Programmable Calculator (TI-59) Programs for Marketing and Price Analysis in Third World Countries

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PREFACE

There is a worldwide revolution in small computer technology underway and scientists are struggling to find ways to utilize this new technology to help solve development problems in the Third World. We are pleased to announce a number of papers on microcomputers in international agriculture will be published in our International Development Papers series. The aim of these papers is to provide timely information about the rapidly changing state of the new micro-processing technology and its use in research. The papers are also intended as guides to agricultural and social scientists on choosing, installing, and maintaining microcomputer hardware and software systems in developing countries.

Some of the papers will also document field experiences of selected established projects using new data processing hardware and software. Other papers will concentrate on developing guidelines for establishing and maintaining successful microcomputer and/or programmable calculator installations for agricultural research in developing countries.

The present paper is the fifth of these new papers. It is based on a Masters Degree research paper written by Michael L. Morris and supervised by Michael T. Weber. It is part of on-going staff work by faculty members and graduate students of the Department of Agricultural Economics, Michigan State University, on cost-effective data collection, management, and analysis techniques for developing country applications. This activity is carried out under the terms of reference of the Alternative Rural Development Strategies Cooperative Agreement--DAN-1190-A-00-2069-00--between the Office of Multi-Sectoral Development, Bureau of Science and Technology of the United States Agency for International Development and the Department of Agricultural Economics at Michigan State University.

Readers are encouraged to submit comments about these new papers on microcomputers and to inform us of their activities in this area. Write directly to: Dr. Michael T. Weber, Acting Director, Alternative Rural Development Strategies Cooperative Agreement, Department of Agricultural Economics, Michigan State University, East Lansing, Michigan 48824-1039.

Eric W. Crawford, Carl K. Eicher, and Carl Liedholm
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I. INTRODUCTION

1.1 Why Price Analysis?

Prices everywhere tend to play a central role in coordinating production and consumption. Whether in a so-called "free-market" system or in a centrally planned economy, prices perform a broad range of vital economic functions, including signalling the demand for production inputs and outputs, influencing the incomes of producers and the welfare of consumers, and determining the level of a nation's export earnings. Because of their crucial role in channelling diverse economic processes, prices constitute an important topic of economic analysis.

Formal price analysis research was for a long time largely descriptive. Although the theory of price determination has long been a subject of interest to economists, quantitative studies originally were hampered by a lack both of the statistical methodologies and of the information collection and processing devices necessary to work effectively with price data. However, during the past few decades advances in econometric theory and, perhaps more importantly, in computer technology have enabled price analysis to come of age as a full-blown economic discipline firmly grounded in empirical quantitative research.

Price analysis is of particular interest to agricultural economists because of the unusual characteristics of many agricultural product prices. Because agricultural commodities are not manufactured but grown, and because the demand for many commodities tends to be highly inelastic, agricultural product prices are subject to unique forces which cause them to behave quite differently from the prices of manufactured goods. On the supply side, the biological nature of agricultural production causes tremendous price instability. As yields vary from season to season and from year to year due to the effects of weather, pests, or disease, actual production often falls short of or exceeds planned production. The time lag between the decision to produce and actual harvest, coupled with the inherent variability of yields, further complicates the achievement of production targets. Crop surpluses and shortages, accepted features of agricultural production, often result in price swings which represent a major source of uncertainty to both producers and consumers of agricultural products.

The biological nature of production also causes price variability within the same year. Unlike manufacturing processes, which can be manipulated to produce a steady stream of output, agricultural production is largely dependent on nature; thus, the production schedule tends to be dictated exogenously. As a result, commodity markets frequently become glutted at harvest time, even though during much of the rest of the year supplies may be scarce. This is particularly true in the case of perishable commodities which cannot easily be stored for later sale. Agricultural product prices reflect this seasonal variability in supply associated with cropping cycles; commodity prices typically fall at harvest time, then climb steadily during the remainder of the year until the cycle is completed.

The price variability associated with agricultural product prices is not caused entirely by supply-side factors. Demand conditions often compound price fluctuations. The demand for many agricultural commodities is highly price-inelastic; the quantity demanded is not affected much by changes in price (i.e., the demand function is steep over the relevant range). Consequently, the supply variability described above results in large fluctuations in price, given the inelastic demand.

Superimposed on the inherent price variability are a number of different price determination mechanisms. The institutional arrangements governing the determination of agricultural product prices range from complete government regulation to free markets. In recent years, however, even the most decentralized economies have tended toward intervention in commodity pricing in an attempt to stabilize prices, redistribute income, improve export earnings, and/or achieve food self-sufficiency. Price policy is increasingly being used to supplement -- and in some cases to replace -- the free market as the allocator of production resources and agricultural products.

The formulation of effective price policy is of course dependent on a complete and accurate understanding of how prices have behaved in the past, how they can be expected to behave in the future, and what the implications will be for the different groups of producers and consumers of agricultural products. Consequently, agricultural economists working on price policy issues typically are interested in:

1) describing the behavior over time of agricultural product prices;
2) forecasting price changes and their economic consequences;
3) estimating specific economic parameters (e.g., price and income elasticities).

Achievement of these objectives necessarily involves analysis of large quantities of data, usually (but not always) time series data. Although in some instances the period of analysis is restricted by structural changes occurring within the industry, as a general rule the accuracy of research results increases the longer the time series, i.e., the larger the sample size. As statistical collection and reporting services have expanded and improved, so have many of the data bases being accumulated for purposes of price analysis research. Meanwhile, sophisticated analytical techniques have been and continue to be developed to analyze the growing body of data, as well as the complex computer hardware necessary for affordable storage, retrieval, and processing of price data. The use of large-capacity mainframe computers is today commonplace; in fact, many current analytical procedures require computers in order to reduce calculation time to reasonable lengths.

1.2 Price Analysis Research in Developing Countries

In principle, there should be little difference between the agricultural price analysis research undertaken by economists working in developing countries and that conducted by economists working in the developed world. Institutional and political circumstances may vary, but the research objective and the analytical methodologies of the price analyst should remain essentially unchanged. Primary emphasis will continue to be placed on the description of past price behavior, the prediction of future prices, and the estimation of quantitative parameters to inform policy decision-making. Nevertheless, despite the similarity in objectives, research in developing countries often takes place under very different working conditions. Economists frequently must design and implement research subject to strong constraints.

The single most important constraint involves a set of problems which collectively can be called "data problems". Many countries have not yet been able to establish effective statistical collection and reporting agencies, particularly those countries in which most agricultural production takes place as subsistence farming in remote areas poorly services by transportation and communication facilities. As a result, often the data on prices, production and marketings which serve as grist for the price analyst's mill simply do not exist. Data have to be gleaned from diverse official or unofficial sources, and they tend to be inconsistent at best. Even official data at times are suspect; occasionally they are altered for political purposes.

Incomplete, unreliable, and sometimes nonexistant data represent a recurring problem for price analysts working in developing countries. Often it becomes necessary to resort to "rough and ready" estimation techniques to perform any kind of analysis at all. Such "rough and ready" techniques typically are implemented in the case of extremely short data series (e.g., 3-5 years of monthly data) or in the case of missing observations (e.g., when several short series have been patched together from different sources). In such instances, formal quantitative analysis becomes difficult or impossible, and statistical estimates tend to be unreliable at best. Unfortunately, the choice frequently boils down to working with imperfect data or not working at all.

A second major constraint can be the lack of computer resources for recording, storing, and processing large quantities of price data. Although the use of computers has blossomed in recent years, particularly among economists working in the developed nations, widespread availability of adequate computer services in developing countries has lagged, and despite technological breakthroughs which have drastically reduced the cost of computer hardware, price tags are still a problem for developing countries facing budgetary constraints. In addition, the appeal of the hardware is diminished by a pressing shortage of trained programmers. Consequently, there has been a tendency for developing-country governments to invest in large, centrally located mainframe computers which can be operated by a relatively small number of technicians to serve a variety of needs.

This strategy, while economizing on computer resources as well as trained personnel, often results in slow turnaround times for submitted jobs. Since much price analysis work requires a great deal of data processing, the price analyst working in the field is faced with another difficult choice: endure the slow turnaround time associated with the use of overcrowded central facilities, or undertake the laborious and error-prone process of hand calculation.

1.3 Objectives of the Study

The objective of this study is to investigate the appropriateness of hand-held programmable calculators as a research tool for economists working on price policy issues in LDC's. The emphasis is on the use of programmables not for purposes of sophisticated analysis of large data sets--something which can be accomplished much more effectively on larger computers--but rather for preliminary anlaysis of the sorts of data economists typically work with in the field.

Programmable calculators are convenient, relatively inexpensive, versatile machines which have gained popularity in the United States in recent years as valuable tools for applied decision-making. Programmables have been used fairly extensively by some agricultural extension services in helping farmers improve their management performance. For example, Michigan State University through the TELCAL network has made available a set of programs to inform farmer decision-making in such diverse areas as farm budgeting, taxation, estate planning, ration mixing, fertilization, etc. Many farmers have found these types of programs sufficiently useful to justify the purchase of a personal machine.

Despite their growing popularity as a farm management tool, programmable calculators have not been used extensively for research purposes.

A few authors have attempted to develop and test research-oriented programs relating to particular fields of inquiry (e.g., see Koehler, 1979); Bernsten, 1982), but such efforts are not yet widespread. This study attempts to expand the scope of these preliminary efforts by exploring the possibility that programmable calculators might be adopted for use by the research economist working on price analysis issues. If hand-held calculators can be programmed to facilitate data transformation and to perform some of the functions normally performed by larger, slower (in terms of turnaround time) and more costly computers, they will represent a valuable addition to the price analyst's tool kit.

The procedure followed by the researcher was to write several data-analysis programs and to test them on actual data samples in order to 1) develop useful software, and 2) weigh the advantages and disadvantages of working with the programmable calculator and thereby form conclusions about its potential usefulness as a field research tool.

The paper is organized as follows. Chapter Two describes the basic machine, emphasizes its unique features, discusses simple programming procedures, and summarizes its major strengths and weaknesses. The treatment remains non-technical, as the purpose of the chapter is to familiarize those with little or no experience working on programmables with the basic operation of the machine. Chapter Three briefly reviews the mechanics of partitioning memory, entering data, and using magnetic cards. Chapter Four focuses on a series of analytical procedures commonly performed by price analysts. The analytical procedures include:

1) deflating time series

2) moving averages, centered moving averages

3) seasonal adjustment

4) trend analysis

Theoretical considerations relating to each of these procedures are presented and discussed. Programs developed by the author to accomplish the procedures are described in detail, including a complete listing of program steps. Comprehensive user instructions, along with user worksheets, provide step-by-step instruction in the use of the programs. A numerical example is worked out in each case to illustrate the application of the program to an actual data set. The examples were designed with two purposes in mind: demonstration of the program, and instruction of potential users. By working through the examples, the reader will be able to learn how to apply the programs to actual data sets. Although rather limited by conventional standards, the short data sets used in the examples resemble those commonly available to economists working in developing countries. Their use here conforms with the objectives of the study, which is to assess the usefulness of hand-held calculators as a field research tool for performing preliminary rather than final data analysis. Chapter Five summarizes the analytical procedures and evaluates the strengths and weaknesses of programmable calculators as a tool for price policy research in developing countries.

II. THE PROGRAMMABLE CALCULATOR

2.1 Characteristics of Programmable Calculators

Electronic calculators and computers in a wide range of sizes, prices, and capacities today can be found practically everywhere. Although rudimentary electronic computing devices go back forty years or more, not until the development and commercial production of miniaturized circuits during the 1960's did the use of electronic calculators become widespread. Two decades later, literally millions of people operate some type of computing device every day, from the consumer who uses a simple calculator to balance the family checkbook to the scientist who relies on a complex mainframe computer to track satellites in deep space.

Because of their applicability to a broad array of tasks, not all computing devices are suitable for all operations. This chapter describes the basic features of the programmable calculator, explains what distinguishes it from more simple and more complex machines, and summarizes its advantages and disadvantages as a tool for field research. Choice of the Texas Instruments TI-59 model for use in this study is justified, and special features of the machine are described.

The most basic electronic computing device is the simple arithmetic-function calculator, with a keyboard containing zero, the nine integers, the decimal point, and a variable number of function keys. Very elementary calculators contain only four function keys: addition, subtraction, multiplication, and division. Most models contain additional keys, typically including logarithmic conversions, scientific notation, powers and roots, and trigonometric functions. Specialized machines furthermore contain keys useful in particular subject-specific applications, for example business, economics, statistics, physical science. The arithmetic-function calculator can be used to perform many useful arithmetic operations. Values are keyed into the machine by the user, and the appropriate function key is stroked each time an operation is performed.

In contrast to simple calculators, computers can perform a broad range of complex operations, using data which are stored in a memory location and operating in a "higher-level" computer language such as BASIC or FORTRAN. Computers can be distinguished from simple calculators by their ability to store data and program instructions, to perform operations without continuous step-by-step instructions from the user, and to recall instructions which can be combined in an infinite number of ways through use of addressable memory.

The programmable calculator combines the arithmetic ability of the simple calculator with the addressable memory of the computer; it is in effect a hybrid cross between the two. Although differences exist between the many available models of programmable calculators, their essential features can be summarized as follows:

2.1.1 Function Keys

The most versatile programmables come equipped with function keys to perform a variety of arithmetic, statistical, and economic operations. The more useful functions include:

- arithmetic operations (addition, subtraction, multiplication, division)
- absolute value, integer, functional part
- reciprocal, roots, powers
- scientific notation, engineering notation
- logarithmic functions (natural logarithms, decimal logarithms)

- trigonometric functions (sine, cosine, tangent, arcsin, arccos, arctan, degrees, radians, degrees/radians conversions)
- statistical functions (summations, mean, standard deviations)
- polar/rectangular coordinate conversions

In addition to these functions, programmable calculators also feature special control function keys used in writing programs and running them. The special control function keys enable the user to:

- enter data into memory, retrieve data
- control and announce memory partitioning
- enter programs, edit programs, list programs
- step through programs forwards and backwards
- call up subroutines
- implement conditional tests with branching
- start and stop program execution
- pause temporarily during program execution
- clear out data registers
- redirect execution to a different program address
- control the printer

This listing of function keys is only a partial listing. It is not intended to be exhaustive, nor can it be, since the precise array of function keys varies from one machine to the next. However, even the partial listing presented above should make clear that programmable calculators come equipped with two basic types of function keys: those which actually perform calculations or conversions, and those which merely control the operation of a program.

At this point, a short digression on alternative methods of keyboard entry would perhaps be appropriate. Virtually every programmable calculator on the market uses one of two entry methods: algebraic notation and reverse Polish notation. Algebraic notation is more widespread and, because it reflects conventional written algebra, easier for most users to start out with. Using algebraic notation, the addition of 50 and 25 is performed by stroking the keys in the sequence 5,0,+,2,5,=. Reverse Polish notation, preferred by many scientists and engineers, requires that the numerical entries be followed immediately by their operators. Using reverse Polish notation, the addition of 50 and 25 is performed by stroking the keys in the sequence 5,0,ENTER,2,5,+. Although reverse Polish notation may seem "unnatural" at first, with practice it becomes quite easy to use. The main advantage of reverse Polish notation is that it requires fewer key strokes, which can become important with long programs. However, as a general rule the two notations are more or less equivalent, and neither can be considered inherently superior or more desirable.

2.1.2 Memory

What most differentiates programmable calculators from non-programmables is their ability to store both data and sequences of keystrokes (program steps). Data storage takes place in data registers; program steps are recorded in a separate section of memory. The number of data registers and program steps varies considerably from one machine to the next. Elementary programmables contain as few as 10 data registers and 10 step program memories, whereas the most advanced programmables may accommodate several hundred data registers and thousands of program steps.

Since memory limitations often restrict the usefulness of the programmable calculator, the memory capacity is an important consideration that should always be taken into account in selecting a machine. (This is especially true if the calculator is going to be used for price analysis, which typically involves large data sets.)

One very useful feature found in some but not all programmable calculators is the option to re-partition the memory. Although most machines normally operate with a pre-determined number of data registers and a corresponding (though usually different) number of program steps, some calculators come equipped with a special control key which enables the user to re-partition the memory limits (i.e., create more data registers at the expense of fewer program steps, or vice versa). Even though re-partitioning is a zero-sum game, the feature can be extremely valuable. Some programs require very few program steps; by repartitioning the memory to create additional data registers, additional observations can be stored for processing. Conversely, other programs may require a large number of program steps even though very little data need to be input; by repartitioning the memory to increase the number of program steps, the lengthy program can be accommodated.

2.1.3 Recording Capability

Keystroking tends to be a laborious, error-prone process, particularly in the case of sophisticated programs comprising hundreds of steps. To limit the need for keystroking, many programmable calculators feature some sort of recording device which enables a program already keystroked into memory to be stored for later re-use. The most common recording device consists of one or more small magnetic cards. When read through the machine, the cards can be used either to record a program or data set already present in memory, or they can be used to write a previously recorded program or data set back into the machine. Quite obviously, this feature is very time-saving, since long and complex programs which are used regularly can be entered into memory in a few seconds. Different data sets to be processed by a single program can also be entered in this way. Furthermore, since the cards are interchangeable among machines, they represent a convenient and inexpensive means of distributing programs and/or data sets among a large group of users.

2.1.4 Printing Capability

Many programmable calculators can be connected to a printer to produce hard-copy output on a strip of paper tape. An obvious advantage of hard-copy output is that intermediate and final results can be recorded for later inspection. An equally important advantage of hard-copy capability is that the processes of editing and debugging programs is greatly facilitated. Anybody who has ever tried to debug a program without a printer will appreciate this point!) The printer can be used to produce a complete step-by-step listing of an entire program, or simply a listing of selected portions of a program. The contents of the data registers can be printed out as well. This makes possible rapid identification of programming errors and data errors.

The printer can also be used for simple graphical applications, for example plots of data against time, histograms, and alphanumeric output. However, it should be stressed that the printer's abilities are quite limited in this area. The narrowness of the printout tape (7.5 cm) and the lack of a high-resolution graphics capacity limit its usefulness as a tool for graphical analysis.

The distinguishing features of the programmable calculator--function keys, memory, recording capacity, printing capacity--enable it to perform many of the functions of much more complex and expensive computers. Programmable calculators can be used to read in data and instructions, store the data and instructions in memory, perform calculations as prescribed, store and/or read out the results while controlling all aspects of the operation. Although limited in terms of memory, the programmable calculator is nevertheless an extremely powerful computing device.

2.2 Advantages/Disadvantages for Field Research

The programmable calculator is particularly well suited for use in the field. The following characteristics recommend it as a powerful research tool:

2.2.1 Economy

Even the most advanced programmable calculators cost as little as $150-$350; printers cost an additional $150 - $300. This places programmables well below the price range of computers and microcomputers. Operating and maintenance costs do not even compare. Since budgetary limitations often pose a major constraint for research organizations, particularly organizations working in developing countries, the relatively modest expense of the programmable calculator makes it an attractive, cost-effective tool.

2.2.2 Portability

Although some programmables are too big to carry around easily, many fit conveniently into a pocket or briefcase, especially when being used without the printer. The portability of the programmable calculator enables the field researcher to "go to the data", an important consideration when a large number of sites must be visited during the course of the research.

2.2.3 Direct Power Source or Battery Operation

Most programmable calculators can be operated either from a direct power source or from a rechargeable battery pack. This option provides tremendous flexibility for the user. Since a great deal of field research takes place in areas in which electrical power is unreliable at best, the ability to switch over to battery operation frees the user from dependence on local power sources. As a result, the researcher using a programmable calculator for data analysis is spared the constant interruptions which plague computer users.

2.2.4 Speed

Even rather simple arithmetic operations can become tremendously time-consuming when the data set is large and calculations have to be performed manually (for example, deflating a long price series). With a short program, calculations that would take hours to perform by hand can be executed in seconds.

2.2.5 Accuracy

Many types of calculations performed on programmable calculators are not so much conceptually difficult as they are algebraically complex. Whenever a large number of complicated operations is keystroked, the likelihood of an error increases. In cases in which the same complicated operation has to be performed repeatedly on different data, a program can be written to perform the operation, keystroked a single time, checked carefully for errors, and used over and over. Since the program is keystroked only once, the chance of an error is minimized.

2.2.6 Simplicity

Unlike more sophisticated computers which must be programmed in a higher level computer language, programmable calculators operate in sequences of algebraic expressions. The simplicity of the keyboard language obviates the need for lengthy and expensive computer science training. Almost everyone can learn to program a calculator with a few hours of practice, and it is not difficult to convey programming skills to others. This makes it easy for the price analyst to combine research and extension activities.

2.2.7 "Hands-On" Tool for Data Analysis

The limited memory capacity of most programmable calculators requires that complex mathematical and statistical procedures be broken down into stages. Intermediate results from each stage are recorded by the user for re-entry as input into the next stage of the analysis. Although this makes the programmable slower to use than a computer, the stage-by-stage procedure forces the analyst to work through all the calculations one step at a time. Many analysts claim that as a result they become much more familiar with the data and eventually come better to understand the procedures being implemented. The close contact between the researcher and the analysis provides a valuable learning experience which is missed when the data is sent off to a distant computer.

2.2.8 Availability of Software

The widespread popularity of the programmable calculator has resulted in the formation of numerous user's groups and program exchange services for developing, publicizing, and distributing software. Literally thousands of user-written programs have by now been made available, covering a wide range of theoretical and applied topics. Many users do not possess advanced programming skills, but rely on public-domain programs for most of their software needs.

The advantages described above (economy, portability, battery operation, speed, accuracy, simplicity, "hands on" characteristic, and availability of software) recommend the programmable calculator as a valuable research tool. However, it must be pointed out that the numerous advantages are partially offset by several disadvantages. For all their attractive features, programmable calculators clearly do suffer from a number of limitations. Disadvantages of programmable calculators include:

2.2.9 Memory

Despite recent hardware innovations which have made possible expansion of memory capacity on some models, programmable calculators cannot be used to perform complex operations on extremely large data sets. This represents a problem for the price analyst, since it complicates multivariate regression analysis on extended data series.

2.2.10 Programming Language

The keyboard programming language, while easy to learn, is inherently limited. The wide range of pre-programmed commands which can be executed on a computer by means of a single command is simply not available for use in keyboard programming. This effectively limits the use of the programmable calculator to applications whose solution can be structured in terms of mathematical operators.

2.2.11 Data Entry

Because data entry into the data register requires laborious and error-prone keystroking, programmable calculators are not particularly well-suited for problems requiring a large number of data entry operations.

2.2.12 Printed Output

Although useful for some purposes (e.g. recording intermediate results and debugging programs), the printed output produced by most programmable calculators is inadequate for formal documentation of final results. Alphanumeric printing requires too much program space to be of real use, and it is in any case impossible to produce manuscript-quality copy on standard (8 1/2" x 11") paper.

2.2.13 Hardware Problems

Like any other piece of complex electronic equipment, the programmable calculator has a tendency to suffer mechanical problems. Bernsten and Banta (1982) have described some of the more common hardware problems encountered during several years of field research with programmables in Asia. In a high-dust, high-humidity environment, the Texas Instruments TI-59 seems to have a life expectancy of 2-3 years. The intricate circuitry apparently can be protected to some extent by storage in a controlled-climate environment, but eventually mold and mildew will prevail. Electrical power surges present another hazard; they have been known to damage the calculator, recharger, and printer. Should maintenance be required, it is often difficult to reach a reliable service center. The major manufacturers are currently expanding their service facilities in the developing world, but users in many countries may face delays in getting defective or damaged machines repaired.

2.3 Justification of the Choice of the TI-59

Two models of programmable calculator which currently enjoy widespread usage -- the Texas Instruments TI-59 and the Hewlett-Packard HP-97 -- combine the features required for price analysis work. Both are advanced programmable calculators with a wide range of function and special control keys. They feature direct and indirect storage, the capacity to record programs on magnetic cards, and a printer option. Both are portable, easy to use, and capable of being operated from a battery pack. The TI-59 uses algebraic notation, while the HP-97 uses reverse Polish (a difference of little significance).

Of the two models, the TI-59 was selected for use in this study. The choice was made based on the following considerations:

1. The TI-59 enjoys more widespread usage at present, particularly for agricultural applications. (Most state extension services in the United States rely on the TI-59.) Instructional manuals are currently available in French and Spanish, facilitating the diffusion of the TI-59 into french- and spanish-speaking parts of the world.
2. The cost of the TI-59 with printer is approximately half the cost of the HP-97.
3. The TI-59 is a more compact machine, making it much more suitable for research in the field. When detached from the printer and operated as a hand-held calculator, the TI-59 can easily be carried around. The HP-97 is more bulky and hence better used as a desk-top unit.
4. The memory capacity of the TI-59 far exceeds that of the HP-97. The TI-59 can be re-partitioned to provide four times as many program steps as the HP-97, or four times as many data registers.
5. The TI-59 can be used with solid-state software modules to dramatically increase operational capacity. A module is a small semiconductor containing up to 5,000 program steps upon which an assortment of useful programs has been permanently etched. Each module can be removed and replaced by a different module containing a new set of programs. Use of the solid-state modules in effect increases the data storage capacity of the calculator, since no program steps are taken up in regular memory, which can therefore be repartitioned to create additional data registers. Modules are currently available with the following titles: Applied Statistics, Real Estate and Investment, Aviation, Marine Navigation, Surveying, Leisure, Agriculture, Securities Analysis, Business Decisions, Math/Utilities, Electrical Engineering, RPN Simulator, Master Library.

6. A large number of user-written programs has been assembled and made available to other users by an organization calling itself Professional Program Exchange. Payment of an annual membership fee entitles the TI-59 user to receive the organization's publications (including a monthly newsletter and a voluminous software catalogue containing listings for thousands of programs). Members may also order programs directly from the program exchange.

2.4 Summary

The purpose of this chapter has not been to attempt a detailed technical analysis of the capacities of the programmable calculator, but rather to acquaint the reader with the basic characteristics of the machine and to highlight those features which make it a potentially valuable tool for field research. Choice of the Texas Instruments TI-59 for use in this study was justified for technical, economic, and practical reasons. (For a complete technical description of the machine and detailed instructions in how to program, refer to the user's manual published by Texas Instruments, _Personal Programming_, 1977.)

III. PRELIMINARY NOTES FOR THE TI-59 USER

Since this is not meant to be an instructional manual, use of the TI-59 calculator is not explained in detail. A basic understanding of technical operating procedures is presumed. (See the user guide published by Texas Instruments, Personal Programming, or the excellent instructional book by Aronofsky, Frame, and Greynolds titled Programmable Calculators: Business Applications.) However, it is recognized that specific operating details are very easily forgotton when the calculator is not being used on an everyday basis. The following pages are therefore included to refresh the memory of the user by elaborating on several key features of the TI-59 and summarizing important operating procedures. Four topics are addressed: 1) Partitioning Memory, 2) Use of Magnetic Cards, 3) Entering a Program, and 4) Entering Data.

3.1 Partitioning Memory

In order better to understand program design, data storage, and use of the magnetic cards, it is important first to understand how the memory of the TI-59 calculator can be partitioned. Recall that the memory of the TI-59 is comprised of program registers and data registers. Program registers are used to store the sequence of keyboard commands which make up a program, while data registers can be thought of as pigeonholes into which are placed a series of variables (usually data used in running the program or processed by the program).

The number of program registers and data registers located in memory at any given time depends on how the memory is partitioned. Normally there are 480 program registers and 60 data registers. Each data register can hold eight program registers, so this represents an equal allocation of memory space to program registers and data registers. When the calculator is first turned on it automatically adopts this "default" partitioning, which will be retained unless specific commands are entered to modify it.

Program registers are numbered consecutively with three-digit numbers starting with 000. Data registers are numbered consecutively with two-digit numbers starting with 00. Thus, the default partitioning (480 program registers, 60 data registers) is written: 479.59.

In certain instances it will be desirable to repartition memory. Typically the need arises when a program exceeds 480 steps (necessitating allocation of more memory space to program registers), or when a relatively short program is being used with a large amount of data (necessitating allocation of more memory space to data registers).

Repartitioning is a zero-sum game. Program registers can be added only at the expense of data registers (in a ratio of 8:1, i.e., eight program registers gained for each data register lost), and vice versa. The trade-off can be made only in units of ten data registers (equivalent to 80 program registers). In other words, beginning with the initial default partitioning of 479.59, 10 data registers can be gained at a cost of 80 program registers (399.69), 20 data registers can be gained at a cost of 160 program registers (319.79), and so on. Moving in the other direction, 80 program registers can be added by giving up 10 data registers (559.49), 160 program registers can be added by giving up 20 data registers (639.39), and so on.

The memory of the TI-59 calculator can be depicted diagrammatically:

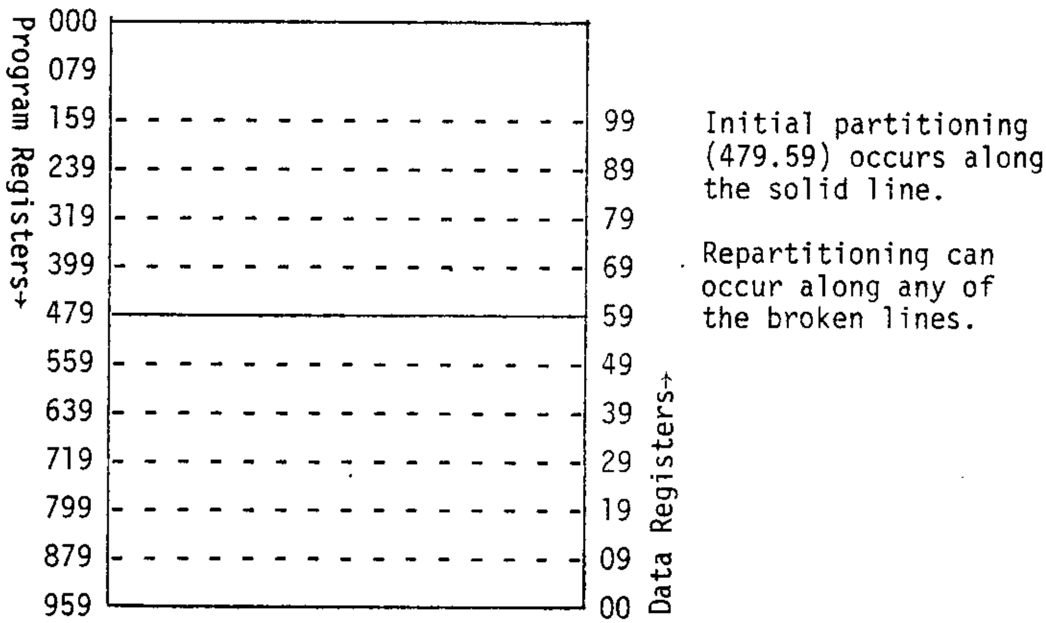

FIGURE 1

MEMORY-PARTITIONING DIAGRAM

Note that the limits to repartitioning are asymmetrical. Although all the data registers can be sacrificed for program registers (959.00), all of the program registers cannot be converted into data registers. At a minimum, 160 program registers must remain, along with the maximum number of 100 data registers (159.99). (Technically, the ceiling on the number of data registers results from the limitation imposed by the two-digit labelling code.)

All four of the programs described below require a different partitioning than the initial default partitioning (479.59). To accommodate these programs, the memory must be repartitioned by means of the special function command, Op* 17. To repartition memory, enter a single-digit number into the display to indicate the number of units of ten data registers desired. (For example, the number 8 indicates 8 units of 10, or 80 data registers desired.) Then press Op* 17. The new partitioning (319.79) will appear in the display, signifying that the memory has been repartitioned.

Be careful not to repartition whenever program steps and/or data values are actually in the calculator, unless they have previously been recorded on a magnetic card. Program steps and/or data values will be erased from those registers which are repartitioned (although values stored in the non-repartitioned registers remain unaffected).

3.2 Use of Magnetic Cards

An extremely important feature of the TI-59 calculator is that the contents of memory, both program registers and data registers, can be stored on magnetic cards. The main advantage of this feature is obvious: lengthy programs and data sets which are used repeatedly need not be keyed in manually more than once. This results in considerable time savings and significantly reduces the likelihood of keystroking errors.

The entire contents of memory, however partitioned, can be stored on two magnetic cards. Each card has two sides on which memory registers can be recorded. The memory of the TI-59 is divided into four banks, corresponding to the four sides of a pair of cards. The banks can be depicted diagrammatically on the memory-partitioning diagram:

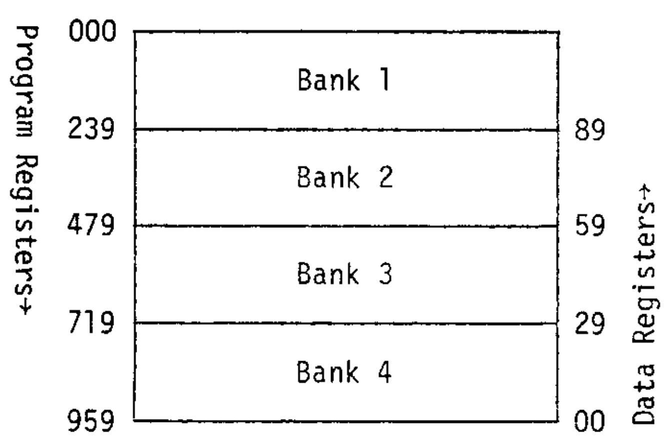

FIGURE 2

LOCATION OF MEMORY BANKS

The process of recording a program or data temporarily stored in the calculator onto a magnetic card is known as writing onto the card. One bank of memory can be written onto each side of a single card. Normally both sides of a card are used (i.e., to store two banks of memory), but on occasion it will be desirable to write on only one side of a card (i.e., to store a short program by itself, or a small data set).

The procedure for writing onto a card is very simple. Enter 1, 2, 3, or 4 into the display to indicate which memory bank is to be written onto the card. Then press Write*. Insert a blank card into the slot on the right side of the calculator, pushing it gently until it is pulled through automatically. The recorded card will emerge on the left, and the bank number (1, 2, 3, or 4) will appear in the display to confirm that the card has been recorded properly. A flashing display indicates that the card was not recorded properly; repeat the entire procedure until the card is recorded successfully.

Be careful to document the card. With a pencil or marker, write the title of the program (or a description of the data) in the spaces provided. Also indicate which banks were recorded, and be sure to note the partitioning of memory. Boxes are additionally provided to record the functions associated with the user-defined label keys, A to E and A' to E'.

The process of entering a program and/or data permanently stored on a magnetic card back into memory is known as reading the card. The procedure for reading a card is equally simple. First, make sure that the memory partitioning in the calculator corresponds to the partitioning on the card. If the two are not identical, the card cannot be read. Press the CLR key and insert the card to be read into the slot on the right side of the machine, pushing it gently until it is pulled through. This method will result in whatever bank is on that side of the card being read. To restrict the calculator to reading only a specified bank, press CLR and then press 1, 2, 3, or 4 to indicate which bank is to be read. If any other bank happens to be on the side of the card fed into the machine, that bank number is flashed on the display, and no read occurs.

Note: Magnetic cards should be handled as little as possible. The working surface (the metallic gray side) is easily scratched or contaminated by contact with moisture, dust, or chemical agents. Even fingerprints can ruin a card, particularly in warm or hot climates. Always try to handle cards by the edges, and avoid placing them on exposed surfaces. The carrying case sold with every set of blank cards provides valuable protection.

3.3 Entering a Program

When a program is used for the first time, it must be entered into the calculator manually. With the calculator in the LEARN mode, the precise sequence of program steps must be keyed in. Once the program has been entered in this fashion, it can be written onto magnetic cards for subsequent re-use.

Manual program entry is quite simple and can be summarized as follows:

1) Turn off the calculator and then turn it back on. This will clear the memory.
2) Partition the memory as directed by the user instructions. (Skip this step if the initial default partitioning of 479.59 is appropriate.)
3) Press the LRN key. The following digits will appear in the display: 000 00. This signifies that the calculator is now in the LEARN mode and is ready to accept program steps, beginning with step 000.

4) Key in the entire program, being careful to avoid mistakes.

5) When the program has been keyed in, proofread it carefully. This can be accomplished manually or with the printer.

   a) Manually: Remain in the LEARN mode and use the SST key (single-step forward) and BST key (single-step backward) to step through the program. Check each program step as it appears in the display. When satisfied that the program is error-free, press the LRN key to return to the RUN mode.

   b) If editing is necessary, return to the LRN mode. Key-stroking errors can be corrected by re-entering the correct step on top of the incorrect step. Superfluous steps can be deleted by use of the DEL* key, and omitted steps can be inserted after a space has been created with the INS* key. (Refer to Personal Programming, pp. IV-21, V-48, 51 for complete editing instructions.)

7) If the program is to be used more than once, write it onto one or more magnetic cards. (See "Use of Magnetic Cards," pp.25, ff.)

3.4 Entering Data

Although the data entry process can be speeded up considerably through the use of magnetic cards, every data set must initially be entered into the calculator by hand. Manual data entry is a simple, though laborious process and can be summarized as follows:

1) Carefully read the user instructions which accompany the program being used. Never begin entering data until the program instructions and input data requirements are well understood.

2) Partition the memory as directed, using the OP* 17 code (see "Partitioning Memory", p.22).

3) Determine the correct format for data entry. Establish exactly what data are needed and what registers they are supposed to go into. Use Worksheet 5 (Data Storage) to avoid mistakes and to provide a written record of what data have been entered.

4) Enter the data manually from the keyboard. Key a value into the display in exactly the form in which it is to be stored, and then press STO nn, where nn is a two-digit number corresponding to a specific data register. To verify that the value has been entered correctly, press RCL nn to bring the contents of the data register nn back into the display. If the value has been entered incorrectly, simply re-enter the correct value on top of the incorrect value.

5) If the calculator is being operated with a printer, the contents of the data registers can be listed for easy proofreading. Enter the number of the first data register to be listed into the display, and then press INV List*. The contents of all data registers will be printed out, beginning with the register entered in the display.

6) If the data are to be used more than once, write the contents of the data registers onto one or more magnetic cards. (See "Use of the Magnetic Cards", p.25).

IV. PROGRAMS

4.1 PROGRAM 1: DEFLATING PRICE DATA

4.1.1 Theoretical Discussion

One problem frequently encountered by price analysts attempting to estimate specific economic parameters from time series data is changes in the general price level caused by inflation (or, much more rarely, by monetary revaluation). It is difficult to analyze a price series for a particular commodity or group of commodities without explicit knowledge of other prices throughout the economy, since the real value of a particular commodity is established relative to the values of other goods and services. Inflation can effectively mask changes in real price. For example, if the nominal price of rice remains constant while all other prices in the economy rise, then the real price of rice has fallen. This type of situation is quite common, particularly in the many countries suffering from high and persistent levels of inflation.

Price analysts routinely attempt to correct for changes in the general price level by deflating nominal prices. Deflation consists very simply of removing the effect of a changing general price level by dividing nominal prices by an index constructed to track the behavior of the general price level. (For a discussion of the construction of price indices, see Allen, 1975; Tomek and Robinson, 1972). The deflated series indicates how the price series being analyzed has changed relative to the index.

Specific reasons for deflating price data include both economic and statistical reasons:

1) Economic theory postulates that with rare exceptions producers and consumers respond only to changes in real prices. Changes in nominal prices, which may be due entirely to inflation, generally do not influence

supply and demand unless there is a "money illusion" effect.

2) In an inflationary economy, nominal prices tend to rise steadily over time. This can present a problem for analysts performing econometric estimations, since a trend of gradual price increases can introduce multicollinearity between prices and other variables, for example, population and income. Deflation often removes the gradual rising trend from price data and thus improves regression results.

3) One important assumption of the classical linear regression model is the assumption of homoscedasticity, which posits that the error terms in a regression equation are distributed with constant variance ($E(U_i^2) = \sigma^2$). Violation of this assumption, or heteroscedasticity, results whenever the variance of the error terms is correlated with an explanatory variable ($E(U_i^2) = \sigma_i^2$). From a purely statistical ppint of view, deflation is justifiable whenever heteroscedasticity is suspected, since it reduces the magnitude of the prices and hence the variability of the error term. if the two are correlated. (For a more extensive treatment of of the role of deflation in agricultural price analysis, see Shepherd, 1963; Tomek and Robinson, 1972.)

4) Market extension economists frequently are asked to prepare historical price information for farmers. When inflation is present, past prices expressed in current terms appear very low; in order to allow meaningful comparisons with current prices, the past prices must be translated into constant denominational units. Either they can be deflated by means of an index based on a past year as the base year, or they can be inflated to current prices by means of an index based on the current year as the base year.

4.1.2 Method and Equations

Deflating a price series is a conceptually simple, although laborious process. Required data include the nominal prices which are to be deflated, as well as a corresponding index. Various price indices are calculated and published regularly by most statistical reporting services; the indices differ in that they are based on different "baskets" of goods (e.g., consumer price index, producer price index, retail price index, wholesale price index). Any year may be used as the base year (index value = 100). Normally, nominal prices in years preceding the base year are augmented, and nominal prices in years following the base year are decreased by the deflation procedure. Occasionally it may be desirable to convert a price series to current-year prices, in which case the current period is used as the base. In this case, all of the nominal prices in the series will be inflated to current-period prices, assuming inflation has occurred.

The program uses the following equation to deflate nominal prices by a price index:

$$\frac{\text{Nominal price}}{\text{Index number (in decimal form)}} = \text{Deflated price}$$

4.1.3 Input/Output

Partitioning: 239.89

Input: The nominal price series and the price index can be entered manually or from a magnetic card. (See "Entering Data", p.28) The program is designed so that up to 40 observations can be entered at a time. For longer series, the data must be entered and processed in groups of 40 observations or less, i.e., the first set of 40 or less observations must be entered and deflated before the second set can be entered and deflated. Use of the worksheet facilitates this process and reduces the risk of errors. Because the memory is partitioned such that all of the program steps are located on bank 1, multiple sets of data can be entered manually or from cards (banks 2,3,4) and processed without any need for re-entering the program itself, which remains unaffected by repeated use. Separate output is generated for each set of input data. This makes it easy to deflate a single long series (in sections) or many different series (e.g., for different commodities) using the same program.

Data entered from magnetic cards must be stored on the card as follows:

Register 00: *n* (number of observations on the card, 0 *n* 40)

Registers 01-40: nominal prices

Registers 41-80: price index numbers (in decimal form)

Registers 81-89: blank

Data entered manually must be keystroked into the appropriate data registers, as described above.

A price series and/or index being stored on magnetic cards can be updated very easily. As long as blank registers remain, the most recent observations can simply be added on to the existing series by manual entry. If no more blank registers remain, it will be necessary to begin a new set of data cards. Always remember to re-record data cards whenever new observations have been entered.

Memory limitations do not allow storage of the price series and the index numbers on separate banks. Although this precludes independent storage of the two series, it is nevertheless quite easy to change one series while leaving the other intact. Read banks 2,3,4 into the calculator to enter both series into the data registers. Then enter the revised series manually, on top of the old series. Finally, re-record banks 2,3,4 to create a permanent record of the revised data.

Output: The program calculates and prints out the deflated prices, preceding each with a label identifying the period. The deflated series is stored in registers 01-40, replacing the nominal price series. In addition, the program calculates a grand total of deflated prices (stored in register 85) as well as an average value for the deflated price series (stored in register 86). These values are useful for linking several series of chronologically related data. If the program is used without the printer, a flag can be set so that the deflated prices are displayed one by one for manual transcription. (See "User Instructions" to learn how to select this option, p.36).

4.1.4 User Instructions

a) Use With Printer

Step	Procedure	Enter	Press	Display (Printed Output)
1	Partition memory to 239.89	9	Op* 17	239.89
2	Read in program (program card 1; bank 1)	1	(enter program card 1, bank 1)	1.
3	Enter price and index data (data cards 1, 2; banks 2, 3, 4)	2	(enter input data card 1, bank 2)	2.
		3	(enter input data card 2, bank 3)	3.
		4	(enter input data card 2, bank 4)	4.
(3a)	(If data are to be entered manually instead of from cards, enter price data and index numbers manually at this point. See example below, "Manual Data Entry Method".)			
4	Deflate price series	-	A	(deflated prices)
(5)	Calculate grand total of deflated prices	-	E	(grand total)
(6)	Calculate average deflated price	-	E'	(average price)
7	Record deflated price series on magnetic cards		INV Fix	
		2	Write* (enter output data card 1, bank 2)	2.
		3	Write* (enter output data card 2, bank 3)	3.
		4	Write* (enter output data card 2, bank 4)	4.
(8)	To deflate another section of the same series, or a different series, repeat steps 3 and 4.			

b) Use Without Printer

The program is designed for optional use without a printer. To select this option, it is necessary to set a flag during the data input stage. The deflated prices (output) are displayed one at a time. When the first price has been transcribed, press the R/S key to obtain the second price, etc.

Step	Procedure	Enter	Press	Display (Output)
1,2,3	(same as above)			
4	Set flag to select No-printer option	- -	St Flg* 0	
5	Deflate first price	-	A	First price
6	Deflate second price	-	R/S	Second Price
7	Deflate third price	-	R/S	Third price
⋮	(continue price by price)			
(8)	Verify current period	-	RCL 87	Current Period
9	Record deflated price series on magnetic cards	-	INV Fix	
		2	Write* (enter output data card 1, bank 2)	2.
		3	Write* (enter output data card 2, bank 3)	3.
		4	Write* (enter output data card 2, bank 4)	4.
(10)	To deflate another section of the same series, or a different series, repeat steps beginning with step 3.			

A blank worksheet, "Deflating Price Data (Worksheet 1)", is included in the appendix. The worksheet can be photocopied for use in conjunction with Program 1.

4.1.5 Example 1: Deflating Price Data

Problem Statement: You are an agricultural economist hired by the government of Ibiapaba region, Brazil, to identify sources of price variability among locally-produced tomatoes. In collecting a series of monthly wholesale prices (in cruzeiros/kg), you determine that Brazil's double-digit inflation has effectively masked changes in real price. Consequently, you decide to deflate the nominal price data you have collected by a consumer price index (1977 = 100). The deflated series will reflect variations in real price only (i.e., holding inflation constant) and thus will be more suitable for further analysis.

Use pre-recorded program and input data cards to enter the program steps and the data (nominal prices and consumer price index in decimal form). (see Section 3.4) Record deflated prices on data output cards.

Data:

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Nominal Prices												
1977	3.15	3.78	4.76	2.22	2.12	3.24	5.42	4.54	3.08	3.57	3.57	3.65
1978	2.13	3.14	7.69	4.78	5.62	4.14	2.30	3.29	4.52	3.81	4.15	4.31
1979	4.39	5.42	7.48	7.05	9.91	8.12	9.36	5.18	2.90	7.11	11.79	12.97
Price Index												
1977	.8476	.8744	.9107	.9478	.9818	1.001	1.022	1.035	1.053	1.082	1.110	1.134
1978	1.164	1.204	1.243	1.285	1.326	1.374	1.413	1.451	1.488	1.531	1.573	1.597
1979	1.655	1.717	1.816	1.835	1.929	1.996	2.083	2.204	2.374	2.498	2.637	2.330

(Data Source: M. Weber, MSU)

Step-by-step procedure:

Step	Enter	Press	Display (Output)	Comment
1	9	Op* 17	239.89	Partition memory
2	1	(enter program card 1, bank 1)	1.	Read in program
3	2	(enter data input card 1, bank 2)	2.	Read in nominal prices, index (bank 2)
4	3	(enter data input card 2, bank 3)	3.	Read in nominal prices, index (bank 3)
5	4	(enter data input card 2, bank 4)	4.	Read in nominal prices, index (bank 4)

Step	Enter	Press	Display (Output)	Comment
Printer Option:				
6.1a	-	A	(1. PER) (3.72)	First period label First deflated price
			(2. Per) (4.32) ⋮	Second period label Second deflated price
No-Printer Option:				
6.1b	-	Set Flg 0		Set Flag 0 (No-printer)
6.2b	-	A	3.72	First deflated price
6.3b	-	R/S	4.32	Second deflated price
6.4b	-	R/S	5.23	Third deflated price
(continue pressing R/S until all deflated prices have been displayed)				
(7)	-	Σ	122.537 SUM	Grand total of deflated prices
(8)	-	Σ'	3.40381 MEAN	Average deflated price
9	-	INV Fix		Remove fix (necessary to ensure non-rounded values are recorded)
10	2	Write* (enter output data card 1, bank 2)	2.	Record deflated prices, index
11	3	Write* (enter output data card 2, bank 3)	3.	Record deflated prices, index
12	4	Write* (enter output data card 2, bank 4)	4.	Record deflated prices, index

Result: The deflated (i.e., real) monthly price series is calculated as follows:

Data:

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Deflated (Real) Prices												
1977	3.72	4.32	5.23	2.34	2.16	3.24	5.30	4.39	2.92	3.30	3.22	3.22
1978	1.83	2.61	6.18	3.72	4.24	3.01	1.63	2.27	3.04	2.49	2.64	2.70
1979	2.65	3.16	4.12	3.74	5.14	4.07	4.49	2.35	1.22	2.85	4.47	4.58

4.1.6 Program 1 Listing: Deflating Price Data

LOC	Code	Key	Comment
000	76	LBL	Start
001	11	A	
002	00	0	
003	42	STO	
004	85	85	
005	42	STO	
006	86	86	
007	01	1	
008	42	STO	Initialize counters
009	87	87	
010	42	STO	
011	88	88	
012	04	4	
013	01	1	
014	42	STO	
015	89	89	
016	43	RCL	
017	00	00	
018	85	+	Set test value = N + 1
019	01	1	
020	95	=	
021	32	X⇄T	
022	76	LBL	Begin loop
023	38	SIN	
024	73	RC*	
025	88	88	
026	55	÷	Calculate deflated price
027	73	RC*	
028	89	89	
029	95	=	
030	72	ST*	
031	83	88	
032	44	SUM	Store result
033	85	85	
034	87	IFF	No-printer option
035	00	00	
036	28	LOG	
037	69	OP	
038	00	00	
039	03	3	
040	03	3	
041	01	1	
042	07	7	
043	03	3	Print period label
044	05	5	
045	00	0	
046	00	0	
047	69	OP	
048	04	04	
049	43	RCL	
050	87	87	

LOC	Code	Key	Comment
051	69	OP	
052	06	06	
053	58	FIX	
054	02	02	
055	73	RC*	Print deflated price
056	88	88	
057	99	PRT	
058	22	INV	
059	58	FIX	
060	01	1	
061	44	SUM	
062	87	87	Increment counters
063	44	SUM	
064	88	88	
065	44	SUM	
066	89	89	
067	43	RCL	
068	87	87	Test for remaining observations
069	22	INV	
070	67	EQ	
071	38	SIN	
072	00	0	
073	42	STO	
074	87	87	Clear counter registers
075	42	STO	
076	88	88	
077	42	STO	
078	89	89	
079	91	R/S	Stop
080	76	LBL	
081	28	LOG	
082	58	FIX	Display deflated price
083	02	02	
084	73	RC*	
085	88	88	
086	91	R/S	
087	22	INV	
088	58	FIX	Continue deflating
089	61	GTO	
090	00	00	
091	60	60	
092	76	LBL	
093	15	E	Grand total option
094	69	OP	
095	00	00	
096	03	3	
097	06	6	
098	04	4	
099	01	1	
100	03	3	
101	00	0	

LOC	Code	Key	Comment
102	03	3	Print sum label
103	00	0	
104	69	OP	
105	04	04	
106	43	RCL	
107	85	85	Print grand total
108	69	OP	
109	06	06	
110	91	R/S	
111	76	LBL	Average price option
112	10	E'	
113	69	OP	
114	00	00	
115	03	3	
116	00	0	
117	01	1	
118	07	7	Print MEAN label
119	01	1	
120	03	3	
121	03	3	
122	01	1	
123	69	OP	
124	04	04	
125	43	RCL	
126	85	85	
127	55	÷	Calculate average deflated price
128	43	RCL	
129	00	00	
130	95	=	
131	69	OP	
132	06	06	Print result
133	42	STO	Store result
134	86	86	
135	91	R/S	Stop

Merged Codes

62 Pgm Ind	72 STO Ind	83 GTO Ind
63 Exc Ind	73 RCL Ind	84 Op Ind
64 Prd Ind	74 SUM Ind	92 INV SBR

4.2 PROGRAM 2: MOVING AVERAGES, CENTERED MOVING AVERAGES

4.2.1 Theoretical Discussion

Agricultural product prices, it has been noted, tend to be highly volatile. Supply-side characteristics (e.g., the biological nature of production, time lags, yield variability, perishability of many commodities) and demand-side characteristics (e.g., inelastic demand for many commodities, seasonal demand) interact to cause extreme price fluctuations. Careful analysis reveals that these price fluctuations generally have both a stochastic (random) and a non-stochastic (non-random, or persistent) component).

Stochastic price changes are for the most part short-term fluctuations caused by day-to-day changes in the literally hundreds of factors affecting prices, including past prices, market conditions, political events, weather, and expectations concerning the future.

Non-stochastic price changes include three major types: 1) seasonality, 2) cycles, and 3) trends. Seasonality can be defined as a regularly repeating price pattern that is completed once every twelve months. Seasonality in prices may be caused by supply conditions (e.g., crop cycles, climate) or by demand conditions (e.g., seasonal consumption patterns, holidays). Cycles are patterns that repeat regularly over time, ostensibly as the result of lagged responses to changes in price, biological growth cycles, and other variables. Although a true cycle is self-energizing and not caused by chance factors, opinions differ as to whether the cyclical behavior exhibited by many agricultural product prices is self-perpetuating or externally induced. (See Tomek and Robinson, 1981, pp. 178,ff). Trends are persistent, long-term increases or decreases in prices thought to be associated with changes in the general price level (i.e., inflation or deflation), changes in the taste preferences of consumers, technological changes in production or processing, changes in institutions, and/or demographic changes (e.g., increases in population and income).

Analysts who want to forecast commodity prices must be able to account for the variability associated with many agricultural product prices. Although techniques exist for quantifying the non-stochastic components (seasonality, cycles, trends), the stochastic component is extremely difficult to predict with certainty. Rather than attempt to quantify short-term stochastic variability, the usual approach is to transform the raw price data by means of some smoothing technique. Smoothing provides a means of removing or at least reducing stochastic variability in time series data. Smoothing greatly facilitates the price analyst's task by making it easier to discern and quantify non-stochastic patterns such as seasonality, cycles, and trends. Once discerned and quantified, these non-stochastic components can be removed or otherwise accommodated.

Perhaps the most widely used smoothing technique is the simple moving average. Calculation of a series of n-period simple moving averages merely involves substitution for each value in a time series by a simple average of its values over the preceding _n_ periods. The degree of smoothing depends on the length of the period chosen: the larger is _n_, the smoother will be the moving average series. Moving averages are typically used on monthly data, which tend to be more highly variable than annual or quarterly data. The length of the period chosen (i.e., the size of _n_) usually depends on the use of which the smoothed series is to be put. Twelve-month moving averages are generally calculated for the construction of seasonality indices (see Program 3), while seven-, four-, and even three-month moving averages are widely used in commodity analysis work.

One problem with the simple moving average is a possible bias due to trend, since only past and current values are used in computing the average. For example, with a strong upward trend the simple moving average will consistently underestimate the actual price in a given period because only (lower) past prices are used in calculating the average. This problem is easily overcome by centering the moving averages at the mid-point of the period over which they are calculated. Centered moving averages are less biased than simple moving averages and are routinely calculated by price analysts working with agricultural commodities.

4.2.2 Methods and Equations

Calculation of simple moving averages and centered moving averages is a straightforward, mathematically simple procedure. However, the computations require a considerable amount of arithmetic and can be quite tedious if performed manually.

a) Simple Moving Averages

The simple n-period moving average is calculated by means of the following equation: $\text{Average price}_n = (\text{price}_1 + \text{price}_2 + \ldots + \text{price}_n)/n$

Subsequent average prices in the series are calculated by incrementing all the subscripts by one, thus shifting the set of prices by one period.

The simple moving average is best illustrated by an example. Assume the objective is to calculate a series of three-month simple moving averages to smooth a series of monthly rice prices. The first three averages would be calculated as follows:

$$\text{(simple) Average Price}_{\text{March}} = (\text{price}_{\text{January}} + \text{price}_{\text{February}} + \text{price}_{\text{March}})/3$$

$$\text{(simple) Average Price}_{\text{April}} = (\text{price}_{\text{Feburary}} + \text{price}_{\text{March}} + \text{price}_{\text{April}})/3$$

(simple) Average $\text{Price}_{\text{May}}$ = ($\text{price}_{\text{March}}$ + $\text{price}_{\text{April}}$ + $\text{price}_{\text{May}}$)/3
(note that averages cannot be calculated for the first (n-1) periods, unless earlier price data are available.)

b) Centered Moving Averages

Centering a moving average is simple when n (the number of periods averaged) is odd. The equation used is nearly identical to the equation used in calculating simple moving averages. The only difference occurs in the subscripts, which are adjusted so that the computed average is located at the midpoint (i.e., associated with the middle observation) of the set of n periods.

The n-period centered moving average where n is odd, centered around period t, is calculated by means of the following equation:

Average price = (price_{t-k} + ... + price_{t} + ... + price_{t+k})/n
where n = (2k + 1), an odd number.

Returning to the rice example, the first three values in a series of three-month centered moving averages would be calculated as follows:

(centered) Average $\text{Price}_{\text{February}}$ = ($\text{price}_{\text{January}}$ + $\text{price}_{\text{February}}$ + $\text{Price}_{\text{March}}$)/3

(centered) Average $\text{Price}_{\text{March}}$ + ($\text{price}_{\text{February}}$ + $\text{price}_{\text{March}}$ + $\text{Price}_{\text{April}}$)/3

(centered) Average $\text{Price}_{\text{April}}$ = ($\text{price}_{\text{March}}$ + $\text{price}_{\text{April}}$ + $\text{price}_{\text{May}}$)/3
(Note that averages cannot be calculated for the first ($\frac{n-1}{2}$) periods unless earlier price data are available.)

Centering a moving average is more difficult when n (the number of periods averaged) is even. In this case, the average calculated by means of the usual equation is centered between two months rather than in the middle of a single, centrally-located month. For example, a twelve-month centered moving average based on a year's worth of data is located, strictly speaking, exactly between June and July.

Several techniques have been developed to remedy this problem. The technique used here centers the moving average in the middle of a particular period by taking the average of two moving averages located at the beginning and at the end of the period. Thus, a twelve-month centered moving average for June would be calculated by summing the twelve-month moving averages centered between May and June and between June and July and dividing the result by two.

The n-period centered moving average where n is even, centered around period t, is calculated by means of the following equations:

(1) $\text{Average Price}_{t/t-1} = (\text{price}_{t-n/2} + \ldots + \text{price}_{t} + \ldots \text{price}_{t+n/2-1})/n$

(2) $\text{Average Price}_{t/t+1} = (\text{price}_{t-n/2+1} + \ldots + \text{price}_{t} + \ldots \text{price}_{t+n/2})/n$

(3) $\text{Average Price}_{t} = (\text{average price}_{t/t-1} + \text{average price}_{t/t+1})/2$

Returning yet again to the rice example, the first value in a series of four-month centered moving averages would be calculated as follows:

$\text{Average Price}_{\text{February/March}} = (\text{price}_{\text{January}} + \text{price}_{\text{February}} + \text{price}_{\text{March}} + \text{price}_{\text{April}})/4$

$\text{Average Price}_{\text{March/April}} = (\text{price}_{\text{February}} + \text{price}_{\text{March}} + \text{price}_{\text{April}} + \text{price}_{\text{May}})/4$

$\text{(Centered) Average Price}_{\text{March}} = (\text{average price}_{\text{February/March}} + \text{average price}_{\text{March/April}})/2$

(Note that averages cannot be calculated for the first $(\frac{n-1}{2})$ periods unless earlier price data are available.)

4.2.3 Input/Output

Important: In order to expand its data-handling capacity, this program has been divided into two separate sub-programs, to be used independently or together. The first sub-program (sub-program 2A) calculates a series of simple moving averages and stores the results in memory. The sub-program can be used without a printer, in which case the output is displayed. The second sub-program (sub-program 2B) uses the results from sub-program 2A to calculate a series of centered moving averages. Sub-program 2B can also be used with or without a printer. The two sub-programs are designed so that they can easily be used in sequence. After sub-program 2A has been executed, a card containing sub-program 2B is simply read into the calculator. The output from sub-program 2A is stored in such a way that it can serve as input for sub-program 2B. Thus, no further data manipulation is necessary in order to run sub-program 2B.

a) Sub-program 2A: Simple Moving Averages

Partitioning: 239.89

Input: The time series data to be smoothed can be entered manually or from a magnetic card.

Sub-program 2A is designed so that up to 75 observations can be entered at a time, or over six years of monthly data. For longer series, the data must be entered and processed in groups of 75 observations or less, i.e., the first set of 75 observations must be entered and processed before the second set can be entered. The memory is partitioned so that the program registers are all on bank 1, while the data registers are located on banks 2, 3, and 4. This means that sub-programs and data sets can be entered and stored independently. Consequently, the same sub-program can be used to process several sets of data, or several different sub-programs can be used to process the same set of data.

Data entered from magnetic cards must be stored on the cards as follows:

Register 00: blank

Registers 01-75: time series data

Registers 76-89: blank

Data entered manually must be keystroked into the data registers, using the same format.

A time series being stored on magnetic cards can be updated very easily. As long as blank registers remain in the data storage section of memory (Registers 01-75), new observations can be added by manual entry. If no blank registers are available, it will be necessary to begin a new set of data cards. Always remember to re-write data cards whenever new observations have been entered!

Output: Sub-program 2A calculates and prints out a series of simple moving averages, identifying each printed value with a label indicating the period for which the average has been calculated. The series of simple moving averages is stored in registers 01-75, replacing the original, unsmoothed time series. Each calculated average is stored in the register whose number corresponds to the period for which the average has been calculated. In other words, the moving average for period 27 is stored in register 27. (Note that depending on the length of the period n, a variable number of registers at the beginning of the new series will be left blank, since the data do not extend far enough back to permit calculation of moving averages all the way back to period 01.) If the sub-program is used without the printer, an option can be selected so that the moving averages are displayed for manual transcription. (See "User Instructions" to learn how to select this option. p.49).

b) Sub-Program 2B: Centered Moving Averages

Partitioning: 239.89

Input: Although it can be used independently, sub-program 2B is really designed to be used in conjunction with sub-program 2A. If the two are used together, when sub-program 2A is executed, the calculator automatically stores all the data necessary to run sub-program 2B. In this case, the data registers (banks 2, 3, 4) can be left intact; the only requirement is that the program steps for sub-program 2B be entered into the program registers on bank 1. This can be accomplished manually, or much more easily be simply reading in a pre-recorded program card. Data entered from magnetic cards must be stored on the cards following the same format as the output from sub-program 2A:

Register 00: blank

Registers 01-75: simple moving averages (calculated by 2A)

Registers 76-81: blank

Register 82: location of last simple moving average ($0 \leq x \leq 75$)

Registers 82-89: blank

Data entered manually must be keystroked into the data registers, using the same format.

Output: Sub-program 2B calculates and prints out a series of centered moving averages, preceding each with a label identifying the period around which the average is centered. The centered moving averages are stored in registers 01-75, replacing the original series of simple moving averages. Each centered average is stored in the register whose number corresponds to the period around which the average is centered. In other words, the moving average centered around period 56 is stored in register 56. (Note that depending on the length of the period n, a variable number of registers at the beginning of the new series will be left blank, since the data do not extend far enough back to permit calculation of centered moving averages all the way back to period 01.) If the sub-program is used without the printer, an option can be selected so that the centered moving averages are displayed for manual transcription. (See "User Instructions" to learn how to select this option. p.51).

4.2.4 User Instructions

Sub-Program 2A: Moving Averages

a) Use With Printer

Step	Procedure	Enter	Press	Display (Printed Output)
1	Partition memory to 239.89	9	Op* 17	239.89
2	Read in sub-program 2A (program card 1, bank 1)	1	(enter program card 1, bank 1)	1.
3	Enter time series data (data cards 1, 2; banks 2, 3 4)	2	(enter input data card 1, bank 2)	2.
		3	(enter input data card 2, bank 3)	3.
		4	(enter input data card 2, bank 4)	4.
3a	(If data are to be input manually instead of from cards, enter time series data manually at this point. See example below, "Manual Data Entry Method")			-
4	Enter n (length of moving period)	n	A	n
5	Enter m (total number of observations)	m	B	m-n
6	Calculate moving averages		C	(simple moving averages)
(7)	Record moving averages on magnetic cards		INV Fix	
		2	Write* (enter output data card 1, bank 2)	2.
		3	Write* (enter output data card 2, bank 3)	3.
		4	Write* (enter output data card 2, bank 4)	4.
(8)	To calculate moving averages for another section of the same series or for a different series, repeat steps 3-6. (If calculating moving averages for another section of the same series, remember to overlap the input data by n periods to avoid a discontinuity in the resulting series of moving averages.)			

b) Use Without Printer

Sub-program 2A is designed for optional use without a printer. All inputs, calculations, and stored output are the same as if the sub-program had been run with the printer; the only difference is that the moving averages are now displayed one at a time instead of printed out on tape. When the first moving average has been transcribed, press the R/S Key to obtain the second moving average, etc... To determine which period the displayed average is associated with, manually recall the contents of register 88.

Step	Procedure	Enter	Press	Display
1-5	(same as above)			
6	Select no-printer option		E	
7	Calculate first average		C	First average
8	Calculate second average		R/S	Second average
9	Calculate third average		R/S	Third average
(10)	Verify current period		RCL 88	Current period
(11)	Record moving averages on magnetic cards		INV Fix	
		2	Write* (enter output data card 1, bank 2)	2.
		3	Write* (enter output data card 2, bank 3)	3.
		4	Write* (enter output data card 2, bank 4)	4.
(12)	To calculate moving averages for another section of the same series or for a different series, repeat steps 3-11. (If calculating moving averages for another section of the same series, remember to overlap the input data by n periods to avoid a discontinuity in the resulting series of moving averages.)			

Sub-Program 2B: Centered Moving Averages

a) Use With Printer

Step	Procedure	Enter	Press	Display (Printed Output)
Note:	If sub-program 2B is being used in conjunction with sub-program 2A, skip steps 1-2 and proceed immediately to step 3.			
1	Partition memory to 239.89	9	Op* 17	239.89
2	Enter simple moving averages data (data cards 1, 2; banks 2, 3, 4)	2	(enter input data card 1, bank 2)	2.
		3	(enter input data card 2, bank 3)	3.
		4	(enter input data card 2, bank 4)	4.
(2a)	(If data are to be input manually instead of from cards, enter simple moving averages data at this point.)			
3	Read in sub-program 2B (program card 2, bank 1)	1	(enter program card 2, bank 1)	1.
4a	If <u>n</u> is <u>odd</u>: Enter n, calculate centered moving averages	n	A	(centered moving averages)
4b	If <u>n</u> is <u>even</u>: Enter n, calculate centered moving averages	n	A'	(centered moving averages)
(5)	Record centered moving averages on magnetic cards		INV Fix	
		2	Write* (enter output data card 1, bank 2)	2.
		3	Write* (enter output data card 2, bank 3)	3.
		4	Write* (enter output data card 2, bank 4)	4.
(6)	To calculate centered moving averages for another section of the same series or for a different series, repeat steps 2, and 4a or 4b. (It is not necessary to read in the sub-program again.) (If calculating centered moving averages for another section of the same series of simple averages, remember to overlap the input data by n periods to avoid a discontinuity in the resulting series of centered moving averages.)			

b) <u>Use Without Printer</u>

Sub-program 2B is also designed for optional use without a printer. (For a brief explanation of what this option entails, see "Sub-program 2A: b) Use Without Printer," p. 49).

To run sub-program 2B without a printer:

Step	Procedure	Enter	Press	Display
1-3	(same as above)			
4	Select no-printer option		E	
5a	If *n* is *odd*: Enter n, calculate first centered moving average	n	A	First average
5b	If *n* is *even*: Enter n, calculate first centered moving average	n	A'	First average
6	Calculate second centered moving average		R/S	Second average
7	Calculate third centered moving average		R/S	Third average
(8)	Verify current period		RCL 86	Current period
(9)	When all averages have been displayed, skip ahead to complete the sub-program (shortcut to be used when many registers are empty)		D	
(10)	Record centered averages on magnetic cards		INV Fix	
		2	Write* (enter output data card 1, bank 2)	2.
		3	Write* (enter output data card 2, bank 3)	3.
		4	Write* (enter output data card 2, bank 4)	4.
(11)	To calculate centered moving averages for another section of the same series or for a different series, refer to step (6) to previous section, "Use with Printer" (P).			

N.B. A blank worksheet, "Moving Averages (Worksheet 2)," is included in the appendix. The worksheet can be photocopied for use in conjunction with Program 2.

4.2.5 Example 2: Moving Averages, Centered Moving Averages

Problem Statement: You are an agricultural economist hired by the government of Upper Volta to forecast millet prices on the Ouagadougou retail market. As part of your analysis, you decide to estimate econometrically supply and demand equations for millet. In collecting monthly retail price data (in CFA/kg), you notice considerable month-to-month variability in the data which you suspect will complicate regression analysis. In order to overcome this problem, you decide first to smooth the data by calculating four-month moving averages, both simple moving averages and centered moving averages.

Use pre-recorded program and input data cards to enter the program steps and the data (monthly retail prices). (see Section 3.4) Record the moving averages on data output cards.

Data:

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1965	2200	2100	2000	2200	2700	2200	2900	2200	2800	1900	2300	2000
1966	2600	2100	1900	2300	2600	2700	2800	2800	3100	2900	2600	2900
1967	2200	2700	2600	2600	2700	3000	3200	3100	2500	2400	3100	2400

Data Source: CRED, 1977)

Step-by-step procedure (Sub-program 2A):

Step	Enter	Press	Display (Printed Output)	Comment
1	9	Op* 17	239.89	Partition memory
2	1	(enter sub-program card 1, bank 1)	1.	Read in sub-program 2A
3	2	(enter data input card 1, bank 2)	2.	Read in price data
4	3	(enter data input card 2, bank 3)	3.	Read in price data
5	4	(enter data input card 2, bank 4)	4.	Read in price data
6	4	A	4.	Enter n (length of period)
7	36	B	33.	Enter m (length of data series)
Printer Option:				
8.1a	-	C	2125 04	First four-period simple average (corresponds to period 04)
			2250 05	Second four-period simple average (corresponds to period 05)
			2275 06	Third four-period simple average (corresponds to period 06)
			⋮	⋮
No-Printer Option:				
8.1b	-	E	-	Select no-printer option
8.2b	-	C	2125	First four-period simple average (corresponds to period 04)
8.3b	-	R/S	2250	Second four-period simple average (corresponds to period 05)
8.4b	-	R/S	2275	Third four-period simple average (corresponds to period 06)
8.5b	-	RCL 88	06	Verify current period
(continue pressing R/S key until all simple moving averages have been displayed)				
9	2	Write* (enter output data card 1, bank 2)	2.	Record simple moving averages
10	3	Write* (enter output data card 2, bank 3)	3.	Record simple moving averages
11	4	Write* (enter output data card 2, bank 4)	4.	Record simple moving averages

Result: The four-period simple moving average series is calculated as follows:

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Four-period Simple Moving Averages:												
1965	----	----	----	2125	2250	2275	2500	2500	2525	2450	2300	2250
1966	2200	2500	2150	2225	2225	2375	2600	2725	2850	2900	2850	2875
1967	2650	2600	2600	2525	2650	2725	2875	3000	2950	2800	2775	2600

Having recorded this series on data output cards, you proceed to center the moving averages by next running sub-program 2B.

Step-by-step procedure (Sub-program 2B):

Step	Enter	Press	Display (Printed Output)	Comment
(Execute sub-program 2A)				
1	1	(enter sub-program card 2B, bank 1)	1.	Read in sub-program 2B
Printer Option:				
2.1a	4	A'		Enter even n and calculate centered moving averages
			2187.5 03	First four-period centered average (corresponds to period 03)
			2262.5 04	Second four-period centered average (corresponds to period 04)
			2387.5 05	Third four-period centered average (corresponds to period 05)
			⋮	⋮

Step	Enter	Press	Display (Printed Output)	Comment
No-Printer Option:				
2.1b	-	E	-	Select no-printer option
2.2b	4	A'		Enter even n and calculate centered moving averages
			2187.5	First four-period centered average (corresponds to period 03)
2.3b	-	R/S	2262.5	Second four-period centered average (corresponds to period 04)
2.4b		R/S	2387.5	Third four-period centered average (corresponds to period 05)
(2.5b)	-	RCL 85	5.	Verify current period
(continue pressing R/S key until all centered moving averages have been displayed)				
(2.6b)	-	D		When all moving averages have been displayed, skip ahead to complete the remainder of the sub-program
3	2	Write* (enter output card 1, bank 2)	2.	Record centered moving averages
4	3	Write* (enter output card 2, bank 3)	3.	Record centered moving averages
5	4	Write* (enter output card 2, bank 4)	4.	Record centered moving averages

Result: The four-period centered moving average series is calculated as follows:

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Four-period Centered Moving Averages:												
1965	----	----	2187.5	2262.5	2387.5	2500	2512.5	2487.5	2375	2275	2225	2225
1966	2200	2187.5	2225	2300	2487.5	2662.5	2787.5	2875	2875	2862.5	2762.5	2625
1967	2600	2562.5	2587.5	2687.5	2800	2937.5	2975	2875	2787.5	2687.5	----	----

4.2.6 Sub-Program 2A Listing: Simple Moving Averages

LOC	Code	Key	Comment
000	76	LBL	
001	15	E	Select no-printer option
002	86	STF	
003	01	01	
004	91	R/S	
005	76	LBL	
006	11	A	Store n (length of period)
007	42	STO	
008	81	81	
009	91	R/S	
010	76	LBL	Store m (number of observations)
011	12	B	
012	42	STO	
013	82	82	
014	75	-	
015	43	RCL	
016	81	81	
017	85	+	Determine location of last average
018	01	1	
019	95	=	
020	42	STO	
021	83	83	
022	91	R/S	
023	76	LBL	
024	13	C	Load n into t-register
025	43	RCL	
026	81	81	
027	32	X:T	
028	01	1	
029	42	STO	
030	88	88	
031	42	STO	
032	84	84	Initialize counters
033	00	0	
034	42	STO	
035	87	87	
036	42	STO	
037	85	85	
038	42	STO	
039	86	86	
040	76	LBL	
041	38	SIN	
042	43	RCL	Sum observations
043	81	81	
044	32	X:T	
045	73	RC*	
046	84	84	
047	44	SUM	
048	87	87	
049	01	1	
050	44	SUM	

LOC	Code	Key	Comment
051	84	84	Increment counters
052	44	SUM	
053	85	85	
054	43	RCL	
055	85	85	Calculations finished?
056	22	INV	
057	67	EQ	
058	38	SIN	
059	43	RCL	
060	87	87	Calculate moving averages
061	55	÷	
062	43	RCL	
063	81	81	
064	95	=	
065	72	ST*	Store result
066	88	88	
067	87	IFF	If no-printer, go to
068	01	01	
069	89	π	
070	01	1	
071	44	SUM	
072	86	86	
073	44	SUM	
074	88	88	
075	43	RCL	
076	83	83	
077	32	X:T	
078	43	RCL	
079	81	81	Increment counters
080	75	-	
081	01	1	
082	95	=	
083	22	INV	
084	44	SUM	
085	84	84	
086	00	0	
087	42	STO	
088	87	87	
089	42	STO	
090	85	85	
091	43	RCL	
092	86	86	Calculations finished?
093	22	INV	
094	67	EQ	
095	38	SIN	
096	07	7	
097	05	5	
098	32	X:T	
099	76	LBL	
100	28	LOG	
101	00	0	

LOC	Code	Key	Comment
102	72	ST*	
103	88	88	
104	01	1	Empty unused registers
105	44	SUM	
106	88	88	
107	43	RCL	
108	88	88	
109	22	INV	
110	67	EQ	
111	28	LOG	
112	07	7	
113	05	5	
114	42	STO	
115	76	76	
116	75	-	
117	43	RCL	Reset counters
118	81	81	
119	85	+	
120	01	1	
121	95	=	
122	42	STO	
123	77	77	
124	00	0	
125	32	X:T	
126	76	LBL	
127	58	FIX	
128	73	RC*	
129	77	77	
130	72	ST*	
131	76	76	
132	01	1	Transfer results to correct registers
133	22	INV	
134	44	SUM	
135	77	77	
136	22	INV	
137	44	SUM	
138	76	76	
139	43	RCL	
140	77	77	
141	22	INV	
142	67	EQ	
143	58	FIX	
144	01	1	
145	42	STO	
146	89	89	
147	43	RCL	
148	81	81	

Merged Codes

62 Pgm Ind	72 STO Ind	83 GTO Ind
63 Exc Ind	73 RCL Ind	84 Op Ind
64 Prd Ind	74 SUM Ind	92 INV SBR

LOC	Code	Key	Comment
149	32	X⇌T	
150	76	LBL	
151	59	INT	
152	00	0	Empty
153	72	ST*	unused
154	89	89	registers
155	01	1	
156	44	SUM	
157	89	89	
158	43	RCL	
159	89	89	
160	22	INV	
161	67	EQ	
162	59	INT	
163	43	RCL	
164	81	81	Print (list)
165	22	INV	results
166	90	LST	
167	76	LBL	
168	89	π	
169	91	R/S	No-printer
170	61	GTO	option
171	00	00	(display
172	70	70	result)

Merged Codes

62 63 64 72 STO 73 RCL 74 SUM 83 GTO 84 92 INV SBR

4.2.7 Sub-Program 2B Listing: Centered Moving Averages

LOC	Code	Key	Comment
000	76	LBL	
001	15	E	Select no-printer option
002	86	STF	
003	01	01	
004	91	R/S	
005	76	LBL	Odd n
006	11	A	
007	42	STO	Store n
008	81	81	
009	42	STO	
010	85	85	
011	85	+	
012	01	1	Calculate location of first centered average
013	95	=	
014	55	÷	
015	02	2	
016	95	=	
017	42	STO	
018	86	86	
019	42	STO	
020	87	87	
021	07	7	
022	06	6	Set t-register
023	32	X:T	
024	76	LBL	
025	38	SIN	
026	73	RC*	
027	85	85	Center moving averages
028	72	ST*	
029	86	86	
030	87	IFF	
031	01	01	If no-printer, go to TAN
032	30	TAN	
033	76	LBL	
034	97	DSZ	
035	01	1	
036	44	SUM	Increment counters
037	85	85	
038	44	SUM	
039	86	86	
040	43	RCL	
041	85	85	
042	22	INV	
043	67	EQ	Transfers finished?
044	38	SIN	
045	61	GTO	
046	89	π	
047	76	LBL	
048	16	A'	Even n
049	42	STO	
050	81	81	

LOC	Code	Key	Comment
051	55	÷	
052	02	2	Calculate location of first centered average
053	85	+	
054	01	1	
055	95	=	
056	42	STO	
057	86	86	
058	42	STO	
059	87	87	
060	43	RCL	
061	82	82	
062	75	-	
063	43	RCL	Calculate location of last centered average
064	81	81	
065	55	÷	
066	02	2	
067	95	=	
068	42	STO	
069	80	80	
070	43	RCL	
071	82	82	
072	85	+	Set t-register
073	01	1	
074	95	=	
075	32	X:T	
076	43	RCL	
077	81	81	
078	42	STO	
079	85	85	
080	76	LBL	
081	39	COS	
082	73	RC*	
083	85	85	Sum the two averages
084	42	STO	
085	77	77	
086	01	1	
087	44	SUM	
088	85	85	
089	73	RC*	
090	85	85	
091	44	SUM	
092	77	77	
093	43	RCL	
094	77	77	Calculate average of the averages
095	55	÷	
096	02	2	
097	95	=	
098	87	IFF	If no-printer, go to x
099	01	01	
100	79	x̄	
101	76	LBL	

LOC	Code	Key	Comment
102	70	RAD	
103	72	ST*	Store result
104	86	86	
105	01	1	
106	44	SUM	
107	86	86	
108	43	RCL	
109	86	86	
110	22	INV	Calculations finished?
111	67	EQ	
112	39	COS	
113	61	GTO	
114	89	π	
115	76	LBL	
116	30	TAN	If no-printer, display result
117	91	R/S	
118	61	GTO	
119	97	DSZ	
120	76	LBL	
121	79	x̄	If no-printer, display result
122	91	R/S	
123	61	GTO	
124	70	RAD	
125	76	LBL	
126	89	π	
127	07	7	
128	09	9	
129	32	X:T	
130	01	1	Empty all unused registers
131	44	SUM	
132	80	80	
133	00	0	
134	72	ST*	
135	80	80	
136	43	RCL	
137	80	80	Unused registers all empty?
138	22	INV	
139	67	EQ	
140	89	π	
141	43	RCL	
142	87	87	Print (list) results
143	22	INV	
144	90	LST	
145	91	R/S	
146	76	LBL	
147	14	D	
148	01	1	

Merged Codes

62 Pgm Ind	72 STO Ind	83 GTO Ind
63 Exc Ind	73 RCL Ind	84 Op Ind
64 Prd Ind	74 SUM Ind	92 INV SBR

LOC	Code	Key	Comment
149	44	SUM	Shortcut past unused registers
150	86	86	
151	61	GTO	
152	89	π	

Merged Codes

62 Pgm Ind	72 STO Ind	83 GTO Ind
63 Exc Ind	73 RCL Ind	84 Op Ind
64 Prd Ind	74 SUM Ind	92 INV SBR

4.3 PROGRAM 3: SEASONAL ADJUSTMENT

4.3.1 Theoretical Discussion

Many agricultural products, particularly field crops, are characterized by seasonality in production and marketing. Biological growth processes and climatic factors interact to more or less dictate when planting and harvest can occur. As a result, the supply of many agricultural products exhibits a regularly repeating pattern that recurs every twelve months. The quantity available on the market peaks at the time of harvest and gradually dwindles throughout the course of the ensuing year, at a rate determined by each crop's perishability. (If a short growing season makes possible multiple cropping, the supply may peak several times during the year.)

The pronounced seasonal pattern associated with the supply of many agricultural commodities is reflected in a corresponding seasonal variation in prices. Seasonality in supply can be thought of as shifts out and back of the supply function; as the supply function shifts, the price of the commodity (determined at the point of intersection with the demand function) rises and falls. Thus, the abundant supply accumulating at harvest is associated every year with low commodity prices (ceteris paribus), while the shortages which normally occur during the growing season and just prior to harvest are associated with high commodity prices (ceteris paribus). (For a more comprehensive discussion of seasonality in supply, see Tomek and Robinson, pp. 170-178.)

Seasonal variation in prices of agricultural products, while caused primarily by supply factors, can also occur as the result of demand factors. Seasonality in demand tends to be related to climatic factors (e.g., high demand for beverages during the summer or dry season) or to holidays (e.g., high demand for sheep at the conclusion of Ramadan, the Islamic month of holy fasting). Seasonality of demand can be thought of as shifts out and back of the demand function, with corresponding effects on prices.

Seasonality is particularly prevalent among production and price data in LDC's. In regions where most food crops are grown primarily by semi-subsistence farmers using traditional cultivation practices, the overwhelming majority of farmers tends to follow virtually the same production schedule. Because most of the crop is harvested at the same time, markets become glutted, and prices fall. With storage facilities scarce in many countries, relatively little commercial buying occurs, even at the depressed post-harvest prices. Farmers tend to store their own food supply, which gradually becomes depleted during the course of the year. As supplies dwindle, prices rise in the market. Depending on the size of the harvest and the condition of storage facilities, supplies may dry up completely in the weeks or even months preceding the next harvest. Prices may soar, forcing many people to rely on less desirable alternative foodstuffs until the beginning of the harvest brings relief. Often this annual cycle is repeated year after year, resulting in marked seasonal variation in commodity prices.

Seasonality, while commonly associated with agricultural products, is by no means restricted to them. Seasonal variation is found very frequently among diverse types of economic time-series data. Typical examples of data containing seasonal patterns include data on production, sales, personal income, expenditures, profits, unemployment rates, imports, and exports.

Price analysts tend to be interested in seasonality for two main reasons. In some instances, they may want to isolate and measure the seasonal component in a series to improve short-term forecasts. More commonly, analysts may want to quantify the seasonal component so that it can be removed, thus facilitating identification and analysis of other persistent patterns, such as trends and cycles. Most techniques for dealing with seasonality seek this latter objective; thus, they aim to produce a series that appears non-seasonal.

The most widely used technique for dealing with seasonality involves calculation of a seasonal index which attempts to measure seasonal variation in a time series. Once calculated, the index can be used to seasonally adjust (or deseasonalize) the series by removing the seasonal component. Seasonal adjustment consists of dividing the original observation from a given period (month or quarter) by the corresponding (monthly or quarterly) index number. The adjusted series in theory should exhibit no seasonal component, i.e., no regularly recurring annual pattern. This should facilitate interpretation of economic developments and improve short-term forecasts.

4.3.2 Methods and Equations

Although numerous techniques exist for measuring seasonal variation in time-series data (see Merrill and Fox, 19 ; Makridakis and Wheelwright, 1978), the ratio-to-moving-average method (or percentage of moving average method) is probably the most widely used. Its popularity and ease of computation have led to its selection for use in Program 3. While conceptually quite simple, the ratio-to-moving-average method usually will produce an index which will remove most, if not all, seasonality from a time series. Nevertheless, it should be kept in mind that the ratio-to-moving-average method is basically an *ad hoc* method requiring a certain amount of subjective judgement.

The first step in calculating a seasonality index by means of the ratio-to-moving-average method is to calculate a series of twelve-month (four-month, if quarterly data are used instead of monthly data) centered moving averages from the data. (See Program 2). This smoothing procedure serves to remove, or at least to reduce, stochastic (random) fluctuations. Recall that the centered twelve-month period is used rather than the calendar year to avoid possible bias from trends in the data.

Program 3 begins at the second step in the procedure, which is to compute the ratio-to-moving-average percentages for each year in the data set by dividing the original observations by the centered moving averages for the corresponding period and multiplying by 100. For example,

$$\text{Ratio-to-moving-average percentage}_{\text{January}_1} = \frac{\text{price}_{\text{January}} \times 100}{\text{centered moving average}_{\text{January}_1}}$$

The third step requires subjective judgement on the part of the analyst. Before mean percentages are calculated for each period (month or quarter), the percentages calculated during the second step should be inspected for extreme values associated with unusual phenomena such as drought, flooding, strikes, war, or simply irregularities in the data. (Data problems arise quite frequently in developing countries, particularly when a data series has been patched together from diverse sources.) Extreme values should be thrown out before the means for each period are calculated to avoid distortion of the index.

The obvious question arises: how extreme does a value have to be for it to be thrown out? Unfortunately, there exists no clear-cut answer. Some analysts have advocated implementation of a formal decision rule, such as automatic rejection of any observation lying more than two standard deviations from the mean. Others suggest automatically throwing out the highest and lowest value for each period. No formal approach is recommended here. If it is suspected that a particular observation is unrepresentative, an effort should be made to determine what event(s) may have caused the irregularity before the decision is made to retain or omit the observation. Once all the data have been inspected, the mean ratio-to-moving-average percentage can be calculated for each period (month or quarter) by summing the ratio-to-moving-average percentages for each period (month or quarter) and dividing by the number of periods.

The fourth and final step in calculating the seasonal index involves adjusting the mean (monthly or quarterly) percentages to an overall mean value of 100. (Occasionally this step will not be necessary, but more often adjustment will be appropriate, especially when observations have been thrown out.) Program 3 automatically adjusts the calculated index numbers. The adjustment factor is calculated by dividing the average of all the means into 100.

For example, with a monthly index:

$$\text{Adjustment factor} = \frac{100}{(\bar{X}_{\text{Jan}} + \bar{X}_{\text{Feb}} + \ldots + \bar{X}_{\text{Dec}})/12}$$

The four-step procedure described above will produce a set of (twelve or four) index numbers reflecting past seasonal variation in the data. Deseasonalization of the original data series can now be accomplished by dividing each observation of the series by its corresponding (monthly or quarterly) index number. The resulting seasonally-adjusted series will more or less be purged of its seasonal component.

4.3.3 Input/Output

Partitioning: 239.89

Input: Program 3 requires as input both the original time series for which the seasonality index is to be constructed, as well as the series of twelve-month (four-month, if quarterly data are used instead of monthly data) centered moving averages. If the centered moving averages have not been calculated, refer to Program 2. (The output from Program 2 is ready for use as input for Program 3.) Note that six (two) moving averages will be missing at either end of the series.

A minimum of two observations is needed to calculate the index for each period, more if observations are eventually thrown out as being too extreme. Thus two years of data are required as an absolute minimum. As with any statistical procedure, the greater the sample size, the more reliable the estimates. As a general rule of thumb, at least five years of data are needed for calculating a seasonal index. Ten or more years of observations would be preferable, if the data are available.

Since visual inspection of the intermediate results will be necessary to identify extreme values, it is recommended that Program 3 be used with the worksheets provided in the appendix. Although the worksheets require a certain amount of writing, they clarify the analytical procedure and provide a useful written record. In the long run, their use will save time.

The centered moving averages may be entered manually or from magnetic cards. If Program 2 has been used to calculate the averages, no action is necessary; otherwise, the averages must be keystroked and stored manually, with the following format:

Register 00: blank

Registers 01-75: centered moving average series (note that either six or two periods at each end will be blank)

Registers 76-89: blank

The series can be updated very easily. As long as blank registers remain, the most recent observations can simply be added to the existing series by manual entry. If no more blank spaces remain, it will be necessary to begin a new set of data cards.

The original observations must be entered manually. To facilitate data entry and minimize the chance for errors, record both the original observations and the centered moving averages in the appropriate columns on Worksheet 3-A before using the program.

Output: Since Program 3 is designed to permit visual inspection of the data, two sets of output are produced: intermediate output and final output.

a) Intermediate Output

Intermediate output consists of the ratio-to-moving-average percentages. These are displayed one at a time as they are calculated and printed (with a label identifying the corresponding period) if the program is being used with a printer. The ratio-to-moving averages should be transcribed into the appropriate column on Worksheet 3-A for visual inspection.

b) Final Output

Once any extreme values have been thrown out, Program 3 calculates the mean ratio-to-moving-average percentages for each period. An adjustment factor is calculated, and the mean percentages are adjusted to a mean value of 100. The adjustment factor and the adjusted percentages (monthly or quarterly index numbers) are printed out, along with labels. If the program is being used without a printer, the index numbers can be displayed one by one.

The output is stored in the data registers in the following format:

Register 00:

Registers 01-75: ratio-to-moving-average percentages

Registers 76-87: adjusted index numbers

Register 88: number of periods (12 if monthly, 4 if quarterly)

Register 89: adjustment factor

4.3.4 User Instructions

a) Use With Printer

Step	Procedure	Enter	Press	Display (Printed Output)
1	Record observations (raw data) and centered moving averages on Worksheet 3-A.			
2	Partition memory to 239.89	9	Op* 17	239.89
3	Enter data:			
(3a)	Run Program 2 (see "User Instructions" for Program 2).			
or				
(3b)	Enter centered moving averages from magnetic cards (data cards 1,2; banks 2,3,4)	2	(enter output data card 1, bank 2)	2.
		3	(enter output data card 2, bank 3)	3.
		4	(enter output data card 2, bank 4)	4.
or				
(3c)	Enter data manually	(first observation) (second observation) (third observation)	STO 07* STO 08 STO 09	first observation second observation third observation
*Note:	If quarterly data are used instead of monthly data, begin storing centered moving averages in Register 04.			
4	Read in Program 3 (program card 1, bank 1)	1	(enter program card 1, bank 1)	1.
5	Enter starting point (7 if monthly data, 3 if quarterly data)	7 or 3	A	6. or 2.
6	Calculate ratio to moving average percentages:			
6a	Calculate first ratio-to-moving-average percentage	(first observation from raw data)	B	(7.P) (first percentage)
6b	Record result on Worksheet 3-A			
6c	Calculate second ratio-to-moving average percentage	(second observation from raw data)	B	(8.P) (second percentage)
6d	Record result on Worksheet 3-A			
	(Continue processing data and recording results until all data have been processed.)			

Step	Procedure	Enter	Press	Display (Printed Output)
7	Inspect Worksheet 3-A and note any extreme values. If it can be determined that any of these values have resulted from unusual circumstances, decide whether or not to omit them.			
8	Transcribe remaining ratio-to-moving-average percentages onto Worksheet 3-B.			
9	Clear counter registers	-	D'	
10	Calculate mean ratio-to-moving-average percentages:			
10a	Enter period number	0<P≤12	C	0.
10b	Sum first percentage	(first percentage)	R/S	1.
10c	Sum second percentage	(second percentage)	R/S	2.
10d	Sum third percentage	(third percentage)	R/S	3.
	(Continue until all percentages for that period have been summed.)			
10e	Calculate mean	-	D	mean percentage
10f	Record mean percentage onto Worksheet 3-B.			
	(Repeat steps 10a-10f for each period--i.e., twelve months or four quarters.)			
11	Calculate adjustment factor, adjusted seasonal index	-	E (monthly) or E' (quarterly)	(ADJ FACTOR) (adjustment factor) (1. INDX) (first index number) (2. INDX) (second index number) (3. INDX) (third index number) etc.
12	Record percentages, adjustment factor, and adjusted index numbers on magnetic cards	-	INV Fix	
		2	Write* (enter output data card 1, bank 2)	2.
		3	Write* (enter output data card 2, bank 3)	3.
		4	Write* (enter output data card 2, bank 4)	4.

b) Use Without Printer

Enter	Procedure	Enter	Press	Display (Printed Output)
1-4	(same as above)			
*	Select no-printer option	-	A'	
5-10	(same as above)			
11	Calculate adjustment factor, adjusted seasonal index	-	E	(first index number)
			R/S	(second index number)
			R/S	(third index number)
12	(same as above)			

4.3.5 Example 3: Seasonal Adjustment

Problem Statement: You are an agricultural economist hired by the government of Pakistan to forecast the retail price of potatoes on the Peshawar market. You are given five years of monthly price data (in rupees/seer), and you notice what appears to be a marked seasonal pattern in the series. In order to isolate the apparent seasonal component in the data, you decide to construct a seasonality index using the ratio-to-moving-average method. To suppress month-to-month random variability, you elect first to smooth the data by calculating a series of four-month centered moving averages.

Once the seasonality index is calculated, you will use it to deseasonalize the five years of available data. In addition, you will be able to use the index to adjust future forecasts.

Data:

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1961	0.44	0.33	0.33	0.33	0.28	0.28	0.43	0.58	0.56	0.58	0.58	0.58
1962	0.58	0.58	0.58	0.40	0.33	0.33	0.33	0.44	0.48	0.48	0.48	0.48
1963	0.48	0.48	0.48	0.38	0.38	0.28	0.28	0.58	0.58	0.60	0.66	0.66
1964	0.52	0.28	0.28	0.57	0.38	0.38	0.38	0.38	0.46	0.66	0.58	0.48
1965	0.28	0.33	0.38	0.38	0.33	0.19	0.19	0.28	0.38	0.38	0.38	0.33

(Data Source: Qurashi, 1972).

Step-by-step Procedure (Program 3):

Step	Enter	Press	Display (Printed Output)	Comment
1	Record price series on Worksheet 3-A (see example below).			
2	Calculate twelve-month centered moving averages (see Program 2) and record averages onto Worksheet 3-A (see example below).			
3	1	(read in program card 1, bank 1)	1.	Read in program
4	7	A	6.	Enter starting point (7 since monthly data)
Calculate ratio-to-moving-average percentages:				
5a	0.43	B	(7. P) (0.9608938547)	Enter next observation from raw price data (column 1), beginning with period 7 and continuing period by period.
5b	Record ratio-to-moving-average percentage onto Worksheet 3-A .			
Repeat steps 5a and 5b with each raw data observation until all the ratio-to-moving-average percentages have been calculated and recorded.				
6	Inspect percentages for extreme values. Delete period 40 in this case. Transcribe remaining percentages onto Worksheet 3-B (see example below).			
7		D'	88.	Clear counter registers.
Calculate mean monthly ratio-to-moving-average percentages, beginning with January:				
8a	1	C	0.	First period (i.e., January)
8b	1.15	R/S	1.	Sum first value
8c	1.12	R/S	2.	Sum second value
8d	1.07	R/S	3.	Sum third value
8e	0.71	R/S	4.	Sum fourth value
8f		D	1.0125	Calculate mean
8g	Record period 1 (January) mean percentage onto Worksheet 3-B.			
Repeat steps 8a - 8g for each of the remaining eleven months.				
9		E	(ADJ FACTOR) (99.41318605) (1. INDX) (100.6558509) (2. INDX) (92.45426303) etc...	Label Adjustment Factor Period Label Adjusted January Index Period Label Adjusted February Index
10	Transcribe adjusted index numbers onto Worksheets 3-A and 3-B.			
11	Manually deseasonalize prices on Worksheet 3-A (Column 2 value ÷ Column 5 value) x 100 = Column 6 value.			
12	Record contents of data registers on magnetic cards.			
	2	Write* (enter output data card 1, bank 2)	2.	Record bank 2
	3	Write* (enter output data card 2, bank 3)	3.	Record bank 3
	4	Write* (enter output data card 2, bank 4)	4.	Record bank 4

Procedure:

Step	Enter	Press	Display (Printed Output)	Comment
No-Printer Option:				
1-3	(same as above)			
3a	-	A'		Select no-printer option
4-8g	(same as above)			
9a	-	E	100.6558509	Adjusted January index
9b	Record January index number onto Worksheet 3-B.			
9c	-	R/S	92.45426303	Adjusted February index
9d	Record February index number onto Worksheet 3-B.			
(Continue pressing R/S to display remaining monthly index numbers one at a time. Record all index numbers onto Worksheet 3-B.)				
10-12	(same as above)			

Result: The adjusted seasonality index is calculated as follows:

January	100.66	July	77.79
February	92.45	August	107.61
March	96.43	September	113.58
April	90.80	October	126.50
May	82.26	November	125.26
June	67.35	December	119.30

This index can be used to deseasonalize past price data for regression analysis, or to adjust forecasts of future prices.

For example, deseasonalizing the data series used to construct the seasonal index produces the following series:

Deseasonalized Prices:

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1961	0.44	0.36	0.34	0.36	0.34	0.42	0.55	0.54	0.49	0.46	0.46	0.49
1962	0.58	0.63	0.60	0.44	0.40	0.49	0.42	0.41	0.42	0.38	0.38	0.40
1963	0.48	0.52	0.50	0.42	0.46	0.42	0.36	0.54	0.51	0.47	0.53	0.55
1964	0.52	0.30	0.29	0.63	0.46	0.56	0.49	0.35	0.41	0.52	0.46	0.40
1965	0.28	0.36	0.39	0.42	0.40	0.28	0.24	0.26	0.33	0.30	0.30	0.28

Example: Seasonal Adjustment (continued)

SEASONALITY INDEX (WORKSHEET 3A)

(1) Period	(2) Original Series	(3) Centered Moving Average (N=12)	(4) Ratio-to-Moving-Average Percentage	(5) Adjusted Index (From Worksheet 3B)	(6) Deseasonalized Series
(1961) 1	0.44	-	-	100.66	0.44
2	0.33	-	-	92.45	0.36
3	0.33	-	-	96.43	0.34
4	0.33	-	-	90.80	0.36
5	0.28	-	-	82.26	0.34
6	0.28	-	-	67.35	0.42
7	0.43	0.45	0.96	77.79	0.55
8	0.58	0.46	1.25	107.61	0.54
9	0.56	0.48	1.16	113.58	0.49
10	0.58	0.50	1.16	126.50	0.46
11	0.58	0.50	1.15	125.26	0.46
12	0.58	0.51	1.14	119.30	0.49
(1962) 13	0.58	0.51	1.15	100.66	0.58
14	0.58	0.50	1.17	92.45	0.63
15	0.58	0.49	1.19	96.43	0.60
16	0.40	0.48	0.84	90.80	0.44
17	0.33	0.47	0.70	82.26	0.40
18	0.33	0.46	0.71	67.35	0.49
19	0.33	0.45	0.73	77.79	0.42
20	0.44	0.45	0.99	107.61	0.41
21	0.48	0.44	1.10	113.58	0.42
22	0.48	0.43	1.11	126.50	0.38
23	0.48	0.43	1.11	125.26	0.38
24	0.48	0.43	1.11	119.30	0.40

Example: Seasonal Adjustment (continued)

SEASONALITY INDEX (WORKSHEET 3A)

(1) Period	(2) Original Series	(3) Centered Moving Average (N=12)	(4) Ratio-to-Moving-Average Percentage	(5) Adjusted Index (From Worksheet 3B)	(6) Deseasonalized Series
(1963) 25	0.48	0.43	1.12	100.66	0.48
26	0.48	0.43	1.11	92.45	0.52
27	0.48	0.44	1.08	96.43	0.50
28	0.58	0.45	0.84	90.80	0.42
29	0.38	0.46	0.82	82.26	0.46
30	0.28	0.48	0.58	67.35	0.42
31	0.28	0.49	0.57	77.79	0.36
32	0.58	0.48	1.20	107.61	0.54
33	0.58	0.47	1.25	113.58	0.51
34	0.60	0.46	1.29	126.50	0.47
35	0.66	0.47	1.40	125.26	0.53
36	0.66	0.48	1.38	119.30	0.55
(1964) 37	0.52	0.49	1.07	100.66	0.52
38	0.28	0.48	0.58	92.45	0.30
39	0.28	0.47	0.60	96.43	0.29
40	0.57	0.47	1.23*	90.80	0.63
41	0.38	0.46	0.82	82.26	0.46
42	0.38	0.45	0.84	67.35	0.56
43	0.38	0.44	0.87	77.79	0.49
44	0.38	0.43	0.89	107.61	0.35
45	0.46	0.43	1.06	113.58	0.41
46	0.66	0.43	1.53	126.50	0.52
47	0.58	0.42	1.38	125.26	0.46
48	0.48	0.41	1.17	119.30	0.40

*Delete

Example: Seasonal Adjustment (continued)

SEASONALITY INDEX (WORKSHEET 3A)

(1) Period	(2) Original Series	(3) Centered Moving Average (N=12)	(4) Ratio-to-Moving-Average Percentage	(5) Adjusted Index (From Worksheet 3B)	(6) Deseasonalized Series
(1965) 49	0.28	0.39	0.71	100.66	0.28
50	0.33	0.38	0.86	92.45	0.36
51	0.38	0.38	1.01	96.43	0.39
52	0.38	0.36	1.06	90.80	0.42
53	0.33	0.34	0.97	82.26	0.40
54	0.19	0.33	0.58	67.35	0.28
55	0.19	-	-	77.79	0.24
56	0.28	-	-	107.61	0.26
57	0.38	-	-	113.58	0.33
58	0.38	-	-	126.50	0.30
59	0.38	-	-	125.26	0.30
60	0.33	-	-	119.30	0.28

Example: Seasonal Adjustment (continued)

SEASONALITY INDEX (WORKSHEET 3B)

Period (Month/Quarter)	Ratio-To-Moving Average Percentages 1	2	3	4	5	6	7	8	9	10	11	12	Period Mean	Adjusted Index Number
January		1.15	1.12	1.07	0.71								1.01	100.66
February	-	1.17	1.11	0.58	0.86								0.93	92.45
March	-	1.19	1.08	0.60	1.01								0.97	96.43
April	-	0.84	0.84	-	1.06								0.91	90.80
May	-	0.70	0.82	0.82	0.97								0.83	82.26
June	-	0.71	0.58	0.84	0.53								0.68	67.35
July	0.96	0.73	0.57	0.87	-								0.78	77.79
August	1.25	0.99	1.20	0.89	-								1.08	107.61
September	1.16	1.10	1.25	1.06	-								1.14	113.58
October	1.16	1.11	1.29	1.53	-								1.27	126.50
November	1.15	1.11	1.40	1.38	-								1.26	125.26
December	1.14	1.11	1.38	1.17	-								1.20	119.30
Quarter I														
Quarter II														
Quarter III														
Quarter IV														

Σ Means: 12.06

Average Mean: 1.005

$$\text{Adjustment Factor} = \frac{100}{\text{Average Mean}}$$

4.3.6 Program 3 Listing: Seasonal Adjustment

Loc	Code	Key	Comment
000	76	LBL	
001	16	A'	Select no-printer option
002	86	STF	
003	00	00	
004	91	R/S	
005	76	LBL	
006	11	A	
007	42	STO	
008	76	76	Enter starting point
009	75	-	
010	01	1	
011	95	=	
012	42	STO	
013	87	87	
014	91	R/S	
015	76	LBL	
016	12	B	
017	55	÷	
018	73	RC*	Calculate ratio-to-moving-average percentage
019	76	76	
020	95	=	
021	72	ST*	
022	76	76	
023	01	1	
024	44	SUM	
025	87	87	
026	44	SUM	
027	76	76	
028	69	OP	
029	00	00	
030	03	3	
031	03	3	
032	69	OP	Print period label
033	04	04	
034	43	RCL	
035	87	87	
036	69	OP	
037	06	06	
038	73	RC*	
039	87	87	Print percentage
040	99	PRT	
041	91	R/S	
042	76	LBL	
043	13	C	
044	85	+	
045	07	7	
046	05	5	
047	95	=	Select register for mean percentage
048	42	STO	
049	00	00	
050	00	0	

Loc	Code	Key	Comment
051	42	STO	
052	89	89	
053	91	R/S	
054	76	LBL	
055	38	SIN	
056	74	SM*	
057	00	00	
058	01	1	Sum percentage
059	44	SUM	
060	89	89	
061	43	RCL	
062	89	89	
063	91	R/S	
064	61	GTO	
065	38	SIN	
066	76	LBL	
067	14	D	
068	73	RC*	
069	00	00	
070	55	÷	Calculate and store period mean
071	43	RCL	
072	89	89	
073	95	=	
074	72	ST*	
075	00	00	
076	91	R/S	
077	76	LBL	
078	15	E	
079	08	8	
080	08	8	
081	32	X:T	Set counter for monthly periods
082	01	1	
083	02	2	
084	42	STO	
085	88	88	
086	61	GTO	
087	00	00	
088	97	97	
089	76	LBL	
090	10	E'	
091	07	7	Set counter for quarterly periods
092	09	9	
093	32	X:T	
094	04	4	
095	42	STO	
096	88	88	
097	00	0	
098	42	STO	
099	89	89	
100	07	7	
101	06	6	

Loc	Code	Key	Comment
102	42	STO	Sum period percentages
103	00	00	
104	76	LBL	
105	28	LOG	
106	73	RC*	
107	00	00	
108	44	SUM	
109	89	89	
110	01	1	
111	44	SUM	
112	00	00	
113	43	RCL	
114	00	00	
115	22	INV	
116	67	EQ	
117	28	LOG	
118	25	CLR	
119	69	OP	
120	00	00	
121	01	1	
122	03	3	
123	01	1	
124	06	6	
125	02	2	
126	05	5	
127	00	0	
128	00	0	
129	02	2	
130	01	1	
131	69	OP	Print label
132	02	02	
133	01	1	
134	03	3	
135	01	1	
136	05	5	
137	03	3	
138	07	7	
139	03	3	
140	02	2	
141	03	3	
142	05	5	
143	69	OP	
144	03	03	
145	69	OP	
146	05	05	
147	01	1	
148	00	0	

Merged Codes

62 · 63 · 64 · 72 STO · 73 RCL · 74 SUM · 83 GTO · 84 · 92 INV SBR

Program 3 Listing (continued)

Loc	Code	Key	Comment	Loc	Code	Key	Comment
149	00	0		201	44	SUM	Any index numbers remaining?
150	55	÷		202	00	00	
151	53	(		203	43	RCL	
152	43	RCL		204	00	00	
153	89	89		205	22	INV	
154	55	÷	Calculate adjustment factor	206	67	EQ	
155	43	RCL		207	89	π	Stop
156	88	88		208	91	R/S	
157	54	)		209	76	LBL	
158	95	=		210	19	D'	
159	42	STO		211	08	8	
160	89	89		212	08	8	
161	99	PRT	Print factor	213	32	X⇌T	
162	07	7		214	07	7	
163	06	6		215	06	6	
164	42	STO		216	42	STO	
165	00	00		217	88	88	
166	76	LBL		218	76	LBL	Set counter registers back to zero
167	89	π		219	79	x̄	
168	69	OP		220	00	0	
169	00	00		221	72	ST*	
170	02	2		222	88	88	
171	04	4		223	01	1	
172	03	3		224	44	SUM	
173	01	1	Print index period label	225	88	88	
174	01	1		226	43	RCL	
175	06	6		227	88	88	
176	04	4		228	22	INV	
177	04	4		229	67	EQ	
178	69	OP		230	79	x̄	
179	04	04		231	91	R/S	
180	43	RCL		232	76	LBL	
181	00	00		233	33	X²	If no-printer, display index number
182	75	-		234	91	R/S	
183	07	7		235	61	GTO	
184	05	5		236	02	02	
185	95	=		237	00	00	
186	69	OP					
187	06	06					
188	73	RC*					
189	00	00					
190	65	×	Adjust period means				
191	43	RCL					
192	89	89					
193	95	=					
194	72	ST*					
195	00	00					
196	87	IFF	If no-printer, go to X^2				
197	00	00					
198	33	X²					
199	99	PRT	Print index				
200	01	1					

Merged Codes

62 63 64 72 STO 73 RCL 74 SUM 83 GTO 84 92 INV SBR

4.4 PROGRAM 4: TREND ANALYSIS

4.4.1 Theoretical Discussion

Trend is the gradual, long-term increase or decrease in a time series resulting from persistent changes in basic factors such as population, income, technology, and economic climate. Agricultural economists frequently encounter evidence of trend in many types of time series data. Typical examples include increases in production and yield resulting from technological advances, increases in consumption attributable to growing population and rising incomes, decreases in the sales of some agricultural products caused by changing taste preferences, and increases in commodity prices associated with inflation in the general price level.

Trend can be represented graphically by a smooth curve fitted to plotted data. Different series vary tremendously in the slope and shape of the curve, as well as in the variations of individual observations from the fitted trend line. Some time series change by a constant amount (more or less) in each period, others by a constant rate (more or less), still others by accelerating and/or decelerating amounts or rates. A large number of specialized growth curves has been described and estimated mathematically to represent biological and other naturally occurring trend patterns (e.g., see Spurr and Boroni, 1973).

Agricultural economists may be interested in measuring trend for three reasons: 1) appraisal of recent trends to determine basic growth/decay tendencies; 2) projection of the trend curve as a long-term forecast; and 3) elimination of trend from the data series in order to facilitate identification and measurement of other patterns (e.g., seasonality). Measurement entails choosing a shape thought to reflect the shape of the actual trend line and implementing some type of mathematical estimation procedure to determine how closely the data adhere to the hypothesized line.

Complex growth curves are best modelled with higher-order polynomial equations and estimated by means of multiple regression techniques. However, a number of simple trend lines can be measured much more easily. Two simple yet common types of trend are linear trend (the values in the time series increase or decrease by a constant amount from one period to the next) and constant rate of growth (the values in the time series increase or decrease by a constant percentage from one period to the next). Although linear trend and constant rate of growth can be measured by means of several procedures, both can be estimated with simple linear regression techniques. The regression approach yields unbiased estimators which can help economists better to appraise past behavior, to understand ongoing economic relationships, and to forecast future events.

4.4.2 Methods and Equations

Program 4 uses the linear regression program contained in the Master Library module to calculate both linear trend and average rate of growth in time series data. The linear regression program is based on the ordinary-least-squares estimation procedure described in most elementary statistics and econometrics texts.

The ordinary-least-squares regression model is based on several simplifying assumptions:

1) The conditional mean value of the population disturbance term, conditional upon the given values of the independent variable, is zero ($E(u_i)=0$).
2) The conditional variance of the population disturbance term is constant or homoscedastic ($E(u_i^2)=\sigma^2$).
3) There is no serial correlation in the disturbances ($E(u_i u_j)=0$) $i \neq j$.

4) The independent variables are either nonstochastic (non-random), or, if stochastic (random), distributed independently of the disturbances.

Whether or not these basic assumptions are justified when time series data are being used depends on the nature of the data. It should be noted that certain types of time series (for example, monthly price series) are liable to contain violations of one or more assumptions. Interpretation of regression results when a violation is suspected is discussed below (see p. 82).

Linear trend is estimated in Program 4 by a simple linear regression of the original data series against time ($t = 1,2,3,\ldots,n$). The regression equation can be written:

(1) $$Y_t = \alpha + \beta X_t$$

where: Y = original data series (dependent variable)

x = time (independent variable)

t = period

The estimated slope coefficient ($\hat{\beta}$) represents the linear trend present in the data and can be interpreted as the average increase (or decrease) in Y associated with a unit change in X (time). In other words, from one period to the next, the values in the original data series on average change by a constant amount, $\hat{\beta}$. It is important to note that the size of the change is unrelated to the absolute size of the dependent variable, which may be large or small. Linear trend thus represents a change which is constant (from period to period) in absolute magnitude, though not in percentage terms.

Program 4 also calculates and stores the standard error associated with $\hat{\beta}$. Under the basic assumptions, this standard error can be used to test hypotheses about $\hat{\beta}$ and to construct confidence intervals. In particular, the t-statistic can be calculated and used (with a table of the t-statistic distribution) to test the hypothesis that β is significantly different from zero, i.e., to test whether the estimated linear trend is statistically significant.

Average rate of growth is estimated by the same simple linear regression procedure. However, since in this case the relationship of the original data series to time is thought to be non-linear, a prior transformation of the data is necessary. Specifically, the values of Y must be transformed into their natural logarithms, resulting in the following equation:

(2) $\ln Y_t = \alpha + \beta X_t$

where: $\ln Y$ = original data series (dependent variable) transformed into natural logarithms

X = time (independent variable)

t = period

The estimated slope coefficient ($\hat{\beta}$) can be used to derive an estimate of the average rate of growth in the data. The rationale is perhaps best illustrated with an example. Suppose an initial price of P_0 is increasing at a constant rate of r per period. Using the standard compounding formula, this can be expressed as:

(3) $P_X = P_0 (1+r)^X$

where: X = period $(1,2,3,\ldots,n)$

Taking the natural logarithms of both sides of equation (3), we obtain:

(4) $\ln P_X = \ln P_0 + \ln(1+r)X$

Equation (4) can be seen to be identical to equation (2) if $\alpha = \ln P_0$ and $\beta = \ln(1+r)$. This means that once equation (2) has been estimated by means of the ordinary-least-squares procedure, r can be extracted easily from $\hat{\beta}$, the estimated slope coefficient:

$$\hat{\beta} = \ln (1+r)$$

$$\text{antilog } \hat{\beta} = 1+r$$

$$r = (\text{antilog } \hat{\beta})-1$$

(The resulting value can be multiplied by 100 to obtain an expression of r in percentage terms.)

The average rate of growth (r) can be interpreted as the average constant percentage increase (or decrease) in Y associated with a unit change in X (time). In other words, from one period to the next, the values in the original data series on average change by a constant percentage, r. Note that the absolute size of the change is related to the absolute size of the dependent variable, unlike the case of linear trend.

Program 4 also calculates and stores the standard error associated with $\hat{\beta}$, the estimated slope coefficient. Under the basic assumptions, this standard error term can be used to test hypotheses about $\hat{\beta}$ and to construct confidence intervals. As above, the t-statistic can be computed and used to test the hypothesis that β differs significantly from zero. Important: Note that the standard error term from equation (2) is associated with $\hat{\beta}$ (a logarithm), not with r (a percentage rate of change derived from $\hat{\beta}$). Hypothesis tests must therefore be performed based on $\hat{\beta}$, not r. Although the program automatically prints out and/or displays the average rate of growth (r), the estimated slope coefficient ($\hat{\beta}$) is stored in register 83. If hypthesis tests are to be performed, $\hat{\beta}$ can be retrieved manually by displaying the contents of register 83 (see "Input/Output," p.84).

a) A Note on Regression of Time Series Data:

Since time series are not probability samples, they are subject to trends, cycles, seasonality, and other regular patterns of change. As a result, violations of the basic assumptions underlying the linear regression model sometimes occur. Probably the most common problem involves serial correlation. Since many time series move in cycles, particularly when agricultural data are involved, it is not uncommon to encounter runs of several successive positive or negative residuals. For example, agricultural prices are notoriously "sticky"; price in a given month tends to be influenced by prices in preceding months, and in turn it tends to exert a similar influence on prices in subsequent months. Consequently, when a trend line is fitted to a monthly prices series, positive residuals tend to be followed by positive residuals, and negative residuals by negative residuals. A similar pattern can result from specification error, as when a straight line is fitted to a curved relationship.

If serial correlation is present in the data, the coefficients estimated by means of the ordinary-least-squares procedure will remain unbiased (distributed evenly around the true population mean) and consistent (converging to the true population mean as the sample size increases without bound). However, the estimates will no longer be efficient (minimum variance among all unbiased estimators). As a result, the usual tests (e.g., t-tests and F-tests) based on the standard error terms cannot be invoked.

Program 4 should therefore be used with caution. Although the estimates of linear trend and average rate of growth will always be unbiased, the standard error term on $\hat{\beta}$ should be retrieved for use in hypothesis testing only if there is little probability of serial correlation in the data. As a general rule of thumb, if the data show signs of cyclical or seasonal movement, hypothesis tests based on the standard error term should not be performed.

4.4.3 Input/Output

Partitioning: 239.89

Input: Program 4 requires as input the time series for which linear trend and/or average rate of growth is to be calculated. The data can be entered manually or from magnetic cards. Up to 70 observations can be processed at a time.

The convention used in preceding programs has been to store each value in the register whose number corresponds to the time period of the value (i.e., value X_1 stored in register 01, value X_2 stored in register 02,..., value X_n stored in register n). This storage format can be used with program 4.

Register 00:	blank
Registers 01-70:	time series data
Registers 71-88:	blank
Register 89:	n (total number of observations)

Since the Master Library module regression program requires that registers 01-06 remain open, the original format described above must be modified by shifting all stored data ten registers up (i.e., contents of register 01 shifted up to register 11, contents of register 02 shifted up to register 12,...) This shift is accomplished automatically when user-defined label C is keystroked.

A time series being stored on magnetic cards can be updated very easily as long as blank data storage registers remain. The new values are simply entered manually into the appropriate registers on the data storage card.

Output: Program 4 produces two different sets of results, depending on whether the linear trend option or the average rate of growth option is selected. If the linear trend option is chosen, the program calculates and prints out (displays) the estimated slope coefficient, $\hat{\beta}$. This result is stored in register 81. The standard error term associated with $\hat{\beta}$ is also calculated and stored in register 82. It can be retrieved manually should hypothesis testing be necessary. If the average rate of growth option is chosen, the program calculates and prints out (displays) the average rate of growth, r, expressed in percentage terms. This result is stored in register 85. The original (logarithmic) slope coefficient, $\hat{\beta}$, and its standard error term are also calculated and stored in registers 83 and 84, respectively. They can be retrieved manually should hypothesis testing be necessary. Remember that the standard error is associated with the (logarithmic) slope coefficient, $\hat{\beta}$, not with the average rate of growth, r, derived from the slope coefficient.

4.4.4 User Instructions

a) Use With Printer

Step	Procedure	Enter	Press	Display (Printed Output)
1	Partition memory to 239.89	9	Op* 17	239.89
2	Read in program (program card 1, bank 1)	1	(enter program card 1, bank 1)	1.
Manual Data Entry:				
(3a)	Enter data manually (i.e., store directly into Registers 01 - 70) and skip steps 3b and 3c.			
Data Entry From Cards:				
(3b)	Read in time series data (data cards 1,2; banks 2, 3, 4)	2	(enter data card 1, bank 2)	2.
		3	(enter data card 2, bank 3)	3.
		4	(enter data card 2, bank 4)	4.
(3c)	Re-format data		C	

Step	Procedure	Enter	Press	Display (Printed Output)
Linear trend option				
4a1	Calculate linear trend		A	(CHANGE/PER) (trend)
4a2	Retrieve standard error		RCL 82	Standard error
Average rate of growth option				
4b1	Calculate average rate of growth		B	(GROWTHRATE) (rate of growth)
4b2	Retrieve slope coefficient ($\hat{\beta}$)		RCL 83	Slope coefficient
4b3	Retrieve standard error		RCL 84	Standard error

b) Use Without Printer

Step	Procedure	Enter	Press	Display
(1-3)	(same as above)			
4	Select no-printer option		E	
Linear trend option				
5a1	Calculate linear trend		A	trend
5a2	Retrieve standard error		RCL 82	Standard error
Average rate of growth option				
5b1	Calculate average rate of growth		B	Rate of growth
5b2	Retrieve slope coefficient ($\hat{\beta}$)		RCL 83	Slope coefficient
5b3	Retrieve standard error		RCL 84	Standard error

N.B. A blank worksheet, "Trend Analysis (Worksheet 4)" is included in the appendix. The worksheet can be photocopied for use in conjunction with Program 4.

4.4.5 Example 4: Trend Analysis

Problem Statement: The Ministry of Planning of the government of the Philippines has asked you to prepare a report on historical growth patterns in the Philippines agricultural sector to be used in a national planning model. You have been given annual crop production data (in 1000's of tons) from the period 1946-1971. As the first step in your analysis, you decide to calculate linear trend and average rate of growth.

Data

Year	Production	Year	Production
1946	3023	1959	10110
1947	4679	1960	10411
1948	5105	1961	10415
1949	5496	1962	11350
1950	5889	1963	11769
1951	6653	1964	12185
1952	6962	1965	12243
1953	7909	1966	12193
1954	8456	1967	12627
1955	8633	1968	13242
1956	8858	1969	13264
1957	9136	1970	15201
1958	9504	1971	15621

(Data Source: Philippines National Economic Development Authority, 1976)

a) Manual Data Entry Method/Printer Option

Procedure

Step	Enter	Press	Display (Printed Output)	Comment
1	9	Op* 17	239.89	Partition calculator to 239.89
2	1	(enter program card 1, bank 1)	1.	Read in program
3		D	11.	Select manual data entry option
	3023	R/S	1.	Enter first value
	4679	R/S	2.	Enter second value
	5105	R/S	3.	Enter third value
(Continue entering data until all observations have been entered.)				
4		A	(CHANGE/PER) (427.30)	Trend label Slope coefficient
5		RCL 82	3240.14591	Standard error
6		B	(GROWTHRATE) (5.09)	Rate of growth label Rate of growth
7		RCL 83	.0496476776	Slope coefficient
		RCL 84	.3921908862	Standard error

b) Data Read in from Magnetic Cards/No-Printer Option

Procedure:

Step	Enter	Press	Display	Comment
1	9	Op* 17	239.89	Partition calculator to 239.89
2	1	(enter program card 1, bank 1)	1.	Read in program
3	2	(enter data card 1, bank 2)	2.	Read in data
	3	(enter data card 2, bank 3)	3.	Read in data
	4	(enter data card 2, bank 4)	4.	Read in data
4		C	1.	Re-format data
5		E	1.	Select no-printer option
6		A	427.3011966	Slope coefficient (trend)
7		R/S	3240.14591	Standard error
8		B	5.090077527	Average rate of growth
9		R/S	.3921908862	Standard error
10		RCL 83	.0496476776	Retrieve slope coefficient
11		RCL 84	.3921908862	Retrieve standard error
12		RCL 85	5.090077527	Retrieve average rate of growth

4.4.6 Program 4 Listing: Trend Analysis

Loc	Code	Key	Comment	Loc	Code	Key	Comment	Loc	Code	Key	Comment
000	76	LBL		051	32	X:T		102	81	81	
001	15	E	Select	052	76	LBL		103	87	IFF	If no-printer,
002	86	STF	no-printer	053	38	SIN		104	01	01	go to TAN
003	01	01	option	054	43	RCL		105	30	TAN	
004	91	R/S		055	08	08		106	58	FIX	
005	76	LBL		056	32	X:T		107	02	02	Print linear
006	12	B		057	73	RC*	Sum data values	108	99	PRT	trend
007	86	STF		058	07	07	for regression	109	22	INV	
008	00	00		059	78	Σ+		110	58	FIX	
009	43	RCL		060	69	OP		111	22	INV	Calculate
010	89	89		061	37	37		112	69	OP	variance
011	85	+	Initialize	062	97	DSZ		113	11	11	
012	01	1	counters	063	08	08		114	34	√X	Calculate and
013	01	1		064	38	SIN		115	42	STO	store standard
014	95	=		065	69	OP	Calculate	116	82	82	error
015	32	X:T		066	12	12	intercept	117	91	R/S	
016	01	1		067	32	X:T	Display slope	118	76	LBL	
017	01	1		068	87	IFF	If average	119	79	X̄	
018	42	STO		069	00	00	growth rate	120	42	STO	
019	09	09		070	79	X̄	go to X̄	121	83	83	
020	76	LBL		071	42	STO	Store linear	122	53	(	
021	33	X²		072	81	81	trend	123	53	(	
022	73	RC*		073	69	OP		124	22	INV	
023	09	09		074	00	00		125	23	LNX	Calculate and
024	23	LNX		075	01	1		126	75	-	store average
025	72	ST*	Transform data	076	05	5		127	01	1	rate of growth
026	09	09	into logarithms	077	02	2		128	54	)	
027	69	OP		078	03	3		129	65	×	
028	29	29		079	01	1		130	01	1	
029	43	RCL		080	03	3		131	00	0	
030	09	09		081	03	3		132	00	0	
031	22	INV		082	01	1	Print linear	133	54	)	
032	67	EQ		083	02	2	trend label	134	42	STO	
033	33	X²		084	02	2		135	85	85	
034	76	LBL		085	69	OP		136	69	OP	
035	11	A		086	02	02		137	00	00	
036	36	PGM	Clear registers	087	01	1		138	02	2	
037	01	01	01 to 06	088	07	7		139	02	2	
038	71	SBR		089	06	6		140	03	3	
039	25	CLR		090	03	3		141	05	5	
040	43	RCL		091	03	3		142	03	3	
041	89	89		092	03	3		143	02	2	
042	42	STO		093	01	1		144	04	4	
043	08	08		094	07	7		145	03	3	
044	85	+		095	03	3		146	03	3	Print rate of
045	01	1	Initialize	096	05	5		147	07	7	growth label
046	00	0	counters	097	69	OP		148	69	OP	
047	95	=		098	03	03					
048	42	STO		099	69	OP					
049	07	07		100	05	05					
050	00	0		101	43	RCL					

Merged Codes

62, 63, 64, 72 STO, 73 RCL, 74 SUM, 83 GTO, 84, 92 INV SBR

Program 4 Listing (continued)

Loc	Code	Key	Comment
149	02	02	
150	02	2	
151	03	3	
152	03	3	
153	05	5	
154	01	1	
155	03	3	
156	03	3	
157	07	7	
158	01	1	
159	07	7	
160	69	OP	
161	03	03	
162	69	OP	
163	05	05	
164	43	RCL	
165	85	85	If no-printer,
166	87	IFF	go to LOG
167	01	01	
168	28	LOG	
169	58	FIX	
170	02	02	
171	99	PRT	Print rate of
172	27	INV	growth
173	58	FIX	
174	22	INV	
175	69	OP	Calculate
176	11	11	variance
177	34	ΓX	
178	42	STO	Calculate and
179	84	84	store standard
180	91	R/S	error
181	76	LBL	
182	14	D	
183	47	CMS	
184	01	1	
185	01	1	
186	42	STO	
187	88	88	
188	76	LBL	
189	39	COS	
190	91	R/S	
191	72	ST*	Manual data
192	88	88	entry routine
193	01	1	
194	44	SUM	
195	88	88	
196	44	SUM	
197	89	89	
198	43	RCL	
199	89	89	

Loc	Code	Key	Comment
200	61	GTO	
201	39	COS	
202	76	LBL	
203	30	TAN	
204	91	R/S	If no-printer,
205	61	GTO	display linear
206	01	01	trend
207	11	11	
208	76	LBL	
209	28	LOG	If no-printer,
210	91	R/S	display rate of
211	61	GTO	growth
212	01	01	
213	74	74	
214	76	LBL	
215	13	C	
216	43	RCL	
217	89	89	
218	42	STO	
219	00	00	
220	85	+	
221	01	1	
222	00	0	
223	95	=	
224	42	STO	
225	87	87	
226	76	LBL	Reformat data
227	89	π	
228	73	RC*	
229	00	00	
230	72	ST*	
231	87	87	
232	01	1	
233	22	INV	
234	44	SUM	
235	87	87	
236	97	DSZ	
237	00	00	
238	89	π	
239	91	R/S	

Loc	Code	Key	Comment

Merged Codes

62, 63, 64, 72 STO, 73 RCL, 74 SUM, 83 GTO, 84, 92 INV SBR

V. CONCLUSION

5.1 Summary and Conclusions

The stated objective of this research was to investigate the appropriateness of the hand-held programmable calculator as a tool for data analysis in the field. Agricultural economists working in developing countries frequently find themselves constrained by tight budgets, short deadlines, and scarce computer facilities. Programmable calculators have been suggested as a means of overcoming these constraints. Numerous features recommend the programmable as a field research tool, including: economy, portability, direct power or battery operation, speed, simplicity, "hands on" characteristic, and software availability. However, these advantages are offset by several disadvantages, including: limited memory, simplistic programming language, cumbersome data entry, rudimentary printing capacity, and hardware problems. Without personal experimentation, it did not seem possible to make a balanced assessment of the machine's actual and potential value.

The Texas Instruments TI-59 machine was selected for this study on the basis of: current popularity, cost, size, memory capacity, solid-state software modules feature, availability of software. Four original programs were developed during the course of the research and are described above. Each program description includes a review of the relevant economic theory, an explanation of the methods and equations used, a description of input and output, a set of user instructions, a step-by-step example based on an actual data set, worksheets which can be photocopied for use with the program, and a listing of program steps. The descriptions and instructions are geared to the non-expert user. Although experienced users of the TI-59 (or other machines) may find them unnecessarily extensive and detailed, the intention was to develop a set of "user friendly" materials which would make the programs accessible to a large number of researchers.

The programs developed during the course of the study include:

1) Program 1 - Deflating Price Data (automatically deflates a series of up to 40 observations).

2) Program 2 - Moving Averages, Centered Moving Averages (calculates a series of n-period simple moving averages an centers them at the midpoint of the moving period).

3) Program 3 - Seasonal Adjustment (uses the output of Program 2 to construct a seasonality index using the ratio-to-moving-average method).

4) Program 4 - Trend Analysis (uses the TI-59 machine's linear regression capability to calculate a linear trend and/or average rate of growth from time series data).

None of these procedures is mathematically complicated. Nevertheless, the programs are extremely useful. All have been designed to take advantage of the major strength of the programmable calculator, namely, its ability to perform long sequences of compound algebraic operations rapidly and accurately. Data can be entered manually or read in from magnetic cards. Output can be printed as hard copy (if the machine is being used with the printer) or displayed. The magnetic card data input feature is particularly noteworthy, since it enables the user to process multiple data sets in rapid succession without having to engage in a great deal of time-consuming manual keystroking. This distinguishes these four programs from the majority of commercially available programs, which for the most part require manual data entry. It is hoped that their unique data-handling capability will make these programs particularly useful to the economist at work in the field.

The experience of writing, testing, and debugging these four quite simple programs made clear both the strengths and the weaknesses of the programmable calculator as a data analysis tool. That a researcher with no prior experience with programmables was able to learn enough programming skills in a few weeks to write effective and useful programs bespeaks the fundamental simplicity of the machine. The programs themselves provide the strongest evidence in favor of the programmable calcultor; they are straightforward, non-technical, and easy to use, yet clearly they can make possible considerable time-savings for economists interested in deflating price series, constructing seasonality indices, or performing trend analysis. It would be difficult to avoid concluding that the ease of writing programs and the ease of using them recommend the programmable calculator for inclusion in the economist's kit of field research tools.

On the other hand, the research experience also confirmed weaknesses of the programmable. Writing and debugging programs is by nature a tedious and at times frustrating undertaking. In this respect, programmable calculators are no different than other sorts of computers. And despite the simple keyboard language used by programmables, their limited memory capacity in a very real sense makes programming all the more a challenge, since a tremendous premium is placed on economy of program steps. For all but the most experienced programmers, it is probably not worthwhile developing and documenting involved programs unless they will be used repeatedly. Finally, mention should be made of hardware problems. The TI-59 is not an infallible piece of equipment. The machine can and does break down. (So, presumably, do other models!) When a backup unit happens to be available, this is not a major problem, but it is easy to imagine situations in the field in which backup equipment might not be available. Needless to say, mechanical breakdowns can wreak havoc on research projects.

5.2 Directions for Future Research

The admittedly limited experience of developing and testing four simple data-analysis programs confirms that the programmable calculator does indeed have useful applications as a research tool. Clearly, however, this modest study has been able to address only a minuscule portion of the wide range of potential applications. The obvious question arises: What comes next on the research agenda?

Any answer to this question--and literally dozens come to mind--depends largely on the interests and subjective needs of the answerer. But in terms of price analysis research, which has been the focus of this investigation, there can be little doubt that the answer is best summarized in three words: multiple linear regression. The programs described above, while certainly time-saving, essentially accomplish little more than transformations of time series data; they enable the analyst to deflate prices, to smooth a series of observations, to perform seasonal adjustment, and to estimate trends. These various procedures are all preliminary procedures undertaken to prepare data for use as input into regression analysis. In attempting to establish statistical relationships between economic variables, price analysts frequently experiment with simple (3-6 variable) econometric models of supply and/or demand. Specific objectives of such modelling may include the quantification of relationships between economic variables, empirical investigation of price and/or income elasticities and flexibilities, and generation of forecasts. In order to accomplish these objectives, a number of statistical procedures must be invoked, e.g., estimation of partial regression coefficients, generation of t-statistics and F-statistics, calculation of correlation matrices and coefficients of determination (R^2), detection of serial correlation and heteroscedasticity, etc... These are the bread and butter procedures of price analysis, and they are a far cry from the more basic procedures addressed during the course of this study.

It may come as a suprise to learn that the programmable calculator is capable of performing many of these and other more complicated linear regression procedures. Dozens of regression programs have already been made available commercially (e.g., see the PPX Software Catalogue), and no doubt additional programs have been developed for private use. Unfortunately, time limitations did not permit a comprehensive survey of the existing software, much less development of original multiple linear regression programs incorporating magnetic card data input capability. Nevertheless, a brief review of several sample linear regression programs obtained through the PPX Exchange suggested that the existing programs, while impressive in terms of what they can accomplish, tend to be slow and cumbersome to use. Data must generally be entered manually (as opposed to being read in from cards), and the limited memory of the TI-59 machine requires that the more complex procedures be broken down into sequences of subroutines, to be performed by different program segments stored on separate cards. Much work remains to be done in streamlining these programs and making them easier and faster to use.

New models currently being introduced into the market may greatly facilitate the development of easy-to-use multiple linear regression software, thus augmenting the usefulness of the programmable calculator as an increasingly sophisticated research tool. The main difference of the newer models is vastly increased memory capacity. The increases in memory made possible by technological advances should soon be reflected in corresponding advances in software design.

The programmable calculator is not and never will be a perfect substitute for the computer. However, when a computer is unavailable (or when use of an available computer is impded by high cost, slow turnaround time, or shortages of trained personnel), the programmable calculator can have an important role to play in the analysis of economic data. Low cost, ease of use, speed, accuracy, and portability combine to make the programmable calculator extremely well-suited for research conducted under difficult field research conditions. Although programmables have to date been most useful to researchers in performing repetitive calculations which otherwise would have to be performed by hand, technological advances resulting in ever-expanding memory capacity continue to broaden the range of applications and to open up new possibilities for performing complex statistical procedures.

VI. APPENDIX - WORKSHEETS

DEFLATING PRICE DATA (WORKSHEET 1)

Period	Nominal Prices	Index	Deflated Prices

Period	Nominal Prices	Index	Deflated Prices

MOVING AVERAGES (WORKSHEET 2)

Period	Original Series	Moving Average (N=)	Centered Moving Average (N=)

Period	Original Series	Moving Average (N=)	Centered Moving Average (N=)

SEASONALITY INDEX (WORKSHEET 3A)

(1) Period	(2) Original Series	(3) Centered Moving Average (N=)	(4) Ratio-to-Moving-Average Percentage	(5) Adjusted Index (From Worksheet 3B)	(6) Deseasonalized Series

SEASONALITY INDEX (WORKSHEET 3B)

Period (Month/Quarter)	Ratio-To-Moving Average Percentages												Period Mean	Adjusted Index Number
	1	2	3	4	5	6	7	8	9	10	11	12		
January														
February														
March														
April														
May														
June														
July														
August														
September														
October														
November														
December														
Quarter I														
Quarter II														
Quarter III														
Quarter IV														

Σ Means	
Average Mean	

Adjustment Factor = $\frac{100}{\text{Average Mean}}$

TREND ANALYSIS (WORKSHEET 4)

Period	Original Series	Index	Adjusted Series

Period	Original Series	Index	Adjusted Series

DATA STORAGE (WORKSHEET 5)

Register	Data	Register	Data	Register	Data
00		30		60	
01		31		61	
02		32		62	
03		33		63	
04		34		64	
05		35		65	
06		36		66	
07		37		67	
08		38		68	
09		39		69	
10		40		70	
11		41		71	
12		42		72	
13		43		73	
14		44		74	
15		45		75	
16		46		76	
17		47		77	
18		48		78	
19		49		79	
20		50		80	
21		51		81	
22		52		82	
23		53		83	
24		54		84	
25		55		85	
26		56		86	
27		57		87	
28		58		88	
29		59		89	

VII. BIBLIOGRAPHY

Allen, R.G.D. Index Numbers in Theory and Practice. (Chicago: Aldine Publishing Company, 1975.)

Aronofsky, Julius; Robert Fame and Elbert Greynolds. Programmable Calculators: Business Applications. (New York: McGraw-Hill Book Company, 1978).

Bahn, Henry M. "The Programmable Calculator As Appropriate Technology For Farm Management Decision Making." (Paper delivered at the Michigan State University Conference on Microcomputers and Programmable Calculators, May 1982.)

Bernsten, R.H. and G. Banta. "The Use of Programmable Calculators in Farming Systems Research in Asia: Selected Experiences, Problems, and Potential." (Paper delivered at the Michigan State University Conference on Microcomputers and Programmable Calculators, May 1982.)

Clark, Charles and Lawrence Schkade. Statistical Methods For Business Decisions. (Cincinnati: South-Western Publishing Company, 1969.)

Engelsohn, Harold S. Programming Programmable Calculators. (Rochelle Park, New Jersey: Hayden Book Company, 1978.)

Espadas, Orlando T. "Programmable Calculator Applications For Agricultural Project Analysis." (Washington: International Bank For Reconstruction and Development, Economic Development Institute Course Notes, 1978.)

Foote, R.J. and Karl A. Fox. Seasonal Variation: Methods of Measurement and Tests of Significance. (Washington: United States Department of Agriculture. Agriculture Handbook No. 48, September 1952.)

Granger, C.W.J. Forecasting in Business and Economics. (New York: Academic Press, 1980.)

Gujarati, Damodar. Basic Econometrics. (New York: McGraw-Hill Book Company, 1978.)

Hepp, Ralph. "Understanding Your TI-59 Programmable Calculator: Instructional Aids." (East Lansing: Michigan State University, Department of Agricultural Economics, 1982.)

Koehler, Henrique Soares. "Use of Programmable Calculators For Analysis of Statistical Data." (Masters thesis, Michigan State University, Department of Forestry, 1979.)

Kuehn, John P. "Deflating Price Series in Regression Models." (In Journal of Northeastern Agricultural Economics Council, VII, 1, April 1979.)

Makridakis, Spyros and Steven Wheelwright. Forecasting: Methods and Applications. (Santa Barbara: John Wiley and Sons, 1978.)

Merrill, William C. and Karl Fox. Introduction to Economic Statistics. (New York: John Wiley and Sons, 19 .)

Mims, Forrest M. "Here are the New Programmable Calculators." (In Popular Electronics, 9(5), May 1976.)

Philippines National Economic and Development Authority (NEDA). Statistical Yearbook of the Philippines (1976).

Pindyck, Robert A. and Daniel L. Rubinfeld. Econometric Models and Economic Forecasts (2nd edition). (New York: McGraw-Hill Book Company, 1981.)

Purcell, Wayne. Agricultural Marketing: Systems, Coordination, Cash and Futures Prices. (Reston, Virginia: Reston Publishing Company/ Prentice-Hall, 1979.)

Qurashi, Salma. Retail Prices of Consumer Goods in Peshawar Market. (Peshawar: University of Peshawar Board of Economic Inquiry, Publication No. 83, 1972.)

Shepherd, Gregory S. Agricultural Price Analysis (5th edition). (Ames, Iowa: Iowa State University Press, 1963.)

Sippl, Charles J. and Roger J. Sippl. Programmable Calculators: How to Use Them. (Champaign, Illinois: Matrix Publishers, 1978.)

Spurr, William A. and Charles Bonini. Statistical Analysis For Business Decisions. (Homewood, Illinois: Richard D. Irwin, Inc., 1973 ed.)

Suits, Daniel B. Statistics: An Introduction to Quantitative Economic Research. (Chicago: Rand McNally and Company, 1963.)

Texas Instruments. Personal Programming (1977).

Texas Instruments. Sourcebook For Programmable Calculators. (New York: McGraw-Hill Book Company, 1979 ed.)

Tomek, William G. and Kenneth L. Robinson. Agricultural Product Prices (2nd edition). (Ithaca, New York: Cornell University Press, 1972.)

Weir, Maurice. Calculator Clout: Programming Methods For Your Programmable. (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1981.)

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