suggesting that other factors have a great deal to do with the determination of price. Whether these other factors are composed of definitive criteria or are simply the market imperfections existing in the stock exchange is beyond the purpose of this analysis to verify. Certainly, no possibility of forecasting price simply on the basis of volume is suggested; indeed the coefficient of determination, R^2, never reached a value in excess of .61, and only exceeded .50 twice.

As Osborne implied in his latest study (28), individually defined criteria, delineating specific significant price and volume events for a particular stock, might well and profitably be used for predicting price. Indeed, the study at hand even suggests this especially when the equity is in a state of flux. It would be during such a period that Osborne's criteria would be satisfied. However, it was not the intent of this work to study particular relationships. A universal statement, generally applicable to the relationship of price and volume, cannot be specified. It is the conclusion here, therefore, that the hypothesis which states that the weekly volume of trading in an individual stock is generally predictive of the weekly price movements of that stock is not upheld or substantiated; thus, it must be rejected. However, from the results gathered here, it does appear that certain profitable technical trading rules could be formulated on the basis of tightly specified and limited criteria to lend credence to the "Technical Analysis" approach to stock market forecasting. As the final empirical analysis of this study exhibited, in many cases the volume of trading for a stock explains between 20 percent and 40 percent of the change in price. Therefore, the null hypothesis cannot be accepted either.

Future studies, utilizing a multiple regression program designed to forecast price, would do well to consider the results discussed above. Volume could, and in many cases does, have a significant and reliable impact on price determination.

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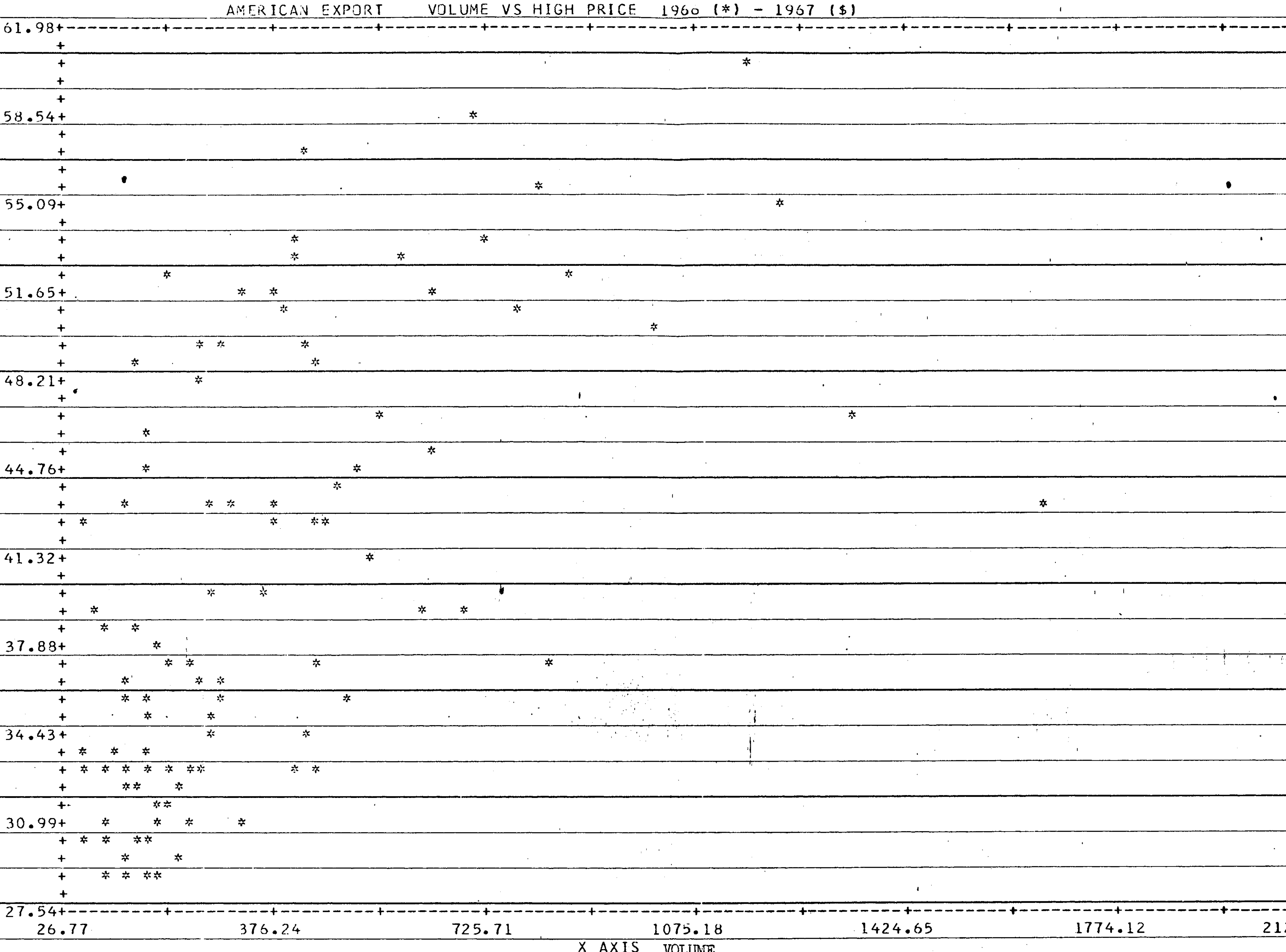
APPENDIX A

EXAMPLES OF GRAPHICAL RELATIONSHIPS BETWEEN VOLUME AND PRICE

Listed below are examples of the computer printouts which were accomplished by utilizing the KSU sub-plot routine on the I.B.M. 360 Computer. These depict the graphical relationships between volume and price in various transformations as noted. A sample program of the type used to extract these graphs from the data cards is included with each respective transformation.

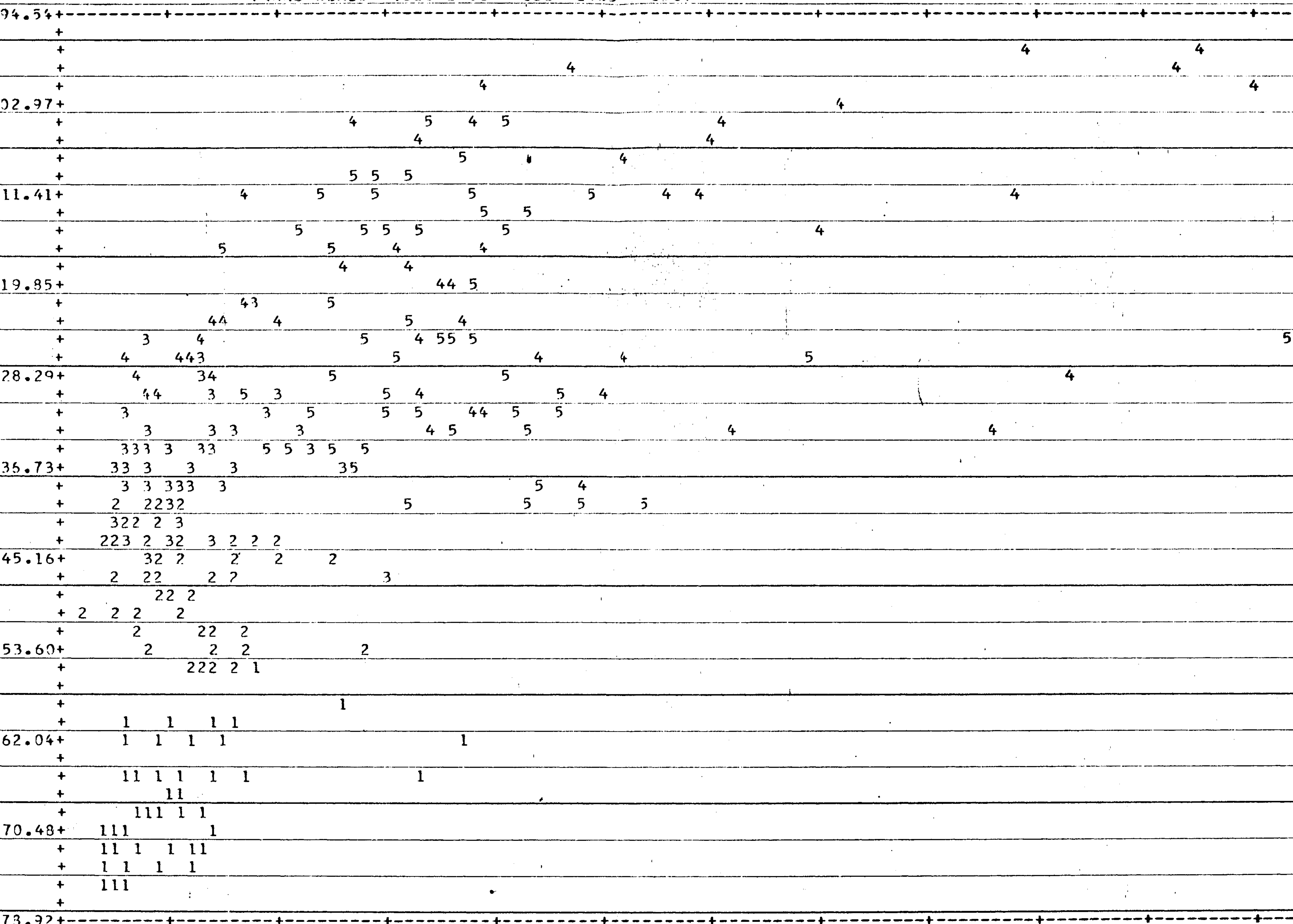
The following graphs depict volume at time (t) - Y-axis, versus price at time (t) - X-axis. The sample program used to extract this data is:

```
      DIMENSION VOL(260),PRICE(260),Z(260)
    5 DO 10 I=1,260
   10 READ (5,15) VOL(I),PRICE(I)
   15 FORMAT (22X,F4.0,25X,F5.2)
      CALL PLOT (VOL,0,PRICE,0,Z,0,260,5,1,3,2,0,1)
      GO TO 5
   20 CALL EXIT
      END
```



AMERICAN EXPORT VOLUME VS HIGH PRICE 1966 (*) - 1967 ($)
61.98
58.54
55.09
51.65
48.21
44.76
41.32
37.88
34.43
30.99
27.54
26.77
376.24
725.71
1075.18
1424.65
1774.12
X AXIS VOLUME

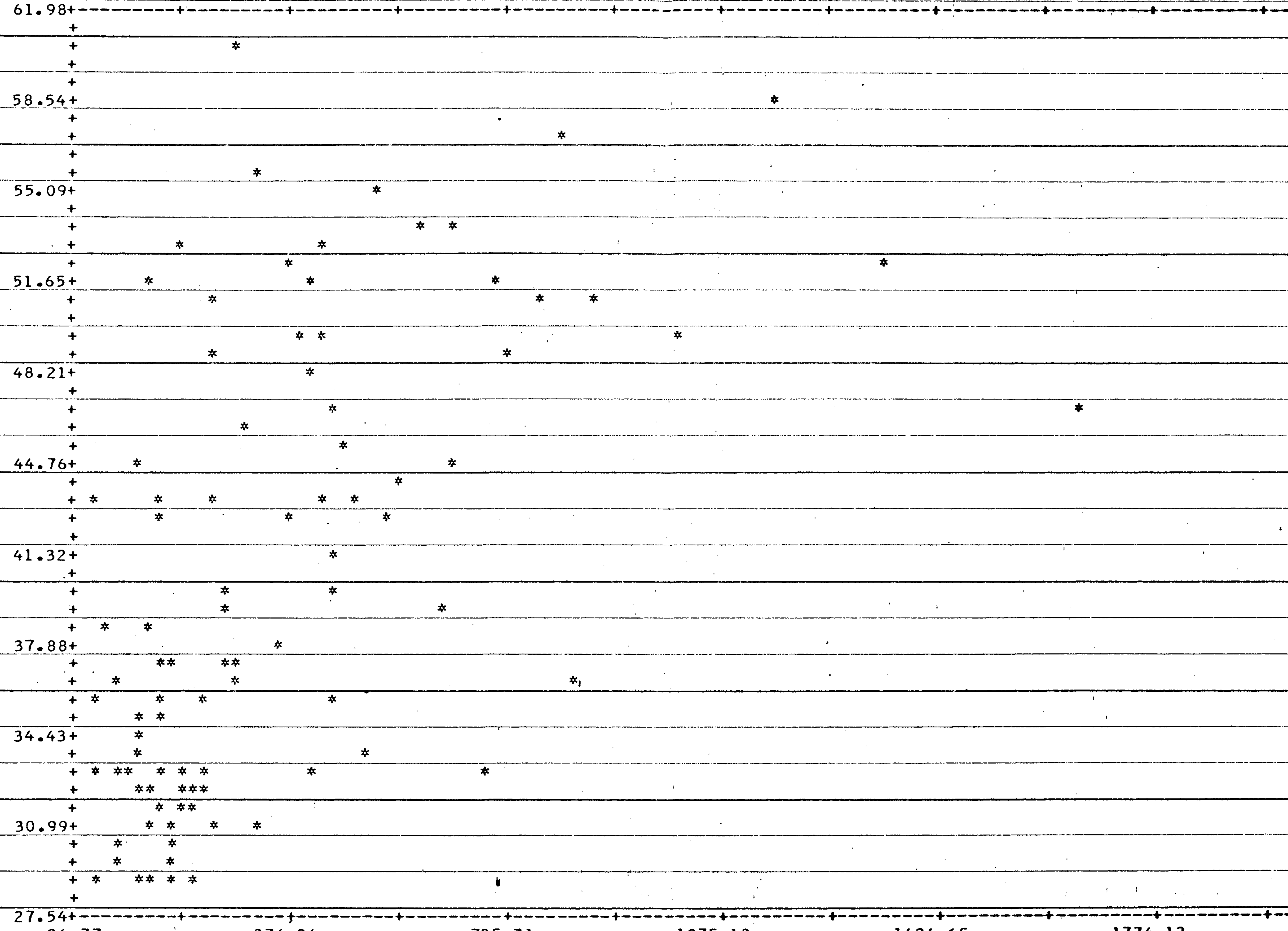
TRANS WORLD VOLUME VS PRICE 1963 - 1967

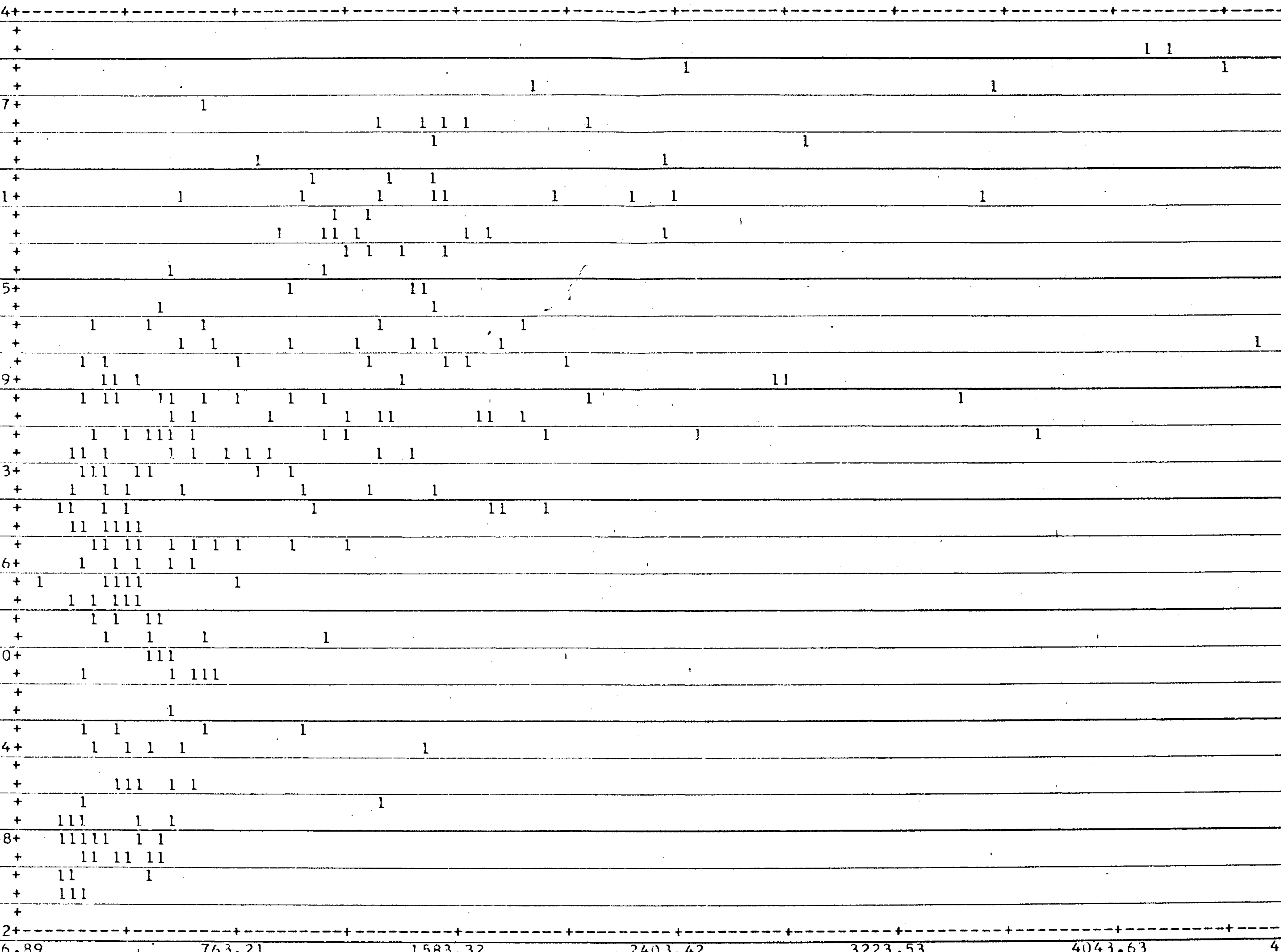


The following graphs depict volume at time (t-1) - Y-axis, versus price at time (t) - X-axis. The sample program used to extract this data is:

```
      DIMENSION VOL(104),PRICE(104),XEWPR(103),Z(104)
    5 DO 10 I=1,104
   10 READ (5,15) VOL(I),PRICE(I)
   15 FORMAT (22X,F4.0,4X,F5.2)
      J=1
      DO 50 I=2,104
      XEWPR(J)=PRICE(I)
      J=J+1
   50 CONTINUE
      CALL PLOT(VOL,0,XEWPR,0,Z,0,103,1,1,3,2,0,1)
      GO TO 5
   20 CALL EXIT
      END
```

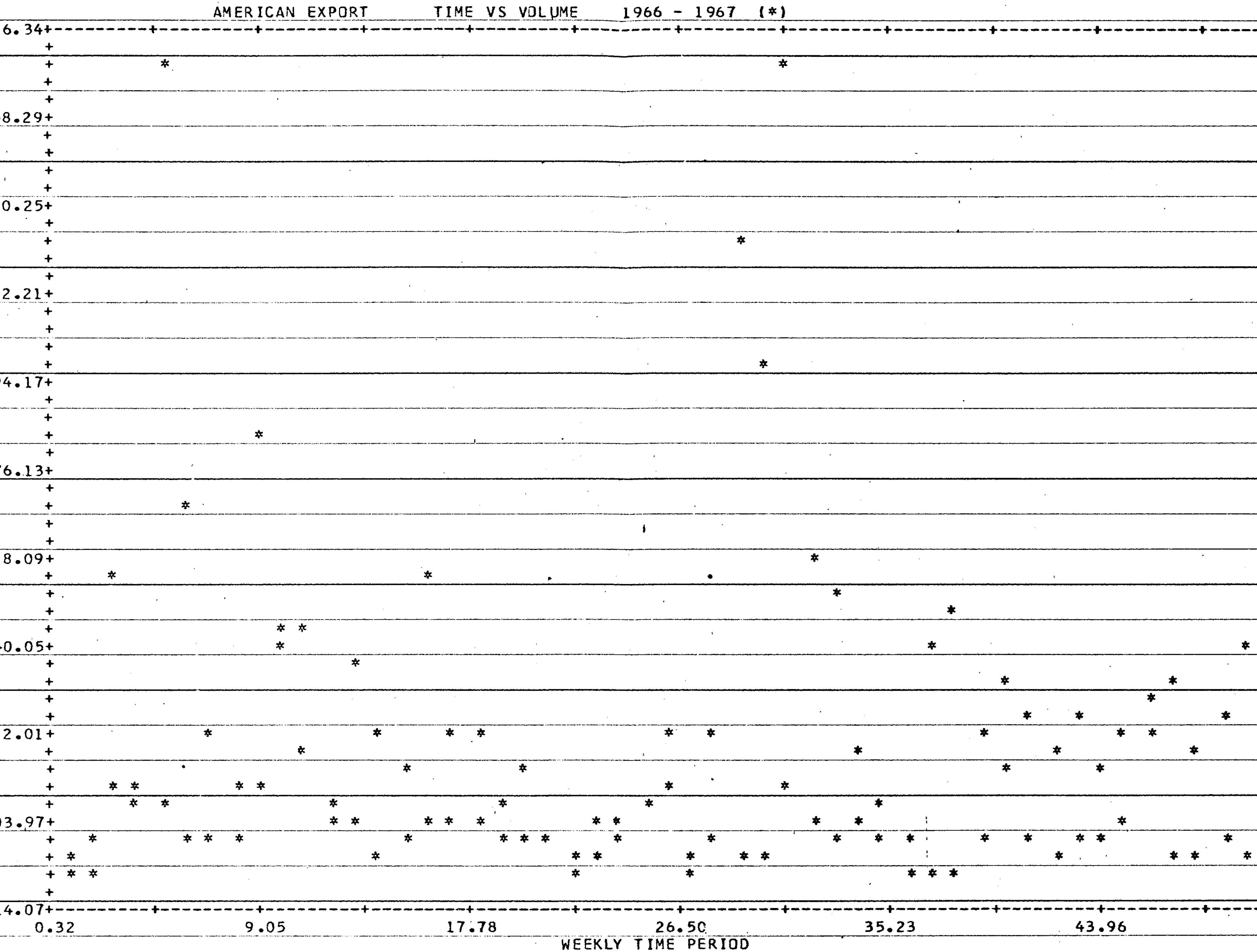
AMERICAN EXPORT VOLUME VS HIGH PRICE 1966 - 1967 (*)




4+
7+
1+
5+
9+
3+
6+
0+
4+
8+
2+
6.89
763.21
1583.32
2403.42
3223.53
4043.63
4

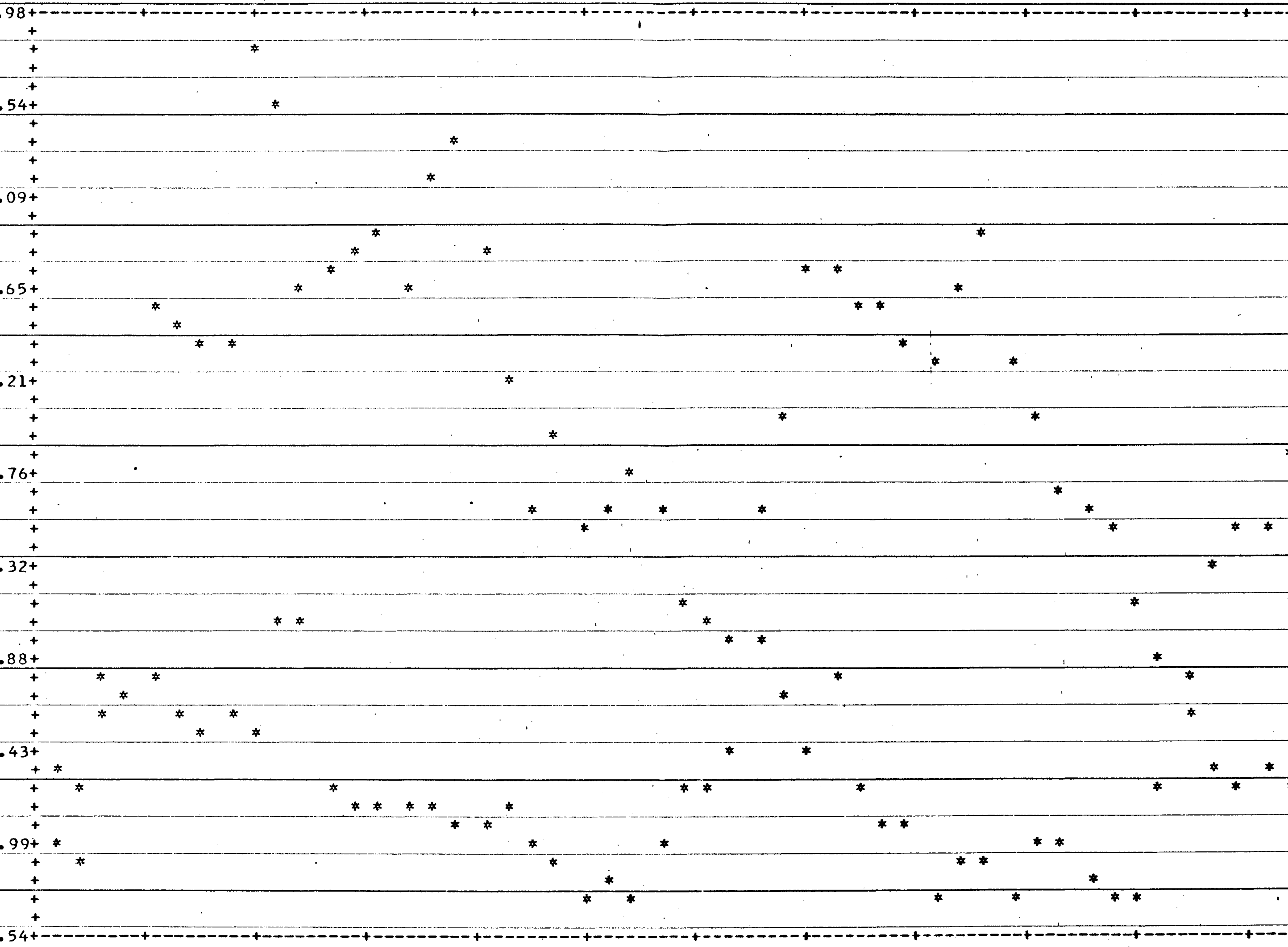
The following graphs depict 1) volume versus time, and 2) pric
ersus time. The sample program used to extract this data is:

```
   DIMENSION TIME(104), VOL(104), PRICE(104), Z(104)
 5 DO 10 I=1,104
10 READ (5,15) TIME(I),VOL(I),PRICE(I)
15 FORMAT (19X,F2.0,1X,F4.0,4X,F5.2)
   CALL PLOT (TIME,0,VOL,0,Z,0,104,1,1,3,2,0,1)
   GO TO 5
20 CALL EXIT
   END
```



AMERICAN EXPORT TIME VS VOLUME 1966 - 1967 (*)
6.34
8.29
0.25
2.21
4.17
6.13
8.09
0.05
2.01
3.97
4.07
0.32
9.05
17.78
26.50
35.23
43.96
WEEKLY TIME PERIOD

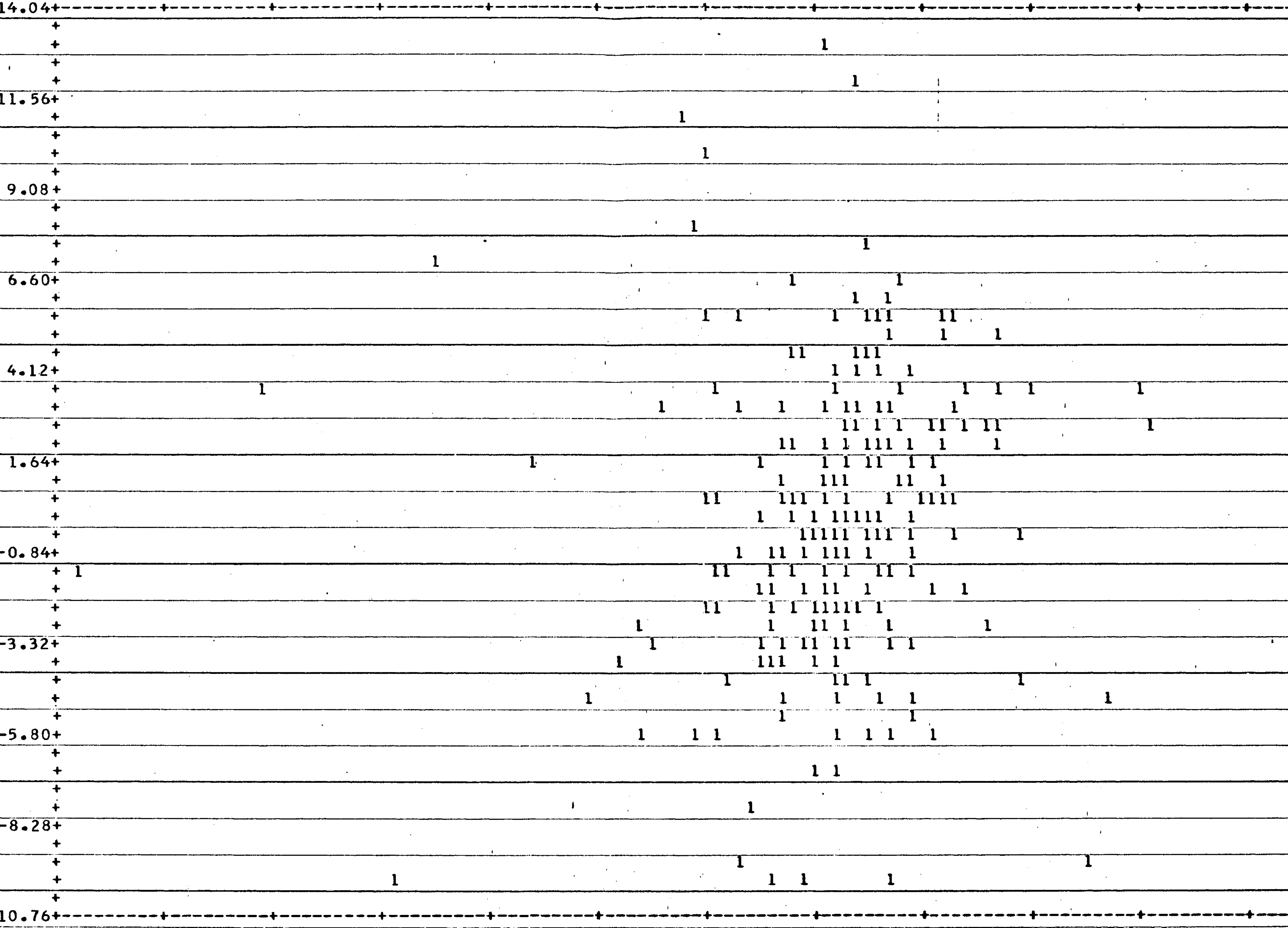
AMERICAN EXPORT TIME VS HIGH PRICE 1966 - 1967 *

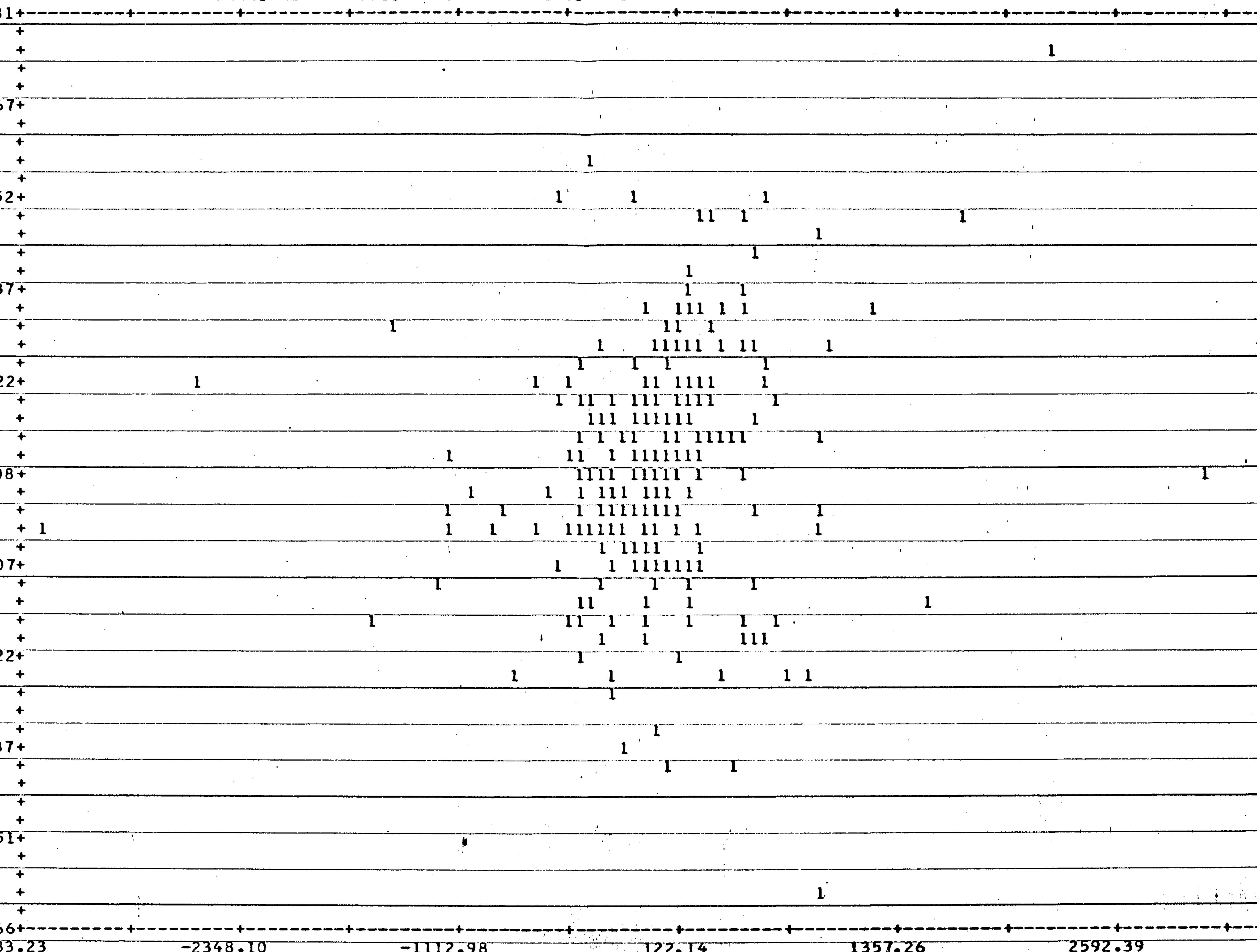


The following graphs depict 1) 1st difference of volume at time (t) versus the 1st difference of price at time (t), and 2) the 2nd difference of volume at time (t) versus the 2nd difference of price at time (t). The sample program used to extract this data is:

```
      DIMENSION VOLD(259),VOLD2(258),CLOD(259),CLOD2(258),Z(259)
      L=0
      DO 500 J=1,252,14
      L=L+14
      READ (5,100) (VOLD(K),CLOD(K),K=J,L)
100   FORMAT (9X,F5.0,F5.3,F5.0,F5.3,F5.0,F5.3,F5.0,F5.3,F5.0,F5.
     1F5.0,F5.3,F5.0,F5.3)
500   CONTINUE
      READ (5,100) (VOLD(K),CLOD(K),K=253,259)
      CALL PLOT (VOLD,0,CLOD,0,Z,0,259,1,1,3,2,0,1)
      L=0
      DO 510 J=1,252,14
      L=L+14
      READ (5,120) (VOLD2(K),CLOD2(K),K=J,L)
120   FORMAT (9X,F5.0,F5.3,F5.0,F5.3,F5.0,F5.3,F5.0,F5.3,F5.0,F5.
     1F5.0,F5.3,F5.0,F5.3)
510   CONTINUE
      READ (5,120) (VOLD2(K),CLOD2(K),K=253,258)
      CALL PLOT(VOLD2,0,CLOD2,0,Z,0,258,1,1,3,2,0,1)
      CALL EXIT
      END
```

TRANS WORLD VOLUME VS PRICE 1963 - 1967

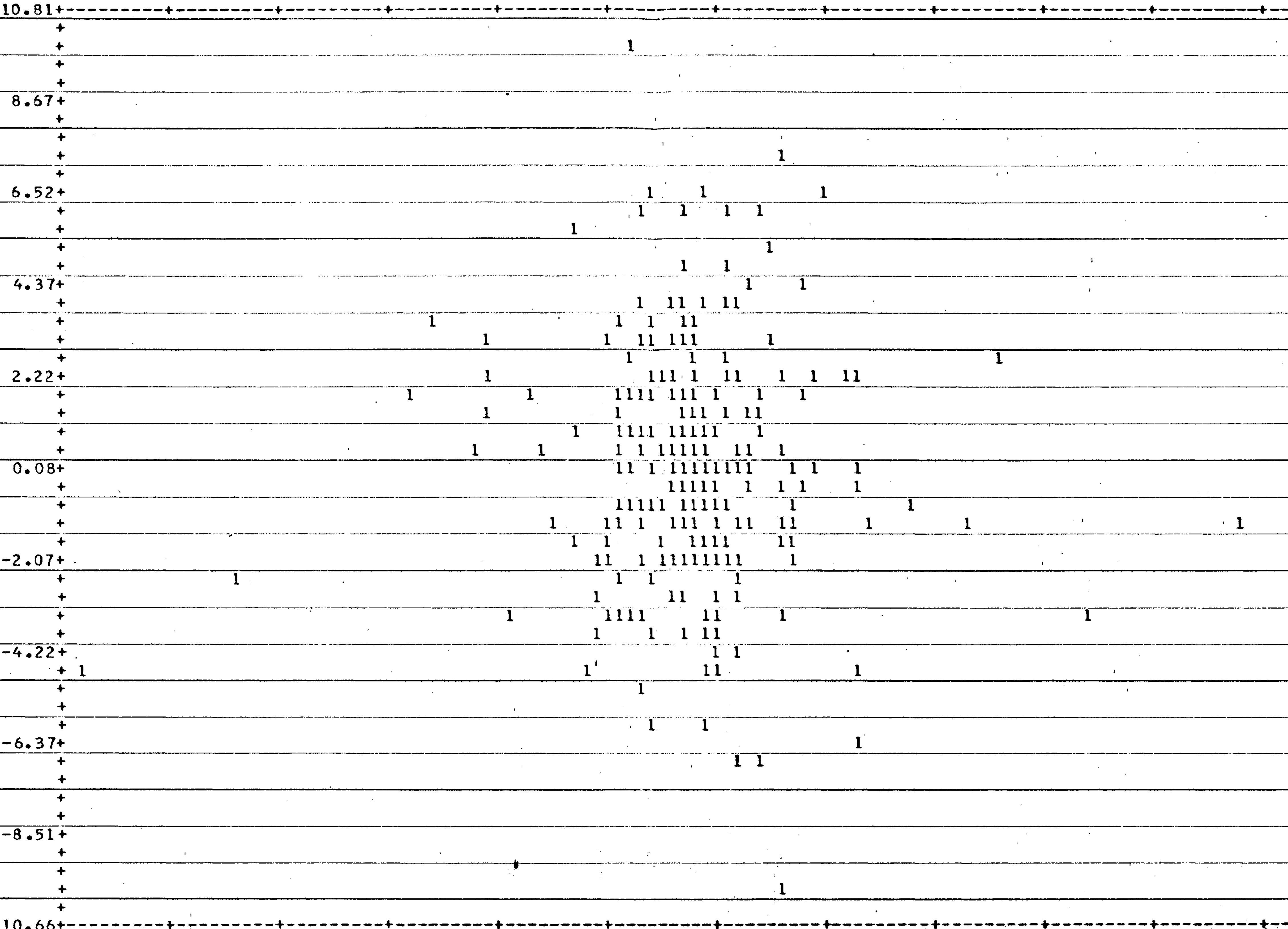



-2348.10
-1112.98
122.14
1357.26
2592.39

The following graph depicts the 1st difference of volume at
ie (t-1) versus the 1st difference of price at time (t). The
ple program used to extract this data is:

```
DIMENSION VOLD(259),CLOD(259),XEWPR(258),Z(259)
L=0
DO 500 J=1,252,14
L=L+14
READ (5,100) (VOLD(K),CLOD(K),K=J,L)
FORMAT (9X,F5.0,F5.3,F5.0,F5.3,F5.0,F5.3,F5.0,F5.3,F5.0,F5.3,
F5.0,F5.3,F5.0,F5.3)
CONTINUE
READ (5,100) (VOLD(K),CLOD(K),K=253,259)
J=1
DO 50 I=2,259
XEWPR(J)=CLOD(I)
J=J+1
CONTINUE
CALL PLOT (VOLD,0,XEWPR,0,Z,0,258,1,1,3,2,0,1)
CALL EXIT
END
```

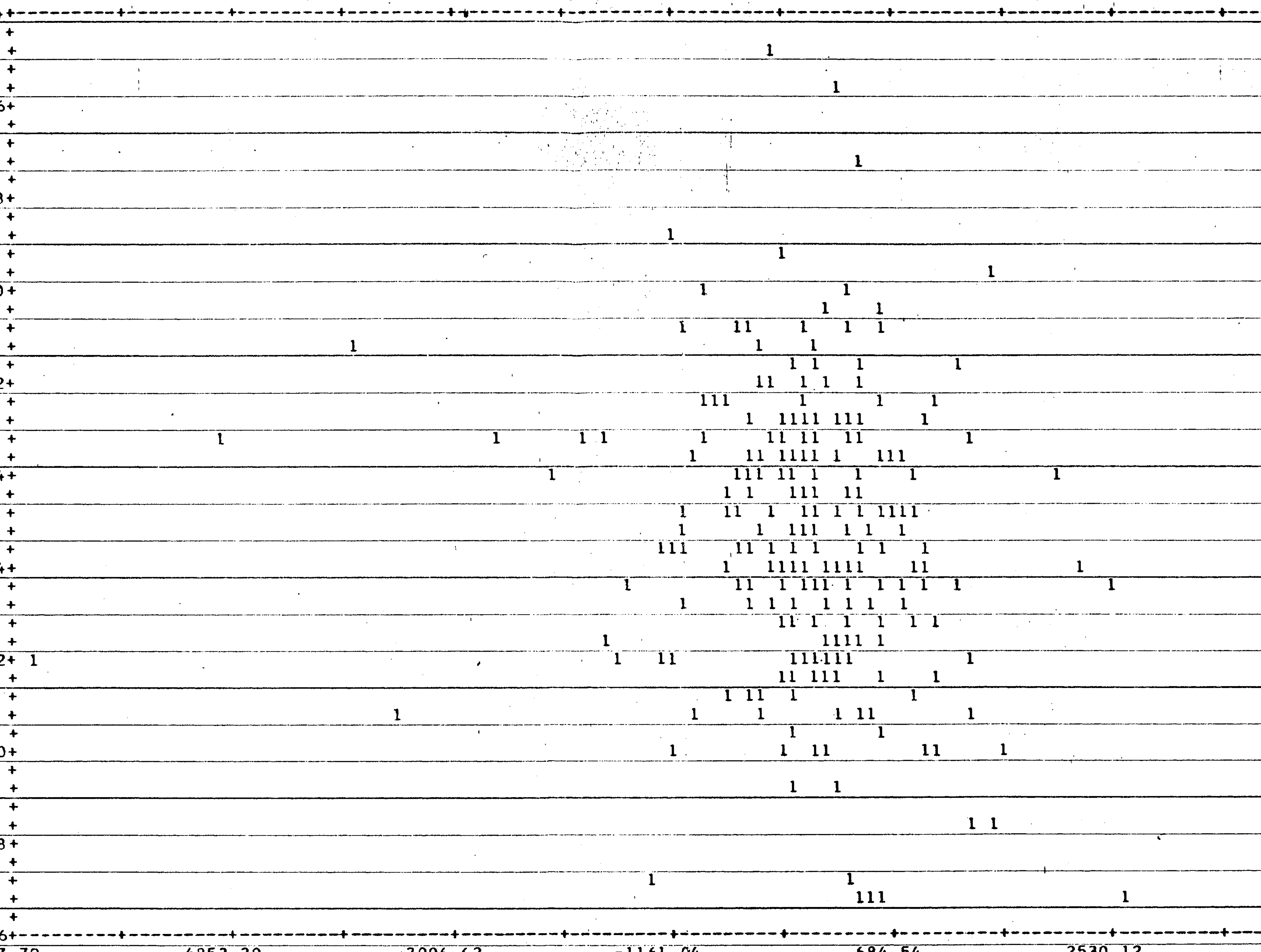
TRANS WORLD VOLUME VS PRICE 1963 - 1967



The following graph depicts the 2nd difference of volume at ime (t-1) versus the 2nd difference of price at time (t). The ample program used to extract this data is:

```
  DIMENSION VOLD2(258),CLOD2(258),XEWPR2(257),Z(258)
  L=0
  DO 510 J=1,252,14
  L=L+14
  READ (5,120) (VOLD2(K),CLOD2(K),K=J,L)
) FORMAT (9X,F5.0,F5.3,F5.0,F5.3,F5.0,F5.3,F5.0,F5.3,F5.0,F5.
 1F5.0,F5.3,F5.0,F5.3)
) CONTINUE
  READ (5,120) (VOLD2(K),CLOD2(K),K=253,258)
  J=1
  DO 50 I=2,258
  XEWPR2(J)=CLOD2(I)
  J=J+1
) CONTINUE
  CALL PLOT (VOLD2,0,XEWPR2,0,Z,0,257,1,1,3,2,0,1)
  CALL EXIT
  END
```

TRANS WORLD VOLUME VS PRICE 1965 - 1987



APPENDIX B

MULTIPLE REGRESSION PROGRAM

```
Q   STMNT        FORTRAN STATEMENT

    C            MULTIPLE REGRESSION PROGRAM - 16K MACHINE REQUIRED
    C            PART I
    C
    C            NO LIMIT ON THE LENGTH OF THE SERIES THAT CAN BE ANALYSED.
    C                    HOWEVER, ALL SERIES MUST BE THE SAME LENGTH
    C            MAXIMUM CF 10 INDEPENDENT VARIABLES
    C            FCR BOTH PARTS - FIXED WORD LENGTH 5
    C            FOR BOTH PARTS - FLOATING WORD LENGTH 10
    C            ALPHANUMERIC FORMAT REQUIRED IN THIS PART
    C            3 WORK TAPES REQUIRED ON NUMBERS 2, 3 AND 4
    C
1                DIMENSION N(1), K(1), LFRM(1), LTO(1), NUM(1)
2                DIMENSION NN(11), YY(11), XX(12), X(11), A(10), B(9),
               1 DIF(11), DAF(11), C(11)
3                READ 1008, (A(L), L=1,10)
    C            (A(L), L=1,10) ARE TEN ORDINAL WORDS EACH TAKING 8 COLUMNS
    C                    THE WORDS ARE - FIRST, SECOND, THIRD, . . . , TENTH
    C
4                READ 1008, (B(L), L=1,9)
    C            (B(L), L=1,9) ARE THE WORDS FOR THE NINE TRANSFORMATIONS, EACH
    C                    TAKING 8 COLUMNS.  THE WORDS ARE -
    C                    LINEAR, SQUARE, SQ ROOT, LOG, 1ST DIF, RECIP, REC SQRT,
    C                    RECIP SQ, AND CUMULTVE
    C
5                READ 1001, N, K, LFRM, LTO, LTYP, LWAY, NDPY
    C            N IS THE NUMBER OF OBSERVATIONS IN A SERIES - CC 1 - 3
    C            K IS THE NUMBER OF INDEPENDENT VARIABLES - CC 5 - 6
    C            LFRM IS THE TIME SHIFT OF INDEPENDENT VARIABLES FROM - CC 7 - 9
    C            LTO IS THE TIME SHIFT OF THE INDEPENDENT VARIABLES TO - CC 10 - 12
    C            LTYP IS THE TYPE OF DATA BEING READ INTO THE PROGRAM - CC 15
    C            TYPE 1 IS WHERE ALL DATA ARE PUNCHED IN SEQUENCE FOR A GIVEN TIME
    C                    PERIOD ON A SINGLE CARD.  THERE WOULD BE AS MANY DATA
    C                    CARDS IN A RUN AS OBSERVATIONS IN A SERIES IN THE RUN.
    C            TYPE 2 IS WHERE THE DEPENDENT VARIABLE IS PUNCHED ON ONE SET OF
    C                    CARDS AND A SINGLE INDEPENDENT VARIABLE IS PUNCHED ON
    C                    ANOTHER SET OF CARDS, WHERE EACH CARD IN A SET CONTAINS
    C                    12 DATA POINTS, EXCEPT POSSIBLY FOR THE LAST CARD
    C            USE THE CODE NUMBERS 1 OR 2 FOR THE VARIABLE LTYP
    C            LWAY DIRECTS TO/OR AVOIDS THE NORMALIZATION OR INDEXING
    C                 AFTER TRANSFORMATION - CC 18
    C            LWAY 1 AVOIDS THE NORMALIZATION AND INDEXING ROUTINES
    C            LWAY 2 DIRECTS DATA THROUGH NORMALIZATION ROUTINE
    C            LWAY 3 INDEXES TO A BASE PERIOD BUT DOES NOT NORMALIZE THE DATA
    C            NDPY IS THE NUMBER OF OBSERVATIONS OF DATA FOR THE BASE PERIOD
    C                    THIS APPLIES ONLY WHEN NORMALIZING OR INDEXING DATA
    C                    CC 19 - 21
    C
                 L = K + 1
                 READ 1003, NN(L), (NN(I), I=1,K)
    C            (NN(I), I=1,L) ARE THE DESIRED TRANSFORMATIONS FOR THE VARIABLES.
    C                    A PUNCH IN COLUMN 1 FROM 1 TO 9 WILL TRANSFORM THE
    C                    DEPENDENT VARIABLE FROM THE FIRST TO THE NINTH
    C                    TRANSFORMATION AS LISTED ABOVE.  COLUMN 2 IS FOR THE
    C                    FIRST INDEPENDENT VARIABLE, ETC.
    C
                 READ 1000, C(L), (C(I), I=1,K)
    C            (C(I), I=1,L) ARE ALPHANUMERIC INDENTIFICATIONS FOR THE
    C                    DEPENDENT AND INDEPENDENT VARIABLES - 8 BLOCKS OF TEN
    C                    COLUMNS EACH ON A CARD.  IF MORE THAN 7 INDEPENDENT
    C                    VARIABLES ARE USED USE A SECOND CARD.  IN ANY LISTING
    C                    IDENTIFY THE DEPENDENT VARIABLE FIRST IN COLUMNS 1 - 10.
    C                    FOLLOW THIS WITH IDENTIFICATION FOR THE FIRST INDEPENDENT
    C                    VARIABLE IN COLUMNS 11 - 20, ETC.
                 DO 2 I=2,4
```

of FORTRAN Statements)

```
2       REWIND I
        NUM = LTO - LFRM + 1
        GO TO (5,25), LTYP
5       DO 10 I=1,N
        READ 1002, X(L), (X(J), J=1,K)
        THE DEPENDENT VARIABLE IS PUNCHED IN COLUMNS 9 - 14 AND A DECIMAL
                POINT IS ASSUMED BETWEEN COLUMNS 13 AND 14.  THE FIRST
                INDEPENDENT VARIABLE IS PUNCHED IN COLUMNS 15 - 20 AND
                A DECIMAL POINT IS ASSUMED BETWEEN COLUMNS 19 AND 20.
                EACH SUBSEQUENT INDEPENDENT VARIABLE IS PUNCHED IN THE
                SUCCEEDING 6 COLUMNS AND ASSUMES ONE PLACE TO THE RIGHT
                OF THE DECIMAL
0       WRITE TAPE 2, (X(J), J=1,L)
        GO TO 40
5       J = 0
8       READ 1002, XX
        12 OBSERVATIONS PUNCHED ON EACH CARD EXCEPT POSSIBLY FOR THE LAST
                CARD IN COLUMNS 9 - 80 EACH OBSERVATION USING SIX COLUMNS.
                EACH BLOCK OF 6 COLUMNS ASSUMES ONE PLACE TO THE RIGHT
                OF THE DECIMAL
        DO 26 I=1,12
        WRITE OUTPUT TAPE 3, 1004, XX(I)
        J = J + 1
        IF(J - N) 26,27,27
6       CONTINUE
        GO TO 28
7       END FILE 3
        REWIND 3
        JJ = K + 1
        L = 0
        J = 12
1       IF(N - (L+12)) 32,33,33
2       J = N - L
3       READ 1002, (XX(I), I=1,J)
        DO 35 I=1,J
        DO 34 M=1,K
4       X(M) = XX(I)
        READ INPUT TAPE 3, 1004, X(JJ)
5       WRITE TAPE 2, (X(M), M=1,JJ)
        L = L + J
        IF(N - L) 40,40,31
0       END FILE 2
        REWIND 2
        REWIND 3
        M = K + 1
        DO 100 L=1,N
        READ TAPE 2, (X(J), J=1,M)
        DO 75 I=1,M
        J = NN(I)
        GO TO (75,51,52,53,54,57,58,59,60), J
1       IF(X(I)) 41,42,42
1       XX(I) = -1.0
        GO TO 43
2       XX(I) = 1.0
3       X(I) = X(I) * X(I) * XX(I)
        GO TO 75
2       X(I) = SQRTF(X(I))
        GO TO 75
3       X(I) = LOGF(X(I))
        GO TO 75
4       IF(L-1) 55,55,56
5       XX(I) = X(I)
        GO TO 75
6       Z = X(I)
        X(I) = X(I) - XX(I)
```

:inuation of FORTRAN Statements)

```
      2       REWIND I
              NUM = LTO - LFRM + 1
              GO TO (5,25), LTYP
      5       DO 10 I=1,N
              READ 1002, X(L), (X(J), J=1,K)
 C            THE DEPENDENT VARIABLE IS PUNCHED IN COLUMNS 9 - 14 AND A DECIMAL
 C                     POINT IS ASSUMED BETWEEN COLUMNS 13 AND 14.  THE FIRST
 C                     INDEPENDENT VARIABLE IS PUNCHED IN COLUMNS 15 - 20 AND
 C                     A DECIMAL POINT IS ASSUMED BETWEEN COLUMNS 19 AND 20.
 C                     EACH SUBSEQUENT INDEPENDENT VARIABLE IS PUNCHED IN THE
 C                     SUCCEEDING 6 COLUMNS AND ASSUMES ONE PLACE TO THE RIGHT
 C                     OF THE DECIMAL
     10       WRITE TAPE 2, (X(J), J=1,L)
              GO TO 40
     25       J = 0
     28       READ 1002, XX
 C            12 OBSERVATIONS PUNCHED ON EACH CARD EXCEPT POSSIBLY FOR THE LAST
 C                     CARD IN COLUMNS 9 - 80 EACH OBSERVATION USING SIX COLUMNS.
 C                     EACH BLOCK OF 6 COLUMNS ASSUMES ONE PLACE TO THE RIGHT
 C                     OF THE DECIMAL
              DO 26 I=1,12
              WRITE OUTPUT TAPE 3, 1004, XX(I)
              J = J + 1
              IF(J - N) 26,27,27
     26       CONTINUE
              GO TO 28
     27       END FILE 3
              REWIND 3
              JJ = K + 1
              L = 0
              J = 12
     31       IF(N - (L+12)) 32,33,33
     32       J = N - L
     33       READ 1002, (XX(I), I=1,J)
              DO 35 I=1,J
              DO 34 M=1,K
     34       X(M) = XX(I)
              READ INPUT TAPE 3, 1004, X(JJ)
     35       WRITE TAPE 2, (X(M), M=1,JJ)
              L = L + J
              IF(N - L) 40,40,31
     40       END FILE 2
              REWIND 2
              REWIND 3
              M = K + 1
              DO 100 L=1,N
              READ TAPE 2, (X(J), J=1,M)
              DO 75 I=1,M
              J = NN(I)
              GO TO (75,51,52,53,54,57,58,59,60), J
     51       IF(X(I)) 41,42,42
     41       XX(I) = -1.0
              GO TO 43
     42       XX(I) = 1.0
     43       X(I) = X(I) * X(I) * XX(I)
              GO TO 75
     52       X(I) = SQRTF(X(I))
              GO TO 75
     53       X(I) = LOGF(X(I))
              GO TO 75
     54       IF(L-1) 55,55,56
     55       XX(I) = X(I)
              GO TO 75
     56       Z = X(I)
              X(I) = X(I) - XX(I)
```

continuation of FORTRAN Statements)

```
              XX(I) = Z
              GO TO 75
     57       X(I) = 1.0 / X(I)
              GO TO 75
     58       X(I) = 1.0 / SQRTF(X(I))
              GO TO 75
     59       X(I) = 1.0 / X(I) ** 2
              GO TO 75
     60       IF(L-1) 61,61,62
     61       XX(I) = X(I)
              GO TO 75
     62       X(I) = X(I) + XX(I)
              XX(I) = X(I)
     75       CONTINUE
              IF(L-1) 76,76,82
     76       DO 77 I=1,M
     77       DIF(I) = 0.0
              DO 78 I=1,M
              IF(NN(I) - 5) 78,100,78
     78       CONTINUE
     79       DO 80 I=1,M
     80       YY(I) = X(I)
              GO TO (90,100,90), LWAY
     82       GO TO (90,81,90), LWAY
     81       IF(L - 2) 83,83,85
     83       DO 84 I=1,M
              IF(NN(I) - 5) 84,79,84
     84       CONTINUE
     85       DO 86 I=1,M
              YY(I) = X(I) - YY(I)
     86       DIF(I) = DIF(I) + ABSF(YY(I))
              WRITE TAPE 4, (YY(I), I=1,M)
              GO TO 79
     90       WRITE OUTPUT TAPE 3, 1004, X(M)
              WRITE TAPE 4, (X(I), I=1,K)
    100       CONTINUE
              GO TO (125,99,125), LWAY
     99       REWIND 2
              END FILE 4
              REWIND 4
C             TAPE 4 CONTAINS THE PERIOD-TO-PERIOD CHANGES
              DO 101 I=1,M
              IF(NN(I) - 5) 101,102,101
    101       CONTINUE
              Z = N - 1
              GO TO 103
    102       Z = N - 2
    103       DO 104 I=1,M
    104       DIF(I) = DIF(I) / Z
              N = Z
C             N IS NOW THE NUMBER OF POINTS IN EACH INDEX
              DO 110 L=1,N
              READ TAPE 4, (X(I), I=1,M)
              DO 106 I=1,M
    106       X(I) = X(I) / DIF(I)
    110       WRITE TAPE 2, (X(I), I=1,M)
C             TAPE 2 CONTAINS THE STANDARDIZED PERIOD-TO-PERIOD CHANGES
              END FILE 2
              REWIND 2
              REWIND 4
              DO 112 I=1,M
              DAF(I) = 0.0
    112       DIF(I) = 0.0
              IF(NDPY - 1) 113,113,114
    113       NDPY = 2
```

(continuation of FORTRAN Statements)

```
114     LL = NDPY - 1
        Z = NDPY
        DO 115 I=1,M
        IF(NN(I) - 5) 115,119,115
115     CONTINUE
        GO TO 117
119     LL = LL - 1
        Z = Z - 1.0
117     DO 116 I=1,LL
        READ TAPE 2, (YY(J), J=1,M)
        DO 116 J=1,M
        DAF(J) = DAF(J) + YY(J)
116     DIF(J) = DIF(J) + DAF(J)
        REWIND 2
        DO 118 I=1,M
118     DIF(I) = (Z * 100.0 - DIF(I)) / Z
        WRITE OUTPUT TAPE 3, 1004, DIF(M)
        WRITE TAPE 4, (DIF(I), I=1,K)
        DO 130 L=1,N
        READ TAPE 2, (YY(I), I=1,M)
        DO 120 I=1,M
120     DIF(I) = DIF(I) + YY(I)
        WRITE OUTPUT TAPE 3, 1004, DIF(M)
130     WRITE TAPE 4, (DIF(I), I=1,K)
        N = N + 1
        GO TO 128
125     DO 126 I=1,M
        IF(NN(I) - 5) 126,127,126
126     CONTINUE
        GO TO 128
127     N = N - 1
128     IF(LWAY - 3) 129,135,129
135     REWIND 2
        REWIND 3
        REWIND 4
        DO 136 I=1,M
136     YY(I) = 0.0
        DO 137 I=1,M
        IF(NN(I) - 5) 137,138,137
137     CONTINUE
         GO TO 139
138     NDPY = NDPY - 1
139     IF(NDPY) 141,140,141
140     NDPY = 1
141     DO 142 I=1,NDPY
        READ INPUT TAPE 3, 1004, X(1)
        READ TAPE 4, (X(J), J=2,M)
        DO 142 J=1,M
142     YY(J) = YY(J) + X(J)
        DO 143 I=1,M
143     YY(I) = YY(I) / FLOATF(NDPY)
        REWIND 3
        REWIND 4
        DO 145 I=1,N
        READ INPUT TAPE 3, 1004, X(1)
        READ TAPE 4, (X(J), J=2,M)
        DO 144 J=1,M
144     X(J) = X(J) / YY(J) * 100.0
145     WRITE TAPE 2, (X(J), J=1,M)
        DO 146 I=2,4
146     REWIND I
        DO 147 I=1,N
        READ TAPE 2, (X(J), J=1,M)
        WRITE OUTPUT TAPE 3, 1004, X(1)
147     WRITE TAPE 4, (X(J), J=2,M)
```

(continuation of FORTRAN Statements)

```
191     129          DO 132 I=3,4
192                  END FILE I
193     132          REWIND I
194                  REWIND 2
195                  J = NN(M)
196                  PRINT 1007, C(M), B(J)
197                  DO 134 L=1,K
198                  J = NN(L)
199     134          PRINT 1006, A(L), C(L), B(J)
200                  N(I) = XLINKF(0)
201    1000          FORMAT(8A10)
202    1001          FORMAT(7I3)
203    1002          FORMAT(8X,12F6.1)
204    1003          FORMAT(11I1)
205    1004          FORMAT(F10.2)
206    1006          FORMAT(1X, 3HTHE 1X, A8, 1X, 20HINDEPENDENT VARIABLE 1X, A10, 1X,
                   1 5HHAS A 1X, A8, 1X, 15HTRANSFORMATION. //)
207    1007          FORMAT(1H1,22HTHE DEPENDENT VARIABLE 1X, A10, 1X, 5HHAS A 1X, A8,
                   1 1X, 15HTRANSFORMATION. ////)
208    1008          FORMAT(10A8)
209                  END
```

```
SEQ    STMNT         FORTRAN STATEMENT

       C             PART II
       C             ALPHANUMERIC FORMAT NOT NEEDED IN THIS PART
       C
  1                  DIMENSION N(1), K(1), LFRM(1), LTO(1), NUM(1)
  2                  DIMENSION DUM(2), VEC(10), SUMX(10), A(10,11), TX(10,10), CR(10),
                   1 AS(10), AX(10), AA(10), AB(10)
  3                  EQUIVALENCE (AA(10), AX(10))
  4                  EQUIVALENCE (AB(10), CR(10))
  5                  LS = 0
  6                  NRUN = 0
  7        1         DUM(1) = 0.
  8                  DUM(2) = 0.
  9                  DO 2 I=1,10
 10                  VEC(I) = 0.
 11                  SUMX(I) = 0.
 12                  DO 2 J=1,10
 13        2         A(I,J) = 0.
 14                  NX = N - XABSF(LFRM + LS)
       C             NX IS THE NUMBER OF OBSERVATIONS FOR THIS RUN
 15                  LL = XABSF(LFRM + LS)
 16                  LX = LFRM + LS
 17                  PRINT 1020, LX
 18                  IF(LX) 61,64,67
 19       61         DO 62 J=1,LL
 20       62         READ TAPE 4, (A(I,11), I=1,K)
 21                  GO TO 64
 22       67         DO 68 J=1,LL
 23       68         READ INPUT TAPE 3, 1021, Y
 24       64         DO 130 L=1,NX
 25                  READ INPUT TAPE 3, 1021, Y
 26                  READ TAPE 4, (A(I,11), I=1,K)
 27                  WRITE TAPE 2, Y, (A(I,11), I=1,K)
 28                  DUM(1) = DUM(1) + Y
 29                  DUM(2) = DUM(2) + Y*Y
 30                  DO 3 M=1,K
 31                  SUMX(M) = SUMX(M) + A(M,11)
 32                  VEC(M) = VEC(M) + Y*A(M,11)
```

(continuation of FORTRAN Statements)

```
            DO 3 J=1,K
            A(M,J) = A(M,J) + A(M,11)*A(J,11)
      3     CONTINUE
    130     CONTINUE
            END FILE 2
            REWIND 2
            DO 50 I=1,K
     50     AX(I) = A(I,I)
            XN = NX
            DO 4 M=1,K
            VEC(M) = VEC(M) - DUM(1)*SUMX(M)/XN
            DO 4 J=1,K
      4     A(M,J) = A(M,J) - SUMX(M)*SUMX(J) / XN
            SY = DUM(2) / XN
            SY = SY - DUM(1)**2 / XN**2
            PRINT 1003
            DO 75 I=1,K
            SI = A(I,I) / XN
            AS(I) = SI
            R = VEC(I) / (XN * SQRTF(SI * SY))
            XR = R
            R = ((XN-1.)*R*R -1.) / (XN-2.)
            R = ABSF(R)
            CR(I) = (SQRTF(R) * 10.) / 10.
            IF(XR) 70,75,75
     70     CR(I) = -CR(I)
     75     CONTINUE
            DO 6 M=1,K
            DO 6 J=1,K
            TX(M,J) = A(M,J) / (XN * SQRTF(AS(M) * AS(J)))
            XTX = TX(M,J)
            TX(M,J) = ((XN-1.) * TX(M,J)*TX(M,J) -1.) / (XN-2.)
            TX(M,J) = ABSF(TX(M,J))
            TX(M,J) = (SQRTF(TX(M,J)) * 10.) / 10.
            IF(XTX) 80,6,6
     80     TX(M,J) = -TX(M,J)
      6     CONTINUE
            DO 7 M=1,K
      7     PRINT 1004, (TX(M,J), J=1,K)
            PRINT 1019
            PRINT 1004, (CR(I),I=1,K)
            IT = K + 1
            DO 8 I=1,K
      8     A(I,IT) = VEC(I)
C           ORIGINAL MATRIX
            DO 15 I=1,K
            R = 1. / A(I,1)
            DO 9 J=1,K
      9     A(I,J) = R * A(I,J+1)
            A(I,IT) = R
            DO 15 M=1,K
            IF(M-I) 10,15,10
     10     R = - A(M,1)
            DO 11 J=1,K
     11     A(M,J) = A(M,J+1) + R*A(I,J)
            A(M,IT) = R * A(I,IT)
     15     CONTINUE
C           INVERSE MATRIX
            DO 16 M=1,K
     16     A(M,2) = A(M,M+1)
            B = DUM(1)
            DO 17 I=1,K
     17     B = B - A(I,1) * SUMX(I)
            B = B / XN
            PRINT 1005, B, (A(I,1), I=1,K)
```

(continuation of FORTRAN Statements)

```
                PRINT 1017
                DO 60 I=1,K
                BETA = A(I,1) * SQRTF((XN*AX(I)-SUMX(I)**2)/(XN*DUM(2)-DUM(1)**2))
      60        PRINT 1018, BETA
                PRINT 1006
                DW = 0.0
                DTSQ = 0.0
                DO 19 L=1,NX
                SUM = B
                READ TAPE 2, Y, (A(I,11), I=1,K)
                DO 18 J=1,K
      18        SUM = SUM + A(J,1) * A(J,11)
                RESD = Y - SUM
                PRINT 1007, Y, SUM, RESD, (A(I,11), I=1,K)
C               DURBIN - WATSON COMPUTATION
                DTSQ = DTSQ + RESD * RESD
                IF(L - 1) 31,31,30
      30        DW = DW + (RESD - DT) ** 2
      31        DT = RESD
      19        CONTINUE
                DW = DW / DTSQ
                PRINT 1002, DW
                XK = K
                TSS = DUM(2) - DUM(1) * DUM(1) / XN
                PRINT 1008, TSS
                DSS = 0.
                DO 20 I=1,K
      20        DSS = DSS + A(I,1) * VEC(I)
                PRINT 1009, DSS
                RSS = TSS - DSS
                PRINT 1010, RSS
                SE = SQRTF(RSS / (XN - XK - 1.0))
                PRINT 1011, SE
                R = 1. - SE**2 * (XN-1.) / TSS
                R = ABSF(R)
                R = SQRTF(R)
                PRINT 1012, R
                L = NX - K - 1
                F = (DSS/XK) / (RSS/(XN-XK-1.))
                PRINT 1013, F, K, L
                PRINT 1014
                DO 21 I=1,K
                S = SE * SQRTF(A(I,2))
                T = A(I,1) / S
      21        PRINT 1015, S, T
                DO 23 I=2,4
      23        REWIND I
                LS = LS + 1
                NRUN = NRUN + 1
                IF(NRUN-NUM) 1,22,22
      22        PRINT 1016
                STOP
    1002        FORMAT(1X//28H DURBIN - WATSON COEFFICIENT 14X,E13.6)
    1003        FORMAT(1X, 62HSIMPLE CORRELATION COEFFICIENT AMONG THE INDEPENDENT
            1    VARIABLES)
    1004        FORMAT(1X,13F9.5)
    1005        FORMAT(1X//45H COEFFICIENTS OF MULTIPLE REGRESSION EQUATION/(1X,
            1   F11.4))
    1006        FORMAT(1H1,131H    OBS Y       EST Y    RESIDUAL      1ST X      2ND X
            1         3RD X      4TH X      5TH X      6TH X      7TH X      8TH X      9
            2   TH X     10TH X)
    1007        FORMAT(1X,F9.2,2(1X,F10.2),10F10.2)
    1008        FORMAT(1X//21H TOTAL SUM OF SQUARES21X,E13.6)
    1009        FORMAT(1X/37H SUM OF SQUARES REMOVED BY REGRESSION 5X, E13.6)
    1010        FORMAT(1X/24H RESIDUAL SUM OF SQUARES 18X, E13.6)
```

(continuation of FORTRAN Statements)

```
1011      FORMAT(1X//27H STANDARD ERROR OF ESTIMATE15X,E13.6)
1012      FORMAT(1X//36H COEFFICIENT OF MULTIPLE CORRELATION 6X,E13.6)
1013      FORMAT(1X//29H        F        K      N -K -1/1X,E12.5,I4,4X,I5)
1014      FORMAT(1X///21H FOR EACH COEFFICIENT//1X,47H STANDARD ERROR
     1  T TABLE SIGNIFICANCE TEST)
1015      FORMAT(3X,E12.5,14X,E12.5)
1016      FORMAT(1H1,11H END OF JOB/1H1)
1017      FORMAT(1X//48H BETA COEFFICIENTS FOR EACH INDEPENDENT VARIABLE/)
1018      FORMAT(1X,E12.5)
1019      FORMAT(1X//83H SIMPLE CORRELATION COEFFICIENT BETWEEN EACH INDEPEN
     1  DENT AND THE DEPENDENT VARIABLE)
1020      FORMAT(1H1,53HTHE INDEPENDENT VARIABLES FOR THIS RUN HAVE A LEAD O
     1  F 1X, I3, 1X, 8HPERIODS. ///)
1021      FORMAT(F10.2)
          END
```

APPENDIX C

OKLAHOMA STATE UNIVERSITY

MULTIPLE LINEAR REGRESSION PROGRAM

```
00000000011111111112222222222333333333344444444445555555555666666666677777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890
C     READ DATA TAPE AND SET UP DATA ON DISK FOR USE WITH MULTIPLE LINEAR
C     REGRESSION
      DIMENSION IYR(260),IWK(260),VOL(260),HIGH(260),XLOW(260),CLOSE
     1   (260),VOLLN(260),CLOSLN(260)
      DO 25 I=1,10
      READ(5) (ICO,IYR(K),IWK(K),VOL(K),HIGH(K),XLOW(K),CLOSE(K),K=1,260
     1)
      DO 10 J=1,260
      VOLLN(J)=ALOG10(VOL(J))
      CLOSLN(J)=ALOG10(CLOSE(J))
      WRITE(4,5) VOL(J),CLOSE(J),VOLLN(J),CLOSLN(J)
    5 FORMAT(F6.0,F9.2,2F10.5,45X)
   10 CONTINUE
      WRITE(4,11)
   11 FORMAT('$END',76X)
   25 CONTINUE
      END FILE 4
      REWIND 4
      CALL EXIT
      END
//GO.FT04F001 DD UNIT=SYSDA,DSN=TEMP,SPACE=(80,3000),
// DCB=(BLKSIZE=1092,LRECL=1088,RECFM=VB),DISP=(,PASS)
//GO.SYSIN DD DSN=PINCHES,UNIT=TAPE9,VOL=SER=T043,DISP=(OLD,KEEP)
// EXEC MULTREG,TIME.GO=5
//GO.FT04F001 DD UNIT=SYSDA,DSN=TEMP,SPACE=(80,3000),
// DCB=(BLKSIZE=1092,LRECL=1088,RECFM=VB),DISP=(OLD,DELETE)
//GO.SYSIN DD *
```

VITA

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Candidate for the Degree of

Master of Business Administration

Thesis: AN ANALYSIS OF THE RELATIONSHIP BETWEEN THE VOLUME OF TRADING AND THE PRICE OF EQUITIES AS EXHIBITED ON THE NEW YORK STOCK EXCHANGE

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