RECENT ECONOMETRIC STUDIES IN AGRICULTURAL MARKETING*

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AN ECONOMETRIC MODEL OF THE WATERMELON MARKET

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I. *Introduction*

IN THIS paper we present a complete, empirically determined supply and demand structure for the watermelon market. In addition to presenting the final model, we shall apply the results to an analysis of some of the dynamic properties of the market. We will investigate its stability, the path of adjustment toward equilibrium, and the speed with which such adjustment would occur, other things being equal. Finally we will employ the model to forecast the watermelon market a year ahead. In the process of our discussion we will make a few remarks about technical problems encountered.

Although a large number of attempts—many of them eminently successful—have been made to determine empirical demand and supply schedules, the present work is one of the few in which both are fitted for the same market. In view of the fact that supply and demand schedules have long been a part of the standard equipment of economic analysis, the absence of complete empirical models of individual markets is remarkable. It is due, I think, primarily to what has been until recently a serious technical limitation. It is now generally recognized that the classical least squares procedure can be properly applied only in situations where a single dependent variable is to be "explained" by a set of independent variables whose values, if not exogenously fixed, are at least predetermined with respect to the dependent variable in question. That is, least squares estimates of the effect of crop on price can be calculated where the demand in the market adapts price—the dependent variable—to the volume of the crop, predetermined by planting, weather, insect pests, etc., and not directly influenced by current price. But least squares regressions cannot be used to determine the supply and demand structure of a market in which price and quantity marketed are jointly determined dependent variables.

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† Particular thanks are due to three students in my course in Applied Economic Statistics in cooperation with whom the model was formulated and the basic calculations prepared in the spring of 1954: to Woodrow Creason and William McGrath for their heroic efforts in calculation, and to Thomas Klein who, in addition, originally pointed out the important role played by cotton in the watermelon supply, and for his helpful criticism of the manuscript. Thanks are also due to Susumu Koizumi of the Michigan Research Seminar in Quantitative Economics who calculated the moving equilibrium of the final system.

In the last several years, however, a number of advances in statistical method have broadened the scope of research possibilities to include the treatment of systems involving a number of jointly determined variables. In terms of adaptability and cost, the most useful of these is the technique of "limited information." It would be fruitless to attempt to explain the method within the confines of this paper. It can be found well described and illustrated elsewhere.[1] Suffice it to say that it constitutes the basic tool of this analysis of the watermelon market.

The model to which this technique is applied is aggregative both in the scope of coverage—it includes total U. S. production, average prices, etc.—and in the fact that it is limited to annual data. Clearly not every aspect of the watermelon market can be adequately treated in this way. The watermelon is produced under widely differing conditions even within its area of heaviest concentration. A complicated pattern of shipping costs and available marketing channels links the growers with their several markets. Moreover, the seasonal timing of supplies in different parts of the producing area, possible seasonality in demand, and the extreme sensitivity of the city markets to temporary weather conditions give the intra-year behavior of the market a "fine structure" exceedingly complex and difficult to capture. In an aggregative model this fine structure is, of course, washed out.

II. *The Model*

Our model of the watermelon market consists of three economically meaningful relationships; (1) a crop supply schedule, (2) a harvest supply schedule and (3) a demand schedule.

(1) The crop supply schedule relates the total crop available for commercial harvest to lagged price and cost factors. Since the crop is perishable, decisions to plant must be made in the absence of knowledge about current prices. Thus the crop supply schedule relates the current commercial crop to the average farm price of the previous season.

In the short run the most important cost involved in the production of watermelons (or any farm crop) is the lost opportunity to produce other things. The most important cost factor in the case of watermelons appears to be cotton, a serious competitor for farm space. This cost factor is included as the average cotton price per pound received by farmers the previous year. It is clear, however, that the price of cotton will not always enter into the cost of watermelon production the same way. In particular the program of cotton acreage allotments put into effect in 1934 and there-

[1] Lawrence R. Klein, *A Textbook of Econometrics*, Row Peterson, 1953, esp. Chapt. III pp. 122–133 and Chapt. IV pp. 169–184. William Hood and Tjalling Koopmans, *Studies in Econometric Method*, John Wiley and Sons, 1953, especially Chapt. 6 pp. 162ff. Gerhard Tintner. *Econometrics*, John Wiley and Sons, 1952, pp. 172–184.

after presumably had some effect on the supply of watermelons. Some effort was devoted to attempts to quantify this program, but it was finally decided that it could best be represented by a dummy variable that had the values 0 before 1934 and 1 for 1934 and thereafter.

Although the production of watermelon is heavily concentrated in the South, it was felt that some more general costs should be included to cover more northern production. An index of the price of commercial truck crops was employed for this purpose, although as will be seen, this proves not to affect the supply significantly. This is probably due to the fact that a relatively small portion of total commercial truck crops actually compete with watermelons for farm space. A more satisfactory result could probably be obtained by constructing an index of such truck crops as are serious competition with watermelons for acreage, but this has not yet been done.

Finally, the supply of watermelons was seriously influenced by the war. The choice was either to omit the war years from the process of fitting the model, or to include some recognition of the effect of the wartime program. The latter alternative was adopted, a second dummy variable being employed to represent the presence of the war. This variable is entered with a lag and has the value 1 during the years 1943 through 1946 and 0 at all other times.

The general form of the crop supply is then:

$$Q = aP_{-1} + bC_{-1} + cJ + dT_{-1} + eK + f \qquad (1')$$

where Q is the commercial crop of watermelons available for harvest, P_{-1}, C_{-1} and T_{-1} are the prices of watermelons, cotton, and commercial truck, lagged one year; J and K are dummy variables representing government cotton policy and the war respectively. In the actual process of fitting the equations all except dummy variables were measured in logarithmic form. Thus the parameters of the actual variables are elasticities, while those of the dummy variables are readily translated into percentage shifts in the schedule. The crop supply equation is fitted to data for the entire period, 1919–1951.

(2) The harvest supply schedule is a relationship between quantity marketed, current farm price, harvesting cost, and the crop for harvest. The crop supply discussed above is, of course, merely the quantity of melons *available* for harvest. The harvest supply dealt with here is the quantity of melons actually harvested and marketed. Unlike the decision to plant, which must be made in absence of knowledge of current prices, the decision to harvest or leave the crop unharvested may be made in light of current price quotations as compared with the cost of harvesting. An index of southern farm wage rates was taken as the best approximation to some measure of harvesting cost. Because of the small number of years available for fitting the market supply schedule it was deemed advisable to save a

degree of freedom by including this variable in the ratio of the current farm price to the current farm wage rate.

In no event can the harvest of melons exceed the crop. Thus the harvest equation has the general form

$$X = a' \frac{P}{W} + b'Q + c' \quad \text{or,} \tag{2'a}$$

$$X = Q \quad \text{whichever is smaller.} \tag{2'b}$$

X is the number of watermelons harvested and W the southern farm wage rate. Information on the magnitude of X is not available before 1930 and the harvest supply is fitted in logarithmic form to data of the period 1930–1951.

(3) The final equation in the model is the demand. In order to make the demand equation fit readily with the two supply functions it was decided to measure demand at the farm level. The demand schedule then relates the current farm price of watermelons to current per capita disposable income and per capita market supply. Moreover, since this is a derived demand, it depends not only on market demand factors proper, but also on the cost of shipping from farm to market. As a measure of this, the function includes the current average cost of farm-to-market rail shipment of watermelons. This is admittedly a crude measure of actual shipping costs. A relatively small portion of all production moves to market by rail. (At present only a fourth to a fifth of all melons are shipped this way.) Moreover, this proportion has been steadily declining over time. Nevertheless the average farm to market rail freight cost must serve at least as an index of freight costs in the absence of any better measure. Where N is population, Y disposable income, and F freight cost, the demand equation has the general form

$$P = a'' \frac{Y}{N} + b'' \frac{X}{N} + c''F + d''. \tag{3'}$$

The farm demand equation is fitted in logarithmic form to data covering the period 1930–1951.

The resulting fitted equations are as follows (figures in parentheses are standard errors);

Crop supply:

$$Q = \underset{(.156)}{.587}P_{-1} - \underset{(.095)}{.320}C_{-1} + \underset{(27.40)}{34.41}J - \underset{(.238)}{.141}T_{-1} - \underset{(45.17)}{155.97}K + 768.735. \tag{1}$$

Harvested Supply:

$$X = \underset{(.110)}{.237} \frac{P}{W} + \underset{(.114)}{1.205}Q - 118.041 \quad \text{or,} \tag{2a}$$

(2b) $X = Q$, whichever is smaller.

Demand:

$$P = \underset{(.088)}{1.530}\,\frac{Y}{N} - \underset{(.246)}{1.110}\,\frac{X}{N} - \underset{(.183)}{.682}F - 140.163. \quad (3)$$

It is clear from equation (1) that the price elasticity of crop supply is about .6, while the cross elasticity of crop supply with respect to the price of cotton is about −.3. The coefficient of the dummy variable J, presumably representing the influence of the cotton acreage allotment program, indicates an increase in watermelon supply of about ten per cent;[2] but as the sampling error shows, this is not significant.

Likewise the cross elasticity of supply with respect to the price of commercial truck, estimated at −.14, is not significant. On the other hand, wartime policy clearly reduced the supply of melons significantly, the size of the parameter corresponding to a reduction of 30 percent.[3]

In equation (2) the price elasticity of harvested supply, given the available crop, is about .2. As may be expected this is considerably lower than the elasticity of crop supply. The harvest increases with the available crop, and percentage wise apparently increases somewhat faster than the crop. Since the model involves averaging effects over a fairly wide region, there is no particular reason why this should not be so, but it may be noted that the coefficient associated with the available crop does not actually differ significantly from one.

The parameters of (3) are not readily interpreted as written. Dividing by the coefficient of X/N yields the more familiar form

$$\frac{X}{N} = 1.378\,\frac{Y}{N} - .901P - .614F - 126.273 \quad (3^*)$$

from which it is clear that the income elasticity of demand is about 1.4 and the price elasticity of demand about −.9. The effect on consumption of an increase in freight rate is, of course, similar to that of an increase in the farm price, since freight costs are a substantial part of the difference between farm price and market price. The magnitude of its influence arises from the fact that farm to market freight charges are, on the average, almost as large as the net farm price itself. Indeed the comparison of these two magnitudes provides a check on the reasonableness of the coefficient measuring the influence of freight costs. During the period (1930–1951) used to fit the de-

[2] As noted in the Appendix, the variables are coded. When dummy variable J takes on the value 1 after 1933, it results in adding 34.41 to the coded log of Q. This amounts to adding .03441 to the actual log of Q; i.e., Q itself is increased by about ten per cent. Similarly when K takes on the value 1 the result is the subtraction of .15597 from the log of Q. This has the effect of multiplying Q by a factor of .7; i.e., Q is reduced by thirty per cent.

[3] See note 2.

mand equation, the magnitude of the average freight cost was about seventy-seven percent of the magnitude of the average farm price. If it is expected that, market demand conditions given, an absolute increase in freight cost will be passed back to reduce the net farm demand price by about the same amount, the coefficient on F in equation (3) would be expected to be somewhere near $-.77$. The empirically determined parameter of $-.68$ in equation (3) is thus eminently reasonable.

III. *Technical Statistical Problems*

Although the emphasis here is on the final result and its applications, a few remarks about the statistical problems involved in fitting the model are in order.

No difficulty was encountered in fitting the crop supply equation. All

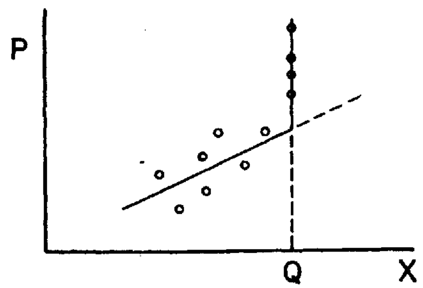


FIG. 1

variables on the right side of that equation are predetermined and the regular regression by least squares gives an unbiased estimation of the parameters. The harvest supply and farm demand, however, involve farm price and harvested crop as mutually determining variables, and the estimation of the parameters of these equations by least squares would lead to biased results. The technique of limited information was employed to obtain unbiased estimates of the parameters. For this purpose the variables Y, N, W, F, and Q were taken as predetermined with respect to the watermelon market. Now this is not strictly the case. While Q and N are predetermined without question, it is surely clear that what farmers receive for watermelons becomes in turn part of the national income; in addition, the price of melons, via its effect on the demand for farm labor, contributes to the determination of farm wages. It was felt, however, that the watermelon market exerted such a minor influence on these other magnitudes that the error involved in neglecting it would not be great.

A second sort of problem arose in connection with the harvest supply equation. The available crop sets a maximum to the amount that can be marketed. Thus the harvest supply schedule is not linear, but has a kink at the price at which the entire crop would be harvested. This kinked supply might be handled by approximating its shape by a smooth curve. The more direct approach followed here is to fit relation (2a) by ignoring all years in which no unharvested crop is reported.

The problem is illustrated schematically in figure 1. X, the actual amount harvested, cannot exceed Q, the available crop. Thus the harvest supply schedule has an upper branch of zero elasticity and a lower branch along which market supply responds to price. In order to fit a regression to the lower branch only, we may drop out data for all those years that presumably appear on the upper branch—i.e. those years in which the entire crop was reported marketed. There were six such years: 1941–1945 and 1948.

IV. *Experimentation with the Form of the Model*

In addition to the construction of the model just given, a number of experiments were tried, of which the following two are of considerable interest.

A. Since the crop supply actually produced in any given year involves not only decisions to plant but also the results of weather conditions, insect pests and similar factors, it would appear that one might get a somewhat better measure of the crop supply function if acreage, rather than actual crop, were taken as the dependent variable. Some of the variation in crop produced by these external factors should be absent from acreage. The use of acreage gave the following interesting result. Where A is acreage,

$$(1^*)\qquad A = \underset{(.175)}{.575P_{-1}} - \underset{(.107)}{.434C_{-1}} + \underset{(30.8)}{103.727J} - \underset{(.278)}{.150T_{-1}} - \underset{(50.6)}{180.744K} + 305.388.$$

A comparison of this result with that of (1) above shows that in neither magnitude nor standard error is there any significant difference between these two formulations of the crop supply, with the single exception of the parameter purporting to measure the effect of the governmental cotton program. This parameter, which was of no statistical significance in the first equation, is highly significant in the alternate form. If the supply of watermelons did not increase after 1934, the acreage planted certainly did with an indicated rise of roughly twenty-five per cent. It should be emphasized, however, that the indicated shift is not necessarily a direct consequence of the restriction of cotton production, but may be due in considerable part to extensification of watermelon production methods quite independent of the cotton program. This issue can only be resolved by detailed technical information as to cropping practices.

B. One shortcoming of the demand equation as formulated in (3) above is the fact that no prices of substitute commodities are included. In an attempt to rectify this situation, cantaloup was taken as a substitute commodity on the grounds that the two commodities are alike and are frequently offered together as choices on the menus of restaurants, and since they have roughly the same seasonality the average annual prices are directly comparable. Since the demand equation was estimated by the method of limited information, this meant in effect introducing the supply of cantaloup implicitly as part of the model of the watermelon market. The calculations were carried far enough to indicate that the parameters that would be estimated were nonsensical (e.g., the price elasticity of watermelon demand appeared positive, while the income elasticity was negative!) and that they would be accompanied by very large standard errors. In other words, whatever the extent to which cantaloup and watermelons are substitutes, the effect is so small relative to the influence of other factors that they cannot be measured in so rough a model.

V. *Application of the Model—the Dynamics of the Market*

The watermelon market is essentially a dynamic one, the year to year behavior tending, as we shall show, to follow a cobweb pattern of oscillation.

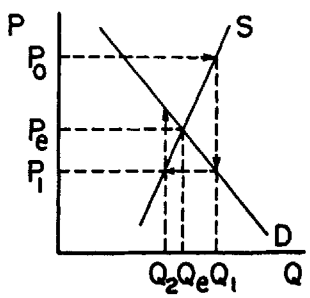


FIG. 2a

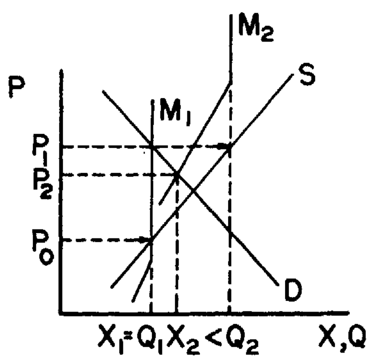


FIG. 2b

The theory of such oscillations is generally familiar, but because the model of the watermelon market contains the harvest supply function as an additional relation, it is worth while to describe the modifications required of the usual textbook model. Figure 2-a depicts the usual two equation dynamic cobweb model. Price P_0 results in production Q_1 the following year, accompanied by price P_1, and so on. The process may or may not converge to the equilibrium price and output defined by the intersection of the two schedules. In figure 2-b, a harvest supply schedule has been included, indicating that the amount supplied depends not only on production, Q, but also on *current* price. Unlike the demand and crop supply equations, the harvest supply function cannot be located as a simple relation between price and quantity. Rather, each possible crop Q is associated with a different short run harvest supply schedule. Thus price P_1 determines production Q_1. This in turn determines the harvest supply schedule, say M_1. The harvest supply together with demand determines quantity marketed (in this case $X_1 = Q_1$) and price P_1. The new price determines a new crop, Q_2 and a new harvest schedule, say M_2, resulting in price P_2 and quantity marketed X_2.

The equilibrium price and quantity are readily identified in the case usually presented, but when the harvest supply is introduced the equilibrium might be either one in which the total crop is marketed (as in figure 3-a,) or one in which production exceeds marketings (as in figure 3-b). In the latter case, price P_e is just sufficient to call forth production Q_e. This in turn determines the harvest supply schedule M_e which in conjunction with demand sets price P_e and quantity marketed X_e.

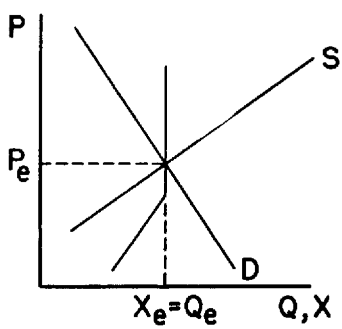


FIG. 3a

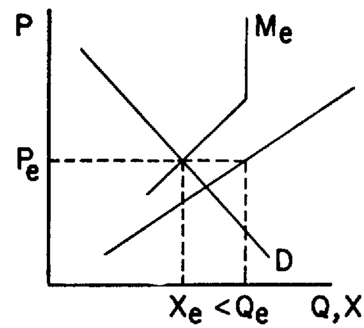


FIG. 3b

The fitted empirical model can be used to investigate a number of the properties of this dynamic process. In the first place we may determine whether the equilibrium is stable. Secondly the dynamic path of adjustment can be investigated to determine whether it is, in fact, a cobweb, or whether approach to equilibrium is one-sided. In the model as customarily presented, the oscillations necessarily take place *around* the equilibrium position. With the addition of the market supply equation it is quite possible to have a monotonic approach toward (or departure from) equilibrium. We may inquire into the speed with which the system tends to approach its equilibrium position, and incidentally determine whether the existence of the harvest supply schedule tends to increase or diminish the speed of adjustment. Finally we may study the equilibrium itself.

In order to explore the dynamic properties of the system we may substitute equations (1) and (2a) into (3), to obtain the difference equation

$$P + .622P_{-1} = H \qquad (4a)$$

where H is a linear combination of the values of the remaining variables.

If the equilibrium of the market occurs at a position in which harvest supply is described by (2a) then the market equilibrium price P_e will also satisfy (4a):[4]

$$P_e + .622P_e = H. \quad (5a)$$

Now, still assuming equation (2a) to hold at the equilibrium we can subtract (5a) from (4a) to obtain a difference equation relating successive deviations of actual price from equilibrium price:

$$p + .622p_{-1} = 0, \quad (6a)$$

where $p = P - P_e$. Difference equation (6a) has the obvious solution

$$p = p_0(-.622)^t, \quad (7a)$$

where p_0 is the deviation of market price from equilibrium at some initial time $t = 0$.

The dynamical properties of the system may readily be deduced from (7a). Since the number in the parentheses is negative, p_t changes sign each period. Thus a price above equilibrium, other things being equal, is followed by one below, and the oscillations of price—even if the market supply has form (2a) at the equilibrium—follow a cobweb pattern around the equilibrium. Secondly, since $-.622$ is smaller than one in absolute value, deviations from equilibrium approach zero in the limit, and the equilibrium is in fact a stable one. Finally the speed of approach is readily determined. If we borrow a term from the physics of radioactive decay, we can ask how long the half life of the process is, i.e., how long it takes to reduce the magnitude of a given deviation from equilibrium by half its original absolute magnitude. Since $(-.6)^2 = .36$, clearly the half life of this process is less than two years. In fact, the "ninety percent life" is slightly less than five years, indicating a heavily damped oscillation with rapid approach to equilibrium.

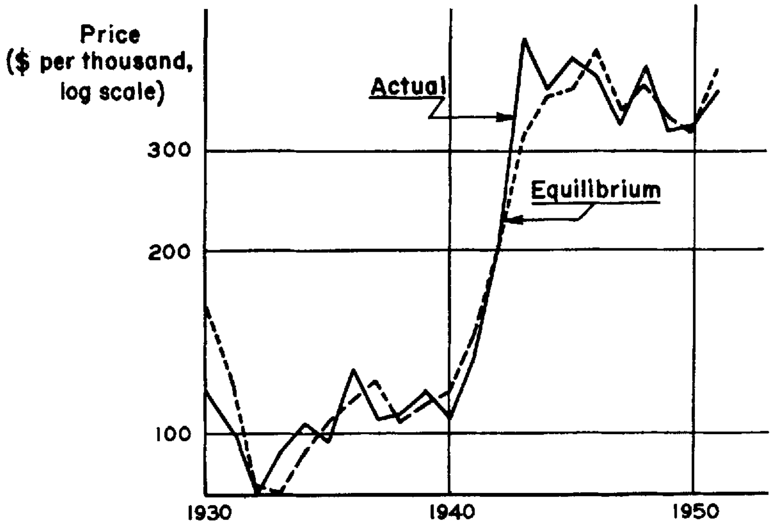
Now let us suppose on the other hand that the equilibrium solution requires that the harvest supply equation have form (2b), i.e., at the equilibrium everything produced is marketed. In this case we repeat the above process, replacing (2a) by (2b) throughout. As a result the final difference equation becomes

$$p_t = p_0(-.652)^t \quad (7b)$$

[4] At the market equilibrium either equation (2a) or (2b) must hold. Which one it is depends on the values taken by the other variables. Since we do not know in advance which it will be, we must investigate both possibilities. It is to be noted, incidentally, that there is no quesion here of the existance of the equilibrium, nor of the fact that it is unique. What is at issue is the question of its stability.

which possess almost identical properties with (7a), except that the adjustment toward equilibrium is somewhat slower, the ninety per cent life of (7b) being slightly longer than five years. To the extent that the additional freedom to adjust implied by the harvest supply function has any effect on the speed of adjustment in the market, the result is to increase it.

To calculate the moving equilibrium position of the model, that is the values that would ultimately result if the conditions of each year should persist indefinitely, we first solve the system (1), (2a) and (3) for its equilibrium values of P_e, Q_e and X_e. If X_e is less than or equal to Q_e, these are the



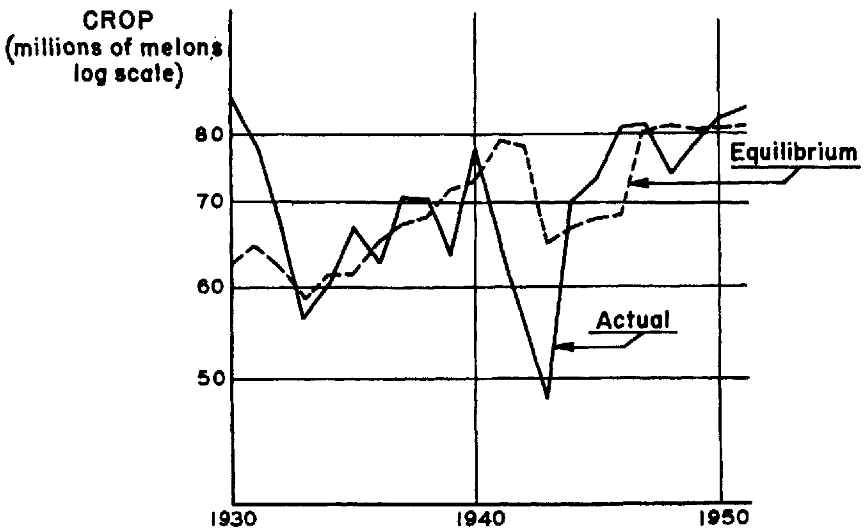
Watermelon Price: Actual and Moving Equilibrium, 1930–1951

FIG. 4

true equilibrium values. If X_e is larger than Q_e, (2b) is used in place of (2a) and the solution yields the equilibrium valves. The moving equilibrium values P_e and Q_e respectively are plotted together with the actual current values of P and Q in figures 4 and 5. In each case, as might be expected, actual price and quantity tend to oscillate around the moving equilibrium. It will be noted moreover that the market price tends to follow its equilibrium value more closely than does the crop. The reason is that any shift in supply or demand conditions, last year's price being given, tends to shift the equilibrium crop away from the actual crop. On the other hand, the same shifts in schedules that tend to alter the equilibrium price tend likewise to carry the current price with them. This can be seen especially clearly during the period immediately following 1940.

VI. *Application of the Model—Forecasting the Watermelon Market*

In principle there is no difficulty in applying the model to the task of forecasting the melon market. The required magnitudes are inserted and the system solved for the resulting values of crop, price and harvest. Unfortunately, however, the practical operation does not go smoothly. There is, in the first place, the obvious fact that price depends on values of per capita disposable income, wages, and freight costs which in the nature of things cannot be definitely known in advance. The statistical errors in the model proper will necessarily be coupled with the errors in forecasting these



Watermelon Crop: Actual and Moving Equilibrium 1930-1951

FIG. 5

other values. Secondly, even the data for the preceding year are frequently available only as preliminary estimates. The "actual" price figure for 1952 presented here is the preliminary estimate published in *Agricultural Statistics*, 1953; the "actual" prices for 1953 and 1954 are based on the behavior of the average prices for June, July, and August of those years. The prices used for cotton and truck crops are likewise crude.

Two separate sets of forecasts have been prepared. In the first set, the "ex post" forecasts, we have used the actual *ex post* values of income, wages, etc. The resulting forecasts are those that would have been obtained if the values of the other variables had been properly predicted. They represent the forecasting performance of the model itself. These values appear in Table I.

TABLE I. "EX POST" FORECASTS OF WATERMELON CROP AND PRICE

Year	Crop[a] (Millions of melons)		Price (Dollars per 1000)		Price Change (Dollars per 1000)	
	Forecast	Actual	Forecast	Actual	Forecast*	Actual
1951		83.3	—	$369	—	—
1952	77.5	81.7	$405	447	+36	+ 78
1953	90.3	n.a.	378	393[b]	−69	− 54[b]
1954	88.4	n.a.	387	280[b]	− 6	−113[b]

[a] Watermelon data have been revised, beginning in 1952. Crop estimates here are comparable to the old series.
[b] Based on the movement of unweighted averages of monthly prices for June, July, and August.
* Difference between forecast P and actual P_{-1}

Where the forecasts employ the more reliable lagged prices (i.e. the forecasts of 1952 and 1953) the comparison shows a fairly satisfactory performance of the model. The forecast of 1954, based on a crude estimate of 1953 price and compared with a crude estimate of 1954 price, shows the "proper" direction of change, but that is about all that could be claimed for it. Whether this really represents a bad forecasting error or derives primarily from the poor data remains to be seen when better data become available.

In Table II are the values forecast on what we have called an "ex ante" basis. That is, each of these forecasts was based on information about the variables that would have been available at the end of the year preceding the year to be forecast. For this purpose the values of wages and freight rates are predicted unchanged over their previous magnitudes, and population was forecast on the basis of its trend. The forecasts of personal disposable income were obtained from a fifteen equation model of the U. S. economy devised by Lawrence R. Klein and Arthur S. Goldberger.[5]

TABLE II. "EX ANTE" FORECASTS OF PRICES

Year	Price (Dollars per thousand)		Price Change (Dollars per thousand)	
	Forecast	Actual	Forecast*	Actual
1952	$415	$447	$+ 46	+ 78
1953	379	393[a]	− 68	− 54[a]
1954	403	280[a]	+ 10	−113[a]
1955	484	—	+204	—
(1955)	(396)[b]	—	(+116)[b]	—

[a] Based on average price June, July, August.
[b] Calculated from *ex post* forecast price, 1954.
* Forecast P less actual P_{-1}.

[5] Lawrence R. Klein and Arthur S. Goldberger, *An Econometric Model for the United States, 1929–1952,* to be published in the near future by North Holland Publishing Co., Amsterdam. The forecasts of personal disposable income were prepared for this paper by Mr. Goldberger.

The resulting price forecasts appear in Table II. The forecasts for 1954 and 1955 are, of course, based on the same crude price averages mentioned above and are open to serious question. The very high price forecast for 1955 derives primarily from the very low figure of $280 estimated as the average price for 1954. As an alternative method of estimation, the 1954 "actual" price was replaced by the *ex post* forecast for 1954. This estimate appears in parentheses in the table, and constitutes, I think, a somewhat better forecast of 1955 price than the one based on the crude average.

Finally, in principle it is possible to use this model at two levels of forecasting. A preliminary forecast can be prepared—as was done here—by using past prices to estimate the coming crop, and forecasting future prices on the basis of this estimate. During the spring when estimates of crop planted become available, a refined forecast could be made on the basis of directly estimated crop.

That this is not illustrated here is due to the fact that the recent revision of watermelon production and price estimates resulted in an increase in currently estimated annual crops of roughly twenty-five per cent. Thus the current crop reports are not comparable to the quantities estimated from equation (1). Price revisions, on the other hand, were of the relatively small order of two or three per cent. Prices from the two stage forecasting process employed here are therefore roughly comparable to the current series. Ultimately an entire new model will be required based upon the revised data.

Appendix

The data employed in measuring the variables were as follows:

Q: Total number of melons available for harvest. Source of data, *Agricultural Statistics, 1952*. Period employed, 1919–1951.

P: Average annual farm price of watermelons, dollars per thousand. Source same as Q. Period, 1918–1951.

C: Average annual net farm receipts per pound of cotton, source and period same as P.

T: Index of farm price of commercial truck. Source: 1918–1923, constructed from data on selected individual truck crops; 1924–1951, *Agricultural Statistics, 1952*.

J: Dummy variable representing the cotton acreage allotment program. Has values 0: 1919–1933, 1; 1934–1951.

K: Dummy variable representing the effect of the war. Has value: 1, 1943–1946; 0 at all other time.

X: Total number of melons harvested. Source: difference between Q and quantities reported unharvested in *Agricultural Statistics, 1952*. Period covered: 1930–1951.

W: Index of farm wage rates, South Atlantic States. Source: derived from cash wage rates of hired farm workers, composite wage rate per month, as summarized in the *Handbook of Labor Statistics, 1950;* extended on basis of wage rate data in *Agricultural Statistics, 1952*.

Y: Disposable income of the United States. Source: Department of Commerce, 1930–1951.
N: Population: U. S. Census Bureau estimates.
F: Index of average shipping cost per ton of watermelons shipped by class I steam railways. Source: computed from data on tonnage of watermelon freight originating and freight revenue received for watermelon shipment given in the Freight Commodity Statistics of the Interstate Commerce Commission.

All except dummy variables are measured in logarithmic form. In the process of fitting the equations the logarithms were coded to read as three-digit whole numbers without characteristics. Where the range of variation made this inconvenient the logarithms were coded to read as three-digit numbers without characteristics, or four-digit numbers with the characteristic one. Since the result of the coding is merely a shift in the decimal point of the coefficients of dummy variables and a change in the size of the constant term of the fitted equation, no effort was made to "decode" the resulting equations.