Irrig. Econ. aspects

Part 3

PROCEEDINGS

Agricultural Economics Seminar

Compiled by

HOWARD F. ROBINSON, *Professor of Agricultural Economics*
FREDERIC A. WILLIAMS, *Professor of Agricultural Economics*

Department of Agricultural Economics
North Carolina Agricultural and Technical State University
Greensboro

February 1969

AGRICULTURAL PRICE ANALYSIS: WHAT'S IT ALL ABOUT*

By
A. C. Johnson, Jr.**

Someone once said that economics is what economists do; an appropriate paraphrase would be to say that price analysis is what a price analyst does. For our purpose today we might define price analysis as a study of past price movements and of the supply and demand factors associated with these price movements. A major objective of agricultural price analysis is to obtain a comprehensive description of the relation between the prices of farm products and the quantities of these products that can be disposed of through commercial market channels at those prices. Such information is of value not only in appraising possibilities for enhancing farm prices and incomes through appropriate marketing programs but also in contributing to our understanding of how markets actually operate to facilitate the exchange of goods and services.

The objective of this paper is to present, within the context of a "typical" problem, the procedures generally followed by the analyst as he studies prices and price movements over time. First, we will consider a typical problem confronting the price analyst. Then as attempt will be made to show how economic theory is used to provide the framework within which the analyst will work. Third, I shall work through an actual example that demonstrates the use of regression analysis, a tool commonly used by price analysts. Finally, we will discuss how the results obtained from a price analysis study of this type are interpreted.

A "Typical" Problem

Suppose a national apple growers' association comes to you and asks you to undertake a price analysis study of the apple industry. They would want to know such things as what factors affect the price of apples, how do these factors affect the price, which ones seem most relevant, and what are the policy implications of results which are obtained. Questions such as these suggest quite clearly that price analysis is really concerned with developing relationships which will permit one to make price predictions That is to say, given the values of certain variables, what would be the expected price. With this in the background, let us proceed with the development of the economic model.

---

* Paper presented at the Economics Seminar, North Carolina Agricultural and Technical State University, Greensboro, North Carolina, December 12, 1967

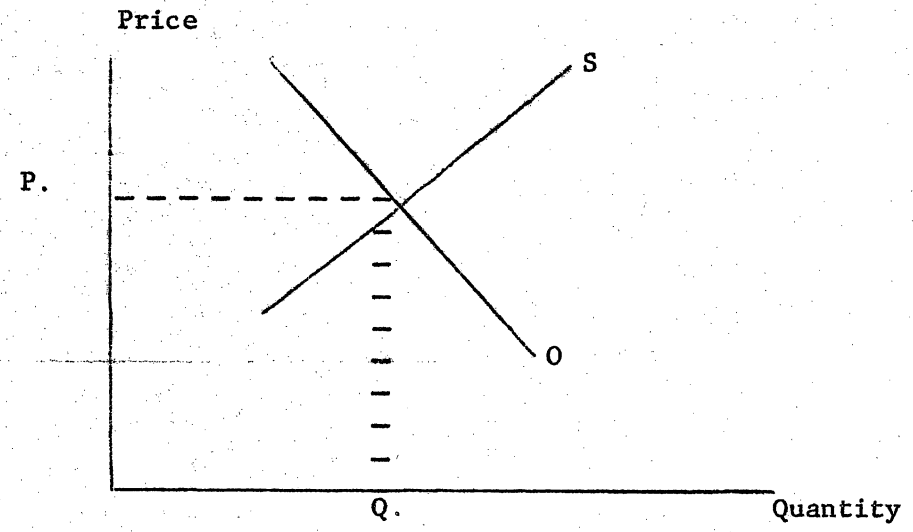
** A. C. Johnson, Jr. is Associate Professor, Department of Agricultural Economics, University of Wisconsin, Madison, Wisconsin.

The Economic Model

Having define price analysis as the study of past price movements and of the supply and demand factors associated with them, the first step would be to identify those factors which would be expected to affect the price of apples. This process of factor identification may be referred to as the development of an economic model. As we shall see in a moment it is this economic model, which is nothing more than a statement delineating the variables relevant to the current problem, that provides the framework within which we will attempt to answer the questions posed in this preceding section.

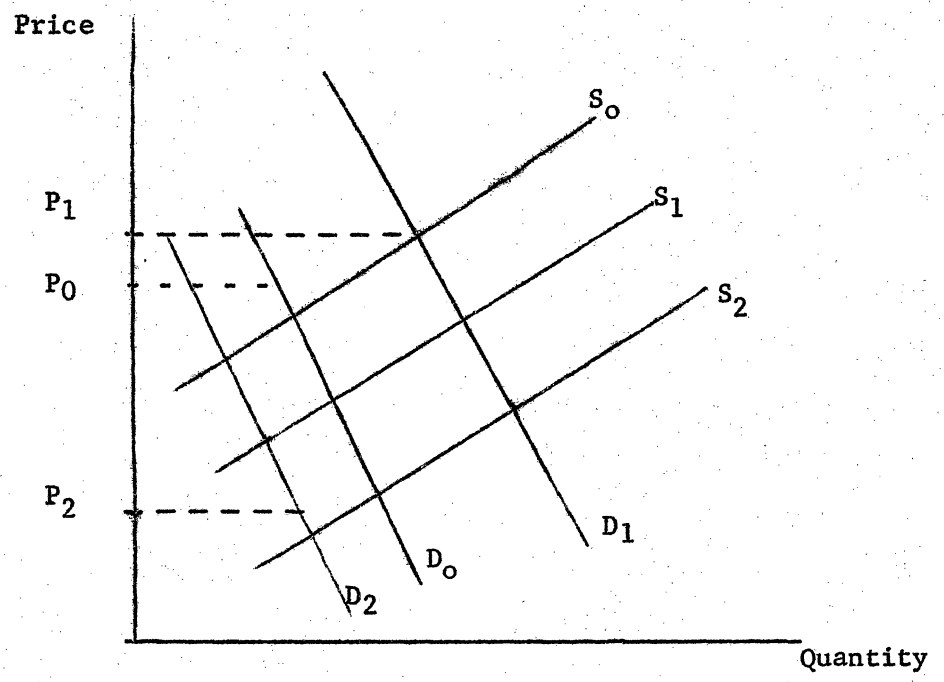
As an economist the first step would be to call upon economic theory to see what it has to say concerning price and price-making forces. We all know from our study of price theory that market price is generated by the interaction of supply and demand curves (See Figure 1). This is the static market equilibrium model which shows how the market price is generated.

Figure 1. The Static Market Model



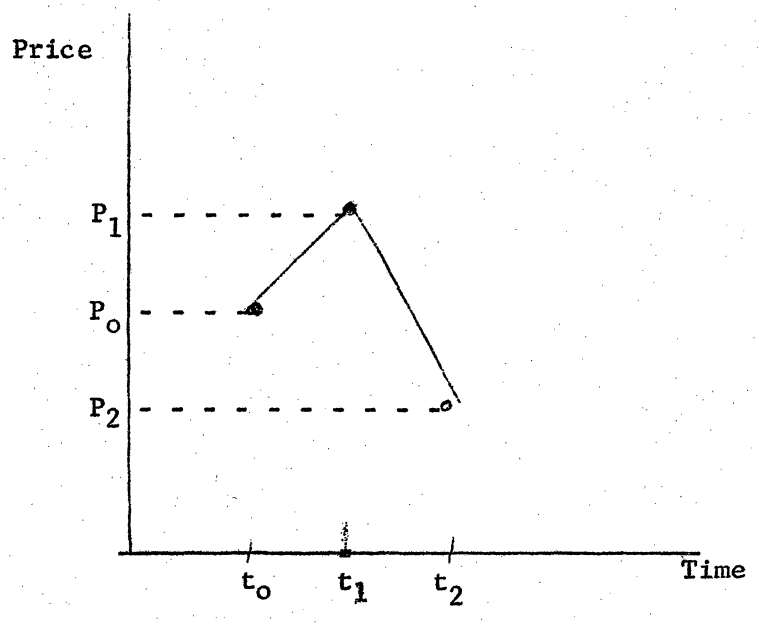
However, in our apple study we are concerned with a dynamic process where prices are changing over time, so we seek a theoretical construct which will generate a time path of prices. This we can do with the aid of Figure 2.

Figure 2. The Dynamics of Price Change.



Suppose we begin with time period $t = t_o$. The intersection of D_o and S_o results in the market price P_o. In the next time period, $t = t_1$, the demand curve has shifted outward to D, while the supply curve has shifted downward to S_1. Thus, in this time period market price is equal to P_1. Similarly, in the next time period, $t = t_2$, the supply and demand curves have shifted in such a w;ay that the resulting market price is P_2. We could, of course, continue this process indefinitely but this is sufficient to suggest that as the demand and supply curves shift from one time period to the next there is likely to be a corresponding change in the market price over time. This may be more clearly seen from Figure 3 where we have plotted the market prices against the time period in which they occured.

Figure 3. The Time Path of Price.



From this analysis our definition of price analysis becomes quite clear because we have shown that it is changes in supply and demand conditions which bring about changes in market price. In the context of our apple study this means that we are really interested in identifying those factors which affect the supply and demand curves for apples.

We must now search for factors which may cause shifts in supply and demand functions and again we turn to economic theory for guidance. Consider first demand functions. Economic theory suggests that changes in consumer income would cause demand functions to shift. For example, all else constant, if a consumer's income were to increase we would expect that the consumer would be willing to pay a higher price for the same quantity of the goods or would be willing to purchase a larger quantity at the same price. In other words, an increase in income would be expected to shift the demand curve upward and to the right. Similarly we would expect changes in the prices of substitutes for the product to cause shifts in the demand function. For example, in the current case suppose that the price for oranges, which substitute in consumption for apples, were to be lowered. We might expect the demand curve for apples to shift to the left, since with lower orange prices, consumers would be less willing to pay the same price for apples. In other words, apples would become more expensive relative to oranges and consumers would eat more oranges and fewer apples, this causing a shift in the demand functions for apples. This kind of

shift would work in reverse fasion, of course, as an increase in the price of a substitute would be expected to shift the demand curve for the good to the right. There are a host of other factors which could be expected to generate shifts in demand functions such as age, sex, and education of the consumer, and so forth. Frequently in applied agricultural price analysis all of these factors are collectively referred to as tastes and preferences. By this we mean simply that if the consumers preference for a certain commodity changes, for any reason, we would expect the demand curve for this commodity to shift in an appropriate fashin. In summary, in our analysis we would be concerned with such demand factors as income, price of substitute, tastes and preferences, and so on. Conceptually our demand function would include every variable which is relevant in determining the quantity of a commodity which the consumer is willing to purchase at the market price.

Now what about shifts in supply curves. One factor which we would expect to cause a shift of the supply curve would be the cost of producing the good. For example, if for some reason, producers were able to produce the product at a lower price we would expect them then to be willing to sell the same quantity at a lower price or sell a larger quantity at the same price. In other words, we would expect the supply function for the commodity to shift downward and to the right. Conversely if, for some reason, the cost of producing the good were to increase, then we would expect the supply curve to shift upward to the left. Another factor which may have some effect on the supply curve would be the price of commodities which can be substituted in production. For example, if a farmer can produce both wheat and feed-grains then the quantity of wheat which he is willing to supply at a certain price will likely be affected by the price of feed-grains. If the price of feed-grains should rise relative to the price of wheat it would be relatively more profitable for him to produce feed-grains, thus we would expect the supply curve for wheat would shift upward and to the left since the farmer would be less willing to supply the same quantity of wheat at the same price. Finally, changes in technology would have some impact on supply curves. As new products become available, as technological changes bring about changes in costs and in production techniques we would expect supply curves to shift in an appropriate fashion. As was the case with the demand function, we would specify our supply function in such a way that it would include every variable which is relevant in determining the quantity of a commodity which a producer is willing to sell at the market price.

Having done this we have specified the economic model which we shall use to study apple prices. So far we have operated largely within the confines of economic theory to specify this model. There is a practical side to this model specification, however. The following is illustrative. Our theory suggested that the price of substitutes is

relevant variables in the demand function. However, it did not give us the slightest clue as to what commodities are substitutes for apples, the commodity which we are currently studying. To solve this problem we must lean heavily upon our own experience the experience of others, and results of previous studies. In the case of the demand for apples I would probably not include the price of water skis but it is likely that I would include the price of oranges since it seems reasonable that the latter would be a substitute in consumption while the former would not. In the final analysis the price analyst must draw upon economic theory and upon his real world experience to develop his economic model. The good price analyst is one who thoroughly understands both economic theory and the characteristics of the commodity he is studying.

Before considering the technique of regression analysis there is a characteristic of agricultural supply which should be recognized because it has an important bearing on how we proceed in our price analysis. This is what I call the concept of fixed supply. Perhaps its significance would be better appreciated if we first return to the market model of Figure 1. What we have shown graphically may be written mathematically as

$$(1) \qquad Q^d = f(P)$$

$$(2) \qquad Q^s = g(P)$$

$$(3) \qquad Q^d = Q^s$$

where Q^d = quantity demanded

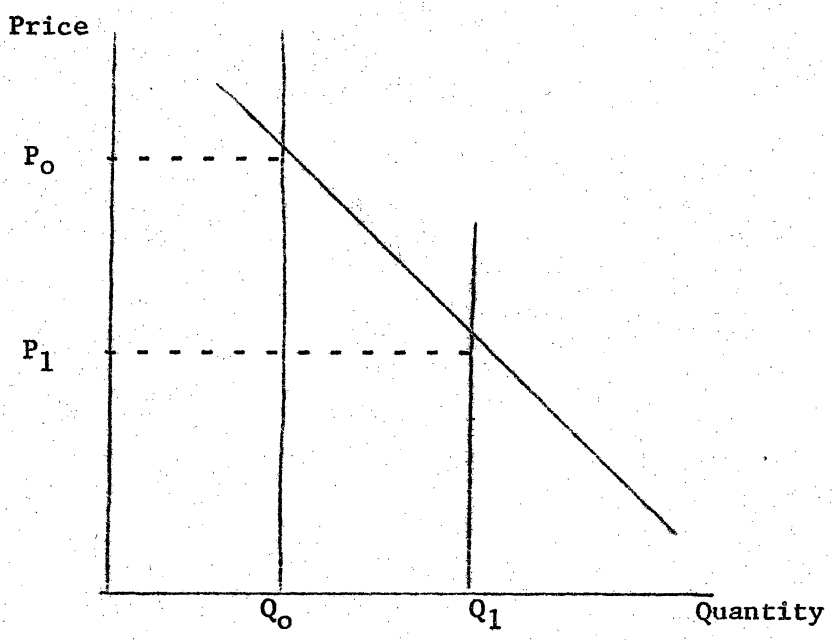
Q^s = quantity supplied

P = market price

This formulation tells us exactly the same thing that the graph tells us, namely, the quantity demanded is some function of price, the quantity supplied is some function of price, and at equilibrium the quantity demanded is equal to the quantity supplied. Mathematically we have three equations and three unknowns, Q^d, Q^s, and P and we know from our study of mathematics that in such a situation we must solve these equations simultaneously. I do not intend to get into the simultaneous-equation problem here but suffice it to say that when, in agricultural price analysis, we are confronted with this situation, we are facted with a ragher difficult problem. In fact, we often seek for some rational which would permit us to restate our problem in such a way that this simultariety is eliminated. This, fortunately, can be done in many cases of applied agricultural price analysis through use of the fixed supply concept.

This concept of fixed supply recognizes the fact that for many agricultural products the quantity which is available for sale during the marketing season is completely determined prior to the marketing season. Fresh fruits and vegetables offer a good illustration. Normally the crop is planted in the spring, cared for during the growing season and then harvested. Once it is harvested the amount which is available for sale is fixed; it cannot be increased nor can it be decreased, short of throwing some of it away. In other words the quantity supplied during the marketing season cannot be changed response to changes in market price. Graphically we have

Figure 4. Fixed Supply.



In period $t = t_o$, the quantity available is fixed at $Q = Q_o$ and our supply curve is vertical at $Q = Q_o$. Similarly is period $t = t_1$, supply is fixed at $Q = Q_1$, and again we have a vertical supply curve at that point. Note that <u>within</u> a season the quantity cannot be altered in response to change in price (See Figure 1 for comparison). From an economic standpoint this means that the given quantity will move into the market and "seek out" that price at which it will all be sold, for example P_o in Figure 4 is that price at which Q_o will all be sold, given the demand curve. In terms of our equation this means that we no longer have three equations and three unknowns because Q^s is already known and by the equilibrium conditions $Q^s = Q^o$, Q^D becomes a known. Thus, we now have only one equation

$$(4) \qquad P = f\ (Q^s)$$

which expresses price as a function of quantity - note that the identical relation is shown in Figure 4. This has tremendous significance for applied agricultural price analysis because now instead of being confronted with a simultaneous equation model and all the problems associated therewith we now have a single equation model which is much easier to work with in a research context, as we shall see momentarily.

Pulling all of the arguments of this section we might postulate for the economic model to guide our study of apple prices the following: Price of apples is considered to be a function of the quantity of apples, consumer income, the price of substitutes such as oranges, peaches and other kinds of fruits, and a taste and preference variable which reflects the changes of consumers desires over time. In summary, by drawing upon economic theory and upon our knowledge of the commodity which we are studying, we have developed what we call our economic model. We will now turn our attention to the statistical model.

The Statistical Model

Now that we have our economic model interest turns to obtaining estimates of this model, that is to say, we want to develop some numbers to talk about. For example, we would like to determine by how much a given change in production will affect the price of apples, all else constant, or we might ask the question if consumer income goes up by 10%, all else constant, what would be the impact upon the price of apples. Of course to get answers to questions of this type we must have some numbers and this relates to our idea of a statistical model.

In practice it turns out that there are many problems associated with going from the economic model we developed above to the statistical model which we will actually use in our analysis. For example, it is often the case that the variables which are used in the statistical model are different from those which are included in economic model. It may be difficult to measure some of the variables in the economic model. A good illustration is the taste and preference variable. Another factor contributing to differences between the statistical and economic models may be lack of relevant data. For example, in our economic model we might include, as a relevant variable the price of avocados, but in a a given research situ;tion it may be that we cannot obtain the needed price data. Hence, although we feel that it is a relevant variable in affecting the price we cannot consider it because we cannot obtain data with which to measure its affects. Finally there are a large number of statistical problems associated with the development of the statistical model. However, I will not discuss any of these here as I feel that it goes beyond the objection

of this paper. Suffice it to say that this is one of the real tough problems in price analysis. Because there are a large number of problems associated with the transition from the economic model to the statistical model we usually end up working with a model which falls short of the ideal model. Consequently our results are generally less than perfect in that we are seldom able to explain all of the observed variation in price. The meaning of this will become clearer in the following section. I would conclude, parenthetically, that even though we cannot obtain perfect results we must still do the best we can with what we have available to us.

Regression Analysis

The technique most frequently used by agricultural price analysts to answer the question confronting us is regression analysis. I shall not develop the underlying theory nor attempt to define it in a rigorous fashion. It is sufficient for us to recognize that regression analysis is concerned with the systematic investigation of the relationships which exist among economic variables and with the attempt to express these relationships in a mathematical form. With the high-speed computers which we have today the type of problem we are considering can be done so rapidly that one often wonders why we bother with the graphic approach to be considered below. I have some strong biases on this point but will not elaborate them here except to say that by plotting our data on graph paper we often discover meaningful relations which would not be "seen" under a giant computer. Also, for problems of modest size it may be much faster to use graphics than the computer. Suffice it to say that students in my Ag Prices Class use graphic analysis in their term problem!!!

In order to illustrate graphic regression analysis I will use a less complex model than if I were actually undertaking a research project concerning factors affecting the price of apples. Specifically we will consider the price of apples as a function only of the quantity of apples and consumer income. We, of course, pay a price for achieving such simplification--because a number of obviously relevant variables, such as prices of competing fruits, are omitted our results will be far from perfect in the sense that we will not "explain" all of the year to year variation in apple price. However, this simple problem is still of sufficient magnitude to clearly demonstrate the use of regression analysis and that is the purpose of this section. How to the graphics.

The data to be used are presented in Table 1. We have retail price of apple,s per capita consumption, and per capita disposible income for the period 1948-62. Observe that during this period apple price has been fluctuating, going from a low of 10.7 cents per pound in 1951 to a high of 17.3 cents per pound in 1961. It is the object of our analysis to see if we can explain these year to year changes in price in terms of changes in quantity consumed and in consumer income.

We begin by considering the relation between price and quantity. These data have been plotted in Graph 1. Note that each year's data have been plotted at the proper-quantity-price coordinate and each year has been identified. The first thing to observe is the definite inverse relation between price and quantity - when quantity has been large price has been low and conversely. This is, of course, what we would expect on the basis of economic theory. (See, for example, Figure 4). The solid line has been drawn in an attempt to show a "smooth" relationship between these two variables - it is an attempt to express the average relation. Accepting this line as an expression of the relation between price and quantity we can then use it to predict what price would be associated with a given quantity. For example, a quantity of 25.0 pounds would result in a price of about 12.1 cents per pound, on the average.

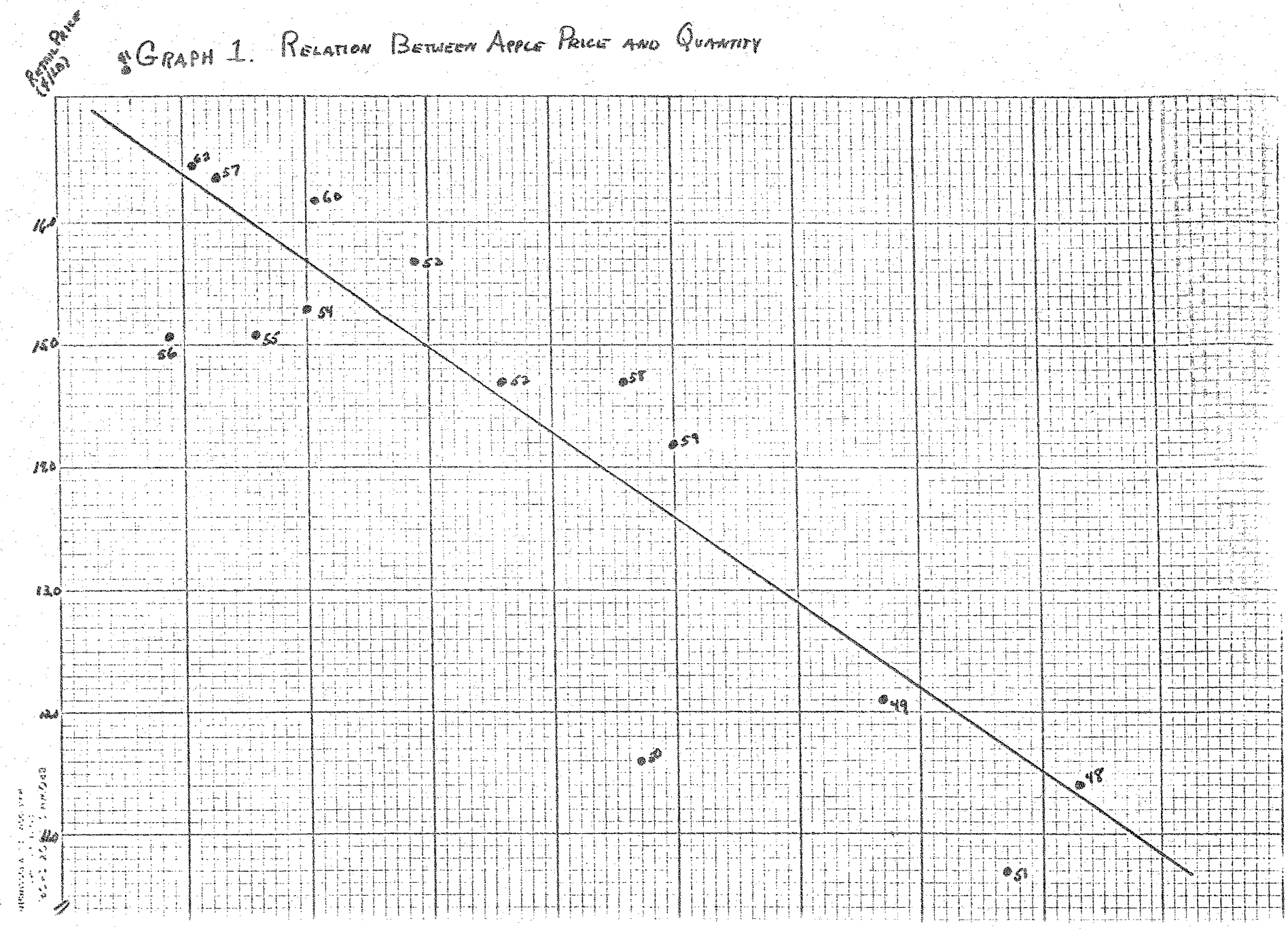
The disturbing feature of Graph 1 is that we do not have an exact relation, in fact, not one year falls precisely on the line. The main reason that this occurs is because, as we know from our above arguments, quantity is not the only factor affecting price. Thus, we should not be surprised or disappointed about the results shown in Graph 1. Quite the opposite, we should be pleased in that we have clearly obtained the inverse relationship which we expected.

Table 1. Data for Use in Apple Price Analysis

Year	Retail Price (cents per pound)	Per Capita Consumption (pounds)	Per Capita Disposable Income (dollars)
1948	11.4	26.3	1,291
1949	12.1	24.7	1.271
1950	11.6	22.7	1,369
1951	10.7	25.7	1.473
1952	14.7	21.6	1,520
1953	15.7	20.9	1,582
1954	15.3	20.0	1,582
1955	15.1	19.6	1,660
1956	5.1	18.9	1,742
1957	16.4	19.3	1,804
1958	14.7	22.6	1,826
1959	14.2	23.0	1,904
1960	16.2	20.1	1,934
1961	17.3	18.6	1,980
1962	16.5	19.1	2,052

Source: "Demand and Price Analysis: Some Examples from Agriculture". USDA, ERS, ESAD, Technical Bulletin No. 1316, Nov. 1964, p. 33.

Graph 1. Relation Between Apple Price and Quantity



Within the framework of regression analysis we argue that the difference between a price which would be predicted from the equation and the actual price which existed for a given year is due to some other variable. For example, in 1954, quantity was 20.0 pounds. Our regression line would predict a price of about 15.7 cents per pound while the actual price was 15.3 cents per pound. It is this difference of .4 cents per pound (often referred to as the "residual") which is attributed to the effect of some other variable.

With this background let us turn to Graph 2. Here are plotted the residuals from Graph 1 against this level of consumer income for this year associated with a given residual. For example, we calculated the residual for 1954 to be .4 cents per pound. In 1954 consumer income was $1,582. Thus the residual (-.4) is plotted against a value of $1,582 on the horizontal axis (note the zero line where plus residuals from Graph 1 are plotted above and negative residuals plotted below). Similarly we plot all residuals from Graph 1 against their respective income levels. Again a general relations is observed, namely, as income rises the residuals increase in size. This is saying that, all else constant, the higher the level of income the higher will be the price which is, of course, exactly what we expected on the basis of economic theory. As with Graph 1 a solid line has been drawn in to represent the average relationship between the residuals and consumer income.

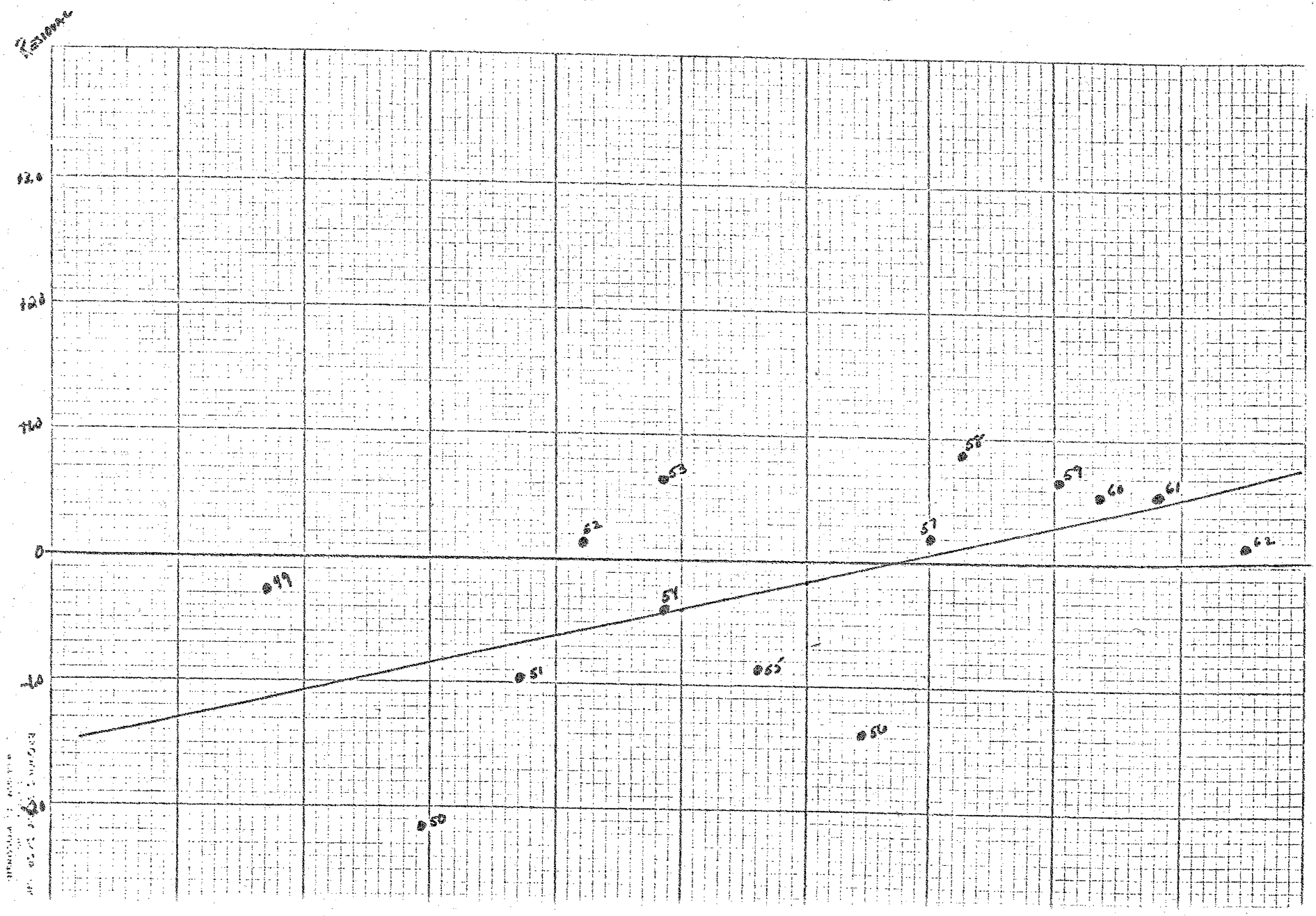
Perhaps it would be helpful to briefly review what we have done. We first considered the relationship between apple price and quantity and found the expected increase relation. However, we also observed that the relationship was not exact that changes in quantity did not fully explain changes in price. The next step consisted of looking at that portion of actual price not explained by quantity (the residuals in Graph 1) in relation to changes in consumer income. As a result we have a graphic system which shows how changes in quantity and in income affect the price of apples. In a true research situation we would look at additional variables. For example, a next logical step might be to relate the residuals from Graph 2 to changes in the price of a substitute commodity, say pears. Conceptually we would consider new variables until finally there would be no unexplained variation left(in practice we never do this).

This, then, is the essence of regression analysis; a tool well designed to assist the price analyst. Hopefully it has been shown to be a process whereby this analysis attempt to determine what variables are relevant to the problem and the nature and extent of their affect.

Interpretation

Let us consider briefly the results obtained and how they could be used for prediction purposes. If the line in Graph 1 were drawn accurately we could determine its slope which, in fact, would turn out to be about -.452. (I calculated this mathematically) For a change in

GRAPH 2. RELATION BETWEEN RESIDUALS ON GRAPH 1 AND CONSUMER INCOME



the opposite direction by .452 cents per pound. Simarly, this slope of the line in Graph 2 turns out to be +.00282 which says that, given the effect of quantity on price, a change in income of one dollar results in a change in price of .00282 cents per pound in the same direction. Thus, we have "quantified" the effect of changes in these variables on price.

Finally, let us see how we can use these results to predict price. Suppose we were told that quantity was going to be 22.0 pounds and that consumer income was going to be $1600 and were then asked what price would be. We would proceed as follows. Using Graph 1, we would predict a price of 14.3 cents per pound---here we use our regression line to read off this price associated with a quantity of 22.0 pounds. From Graph 2 we determine that the residual when income is $1600 is equal to -.4, which means that to adjust our price for the effect of income we should subtract .4 cents from it. Thus, our predicted price would be 143 - .4 = 13.9 cents per pound when quantity = 22.0 pounds and income = $1,600.