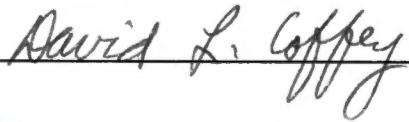


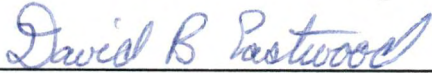
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SEQUENTIAL CROPPING OF VEGETABLES
FOR MARKET WINDOWS

A Thesis
Presented for the
Master of Science
Degree
The University of Tennessee, Knoxville

Michael John Best

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ABSTRACT

With the decline in profitability of several Southern commodities, farmers in Tennessee and other surrounding areas have been forced to re-evaluate the crops they are producing. This study provides information that is beneficial to these farmers on alternative crops they can use in their decision making processes.

How good an alternative crop is at producing income on average can be determined by using simple statistical procedures and price data for different crops. Price risk, which is one of the most important risks to be considered when growing vegetables, can be observed by finding the standard deviation that goes with the average price. A coefficient of variation can be found using the average price and the standard deviation for a product. The coefficient of variation provides a relative risk rating for comparison of the vegetables in this study. Production risk can also be looked at using temperature data in the same manner as price data.

Data needed for the study came from several different sources. The price data for the vegetables came from wholesale market reports at different locations in the region. The temperature data used came from the state of Tennessee. Other budgets and expenses came from different publications and businesses around the area.

Vegetable production in Tennessee appears to be profitable under the conditions of this study. Depending on the actual size of his farm and his current financial condition, a farmer can produce for market windows

by targeting his harvest dates and increase his income. Other farmers with fewer resources who prefer lower risk can sequence crops and make the most effective use of their land and other limiting resources.

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CHAPTER I

INTRODUCTION

A. OVERVIEW

The decline in profitability of several traditionally Southern commodities has forced many farmers to re-examine their farm production decisions (Estes). Some farmers are considering growing vegetables as alternatives to traditional Southern crops. These new vegetable growers, and experienced vegetable growers, have the task of determining the production and marketing risks associated with each potential enterprise. Production risks for vegetables are determined by many factors, including climate. A farmer's options regarding crop selection are constrained by temperature and rainfall, as well as soil type and topography. While farmers across Tennessee are confronted with numerous production opportunities due to variation in climate and soil, justification for expending the resources to produce selected crops depends upon the ability of growers to sell the final product successfully. Before undertaking new enterprises, the farmer should be aware of marketing opportunities as well as production opportunities in his location.

A market window is a period of time during which a product can be produced and be sold at a relatively high price. These market windows are periods when the crop of interest is in shorter supply than at other periods. This shorter supply usually means the price will be temporarily higher. Theoretically, the higher price should compensate the farmer for

accepting the additional risk of experiencing a crop damaging freeze.

The idea of the market window is important because it could assist in identifying ways of enhancing income. Knowledge of market windows could help to reduce the price-risk that confronts vegetable farmers. A market window allows an opportunity to plan the time of harvest in order to have a better chance of receiving higher prices. While this planning can reduce the risk of low prices, it can also increase the risk of low yields due to the crops being adversely affected by the weather, especially frost.

Growers already engaged in timed production and sequential cropping could use insight into the benefits of producing for market windows, as well as knowing how they can reduce per unit-of-output costs. The chemicals applied to the first crop may reduce the need for this input during the production cycle of the second or third crop produced on this single piece of land during one growing season. The quantities of certain chemicals required to produce two or three crops in sequence on the same plot should be less than the amounts used when each crop is produced on separate pieces of land. Hence, sequential cropping and market window analysis will have applicability to the limited resource farmer because of the pressure on available land and to other farmers because they will help identify the trade-off relationship between risk and revenue.

Efforts of farmers to enhance their economic well being by extending the production season to accommodate either sequential cropping and/or targeting of harvest to coincide with certain market windows could be more effectively directed if such farmers were provided information regarding the trade-off between potential returns and production risk. Sequential

cropping permits a farmer to reduce the per unit costs of vegetable crops by allowing him to spread the cost of certain fixed items over more units of output. Fixed cost items like tractors, tools, plastics, and irrigation equipment can be spread over two or three crops per year rather than just one crop. Shifting the production period for some crops either closer to the beginning of spring or closer to the end of fall will permit harvests to coincide with certain market windows.

Another component that could be included is the effect on production quality and yields from planting crops at times that are, perhaps, less than optimal from a growing perspective. Planting earlier in the spring to have a crop ready to market during an anticipated market window presents a trade-off to the farmer. Is the possibility of securing a higher price worth the increased risk of reduced quality and/or yield? The answer to this empirical question could be of considerable benefit to farmers regarding decisions about what crops to produce and the timing of production within the available growing season.

Consideration of vegetable production as an alternative enterprise to agronomic crops presents a new experience to many farmers in the Tennessee Valley Region. Unlike cotton and soybeans that can be harvested and easily stored until an acceptable price is offered, most fresh vegetable crops must be sold on the open market for the prevailing price at the time of harvest. Therefore, the concept of timing production to enter certain markets and the impact on output from engaging in sequential cropping presents a decision making environment that many growers are unaccustomed to handling. New vegetable growers, and even experienced growers, could benefit from improved information regarding optimal

enterprise combinations based upon probabilities of receiving certain prices and attaining certain levels of output.

The probability of crop damaging temperatures occurring on calendar dates could be used by growers to help identify the level of temperature risk they are accepting. Some growers may be in a position to accept more risk than other growers. A growers position could depend upon the financial condition of the total farm, the current tax situation, or any number of factors that may affect an individual farmer's ability and /or willingness to accept risk. Regardless of financial status, growers of fresh vegetables should be aware of the risks they are accepting by selecting a particular planting date.

While the analysis in this project will be limited to Tennessee, the results should be applicable to other areas of comparable climate and soil. Growers with similar temperature patterns and growing seasons should be able to use the results directly in management decision-making deliberations. Additionally, growers in other areas will be able to benefit from the conceptualization of this risk-analysis research and the insight provided by the comparison of returns associated with various scenarios.

B. OBJECTIVES

The general purpose of this project was to provide insight to growers and other interested industry participants about the trade-off between vegetable production in the "safe" part of the available growing season and the income opportunities of production during more "risky" time

periods. Specifically, three objectives were to:

1. discover the market windows available to Tennessee vegetable producers during the relevant growing period,
2. determine the appropriate combinations of vegetables to include in a sequential growing pattern and the expected yields from the sequence during one growing period, and
3. develop an appropriate technique to permit evaluation of the net returns to growers from selected scenarios by combining the results from objective one and two.

C. PROCEDURE

The scope of this project was focused on Knoxville and four representative production areas within Tennessee-Greeneville, Columbia, Covington, and Monteagle. Due to the data requirements regarding temperature probabilities and time constraints, these four locations were selected to be representative of Tennessee's climatic diversity. Daily temperatures for 24 years were used to generate the dates associated with the occurrence of 28, 30, and 32 degrees Fahrenheit at five probability levels (Brooker and Gray, Ingram). This data set was also used to calculate the average daily heat units available at each station for six threshold levels - 40, 45, 50, 55, 60, and 65 degrees Fahrenheit.

The wholesale market prices at Atlanta, Baltimore, Chicago, and Cincinnati were used to calculate expected weekly prices and variability.

For each vegetable, the wholesale prices over the relevant time period were examined to reveal seasonal patterns and the consistency of these patterns. The standard deviation around the means was used to assess the confidence level attached to market windows. In other words, while prices may be seasonally higher during a particular part of the growing season, the variability of prices during this time period may indicate potential for a considerable loss.

Objective 1. required the collection and analysis of price data for the nine vegetables included in this analysis. Price data for the years 1979 through 1989 were used for this analysis. The prices were at the wholesale level for U.S. number one produce. The fresh vegetables considered in the market window analysis were green beans, broccoli, cabbages, corn, cucumbers, okra, green peppers, yellow squash, and tomatoes. They were selected based on results of conferences with Dr. David Coffey and Dr. Al Rutledge who are plant scientists at the University of Tennessee (Coffey and Rutledge, 1989). The crops to be grown in sequence were constrained by the established guidelines of crop rotations according to plant groupings. In addition, the possible sets of crops and combination of crops in a sequential cropping pattern were further refined by information regarding consumer demand for fresh vegetables.

Work on objective 2. included solicitation of input from plant scientists regarding the appropriate combinations of vegetables to include in sequential patterns and/or crop rotations (Coffey and Rutledge, 1989). The vegetable combinations selected for detailed analysis in the simulation model of objective 3. may vary among the four study locations.

This variation would be due to the climatic differences in Tennessee's four regions. While this study examined combinations from a restricted list of nine crops in four growing locations, the results were expected to be applicable to other production areas.

To accomplish objective 3., the results of objectives 1. and 2. were combined to permit comparison of selected alternative scenarios. Vegetables, more than most other agricultural commodities, endure substantial price variability during a season and from year to year. Potential vegetable growers should select the scenario that best fits their situations and examine the generated results to see if the short and long-run results are acceptable. Acceptability will depend on each grower's opportunity costs for the farm's productive resources and attitude regarding risk aversion.

CHAPTER II

LITERATURE REVIEW

A. MARKET WINDOW ANALYSIS FOR VEGETABLES

A market window analysis for vegetables involves determining a period of time in which a particular vegetable has a comparative profit advantage on the market (Venturella *et al.*). These windows usually occur when the quantity supplied of a product is relatively low, and all other factors remain constant. Due to the low quantities and constant retail demand, the price of the product should be relatively high. In order to determine if a window exists for a certain area and product, the question must be answered as to whether a grower is able to produce a crop at a cost that permits a return to compensate for the risk of producing during these favorable times (Venturella *et al.*).

Market windows can vary in length depending on seasonal conditions. These conditions can depend on the weather and when the total acres were planted of a certain crop in a state that leads the nation in production of that crop. A good example of this is the tomato industry in the Southeast. In June the harvesting in Florida is usually decreasing, and this is when the rest of the Southeast is just starting to produce in a normal year. There is an impact on the tomato price in June caused by the season ending in Florida. If Florida production is late entering the market or if their season lasts longer than normal, then the tomato prices for June will usually be low. Therefore, no market window will exist

under this scenario. However, if Florida tomato shipments end before the rest of the Southeast begins shipping, the price may be higher, and the possibility of a market window exists (Venturella, *et al.*).

The economic feasibility of fresh vegetable growing depends on yield potential of the area along with the availability of outlets for the produce, potential for an adequate market price, and the cost of production. The competitive position of any production area is enhanced when its total costs of producing, marketing, and transporting a product are lower than other competing regions. Also, when the area's average price is higher than in other competing regions, a farmer in that area can have a competitive position (Mizelle).

Price expectation is a major factor to consider when formulating a farm plan. Farmers must have some expectation of the price they will receive for their crop before they will plant it. The expectation of price is more important in vegetables than in many other traditional southern crops because vegetables are a nonstorable commodity. In the fresh market, it is not uncommon for the price of a vegetable to fluctuate dramatically from week to week, depending on supply. Because vegetables and fruits are largely nonstorable produce goods, wholesale price variability can lead to income variability for the farmer. As a direct consequence farmers should not use seasonal averages to estimate price expectation.

The market window technique is considered an inexpensive and reliable screening device for farmers interested in seeing the market potential for different crops. Market window analysis also aids in determining what effect changes in production costs, yields, and transportation costs will

have on the feasibility of a crop (Mook).

B. METHODOLOGICAL APPROACH TO MARKET WINDOWS

Past research using market window analysis to determine possible market opportunities has utilized techniques ranging from simple visual analysis of prices to more complex programming models (Mook). In all cases the first step is to determine which commodities are to be examined. Once the commodities have been identified, then information on the production possibilities and limitations of these vegetables must be obtained.

The next step is determining the feasible marketing period for those crops that have been chosen. This is an integral part in the analysis of marketing alternatives. The feasible marketing period is the time when quality crops can be produced and delivered for sale from an area. The feasible marketing period for an area is dependent upon the climate, biological factors, and other production and marketing constraints (Mook).

Once the feasible crops and marketing periods have been found, target markets must be defined. These markets can include terminals, such as Atlanta or Baltimore, or even smaller secondary markets such as Richmond, Virginia (Mook). Reports on wholesale prices at these terminal markets can be obtained and are very useful as a starting point. Also, f.o.b. shipping point prices are reported by the USDA. The wholesale terminal market prices differ from f.o.b. prices by transportation costs and terminal market price markup. There is a difference in the two levels of prices in that the price spreads between the two show wide variation in

vegetable crops, within and between years. The approach used by Zwingli, *et al.*, which used terminal prices discounted by 15 percent to cover transportation costs and brokerage fees, has an advantage of revealing additional information about demand when using wholesale prices rather than f.o.b. prices (Hinson, Lanclos).

When the price data for the vegetables have been obtained, they can be used in several different ways. Price expectations must be formed in order to develop a market window analysis. These price expectations may be derived using several different methods. The first method is to assume that the price next period will be the same as the price in the current period. The second method is to use an average of several past years' prices. This method can be used as a simple visual aid and involves plotting the average prices per week on a chart. This method allows observation of when average price will be the highest, but does not reflect how accurately the average value predicts the price. The third method uses price averages and variation to reveal the level of price risk associated with designated market windows. This method is one that includes measurement of risk that comes from the variation in the product prices (Hinson, Lanclos). There are other sources of risk involved in vegetable farming but none that seems as important as price-risk.

When analyzing time series price data, four sources of variation can be found. These sources are due to secular trends, cyclical movements, seasonal fluctuation, and/or a random component of what is left after the first three have been taken into account. Farmers must deal with both the random and systematic variations in price; therefore the prediction of the amount of random variation is just as significant as the others (Mathia).

As far as the farmer is concerned, it is better for variation in prices to be systematic rather than random. Systematic variation is better because the larger the random component relative to total variation, the more risk the farmer feels he is taking. Even though total variation may be the same, the perception is different (Mathia).

Standard deviation or variation is used to determine the level of risk. The larger the variation in price, the higher the level of risk farmers will have to accept. The coefficient of variation is used in order to provide a relative ranking of the price-risk that farmers of different crops will confront. In most market window studies, a coefficient of variation of 20 percent or below was used to indicate low risk; 20 to 35 percent a moderate risk; and above 35 percent, a high risk crop (Venturella, et al.).

Once the price analysis has been accomplished to determine if a market window exists, one must know what the cost of production is for that crop. The total cost of production for an acre of any vegetable depends on the total fixed cost and the total variable costs for that acre. However, in the market window analysis one should only be concerned with the cost and return per unit of production, whether the cost be per 20 pound box, per crate, or some other unit. In this case for a market window to be considered open, the predicted price would have to be higher than the anticipated per unit cost of production.

To obtain an average total cost per unit of output, some assumptions must be made concerning vegetable production. This is due to the average total cost per unit of production being dependent on the number of units of final production. In vegetable production, output can vary even when

controllable inputs are held constant. Variation in output is due to the uncontrollable inputs such as weather. Therefore, assumptions must be made about the level of these uncontrollable inputs in order to arrive at an estimate of the cost of production (Hinson, Lanclos).

Cost per unit of output depends on the level of all inputs including quality of management and weather conditions. Even assuming constant technology and consistent management practices, variation in weather conditions may cause a producer to have average, below average, or above average yields. The percentage reduction in yield will not be the same as the increase in cost per unit of output. The difference is due to the variable cost being reduced but fixed costs staying the same. For instance, three different yield outcomes will create three different production cost lines on the market window graph. These different production cost lines are useful because they show the producer what might happen to the market window if he has a below average yield one year (Hinson Lanclos).

C. SEQUENTIAL CROPPING FOR VEGETABLES

In Tennessee the typical farmer grows one crop during one growing season on the same plot of land. The process of growing one crop a year on the same plot of land is also true throughout neighboring states. But in the rest of the world and some southern states, the practice of sequential cropping is being used. The term sequential cropping is defined in this study to represent a system where more than one crop is grown in succession on a single plot of land during the same growing

season.

Sequential cropping may allow vegetable farmers to increase their incomes. This way of growing vegetables requires the farmer to use a large share of the growing season, instead of the spring planting practice that is presently being used. Sequential cropping has already been shown to be both possible and profitable in southern Georgia (Alexander *et al.*). The growing season of southern Georgia is favorable for multiple sequential cropping. In the Georgia study they were able to use triple cropping rotations in which several combinations of crops demonstrated enhanced profitability (Alexander *et al.*).

Sequential cropping is beneficial by spreading out production costs and by a more intense use of land. Although costs for startup are high on plastic mulch, trickle irrigation, and soil fumigation, they become less expensive per unit of production when sequential cropping is employed. Also planting in sequences is useful for other reasons other than the land limitations of any farmer. The producer can attempt to have crops ready to be harvested when the price of a vegetable is usually high.

An Alabama study has shown that the wholesale potential for cabbage in the late spring is good, and for tomatoes it is good in the summer and fall, and for broccoli it is best in the fall. With potential for an 8-month growing season in Alabama, the possibility exists to grow all of these sequentially for some of the best prices during the year. The prices were based on reports from wholesale markets in Atlanta, Cincinnati, and St. Louis (Zwingli *et al.*).

When a farmer is contemplating the adjustment to a double or triple crop system from a single crop system, timing of production is crucial.

Timing of production is necessary to be able to fit in the correct sequences for the climate. There are a several ways a farmer can do this. One way is to estimate the length of time it will take for the crops to go from seed to harvest. Then he can compare the number of days to maturity of the sequence with the number of frost-free days in his area. Comparison of the numbers will determine if the sequence is feasible for his growing season (Brooker, Gray, Ingram).

There are two ways of estimating the number of days to maturity. One way is to use the seed catalog's statement regarding days to maturity. Another, and maybe more accurate way of calculating the days to maturity is to consider the number of heat units required to bring a vegetable to harvest. The number of heat units occurring in a 24 hour period is calculated by subtracting a plant's threshold temperature from the average temperature for that day. The threshold temperature for a vegetable plant is the critical temperature below which growth will not occur. Based on the total number of heat units required to develop the plant from seed to maturity, an approximation of how many days a plant will take to reach maturity from planting at any time in the season can be determined (Brooker, Gray, Ingram). The reasoning behind the heat unit system is that plant growth is proportional to temperature. The heat unit system assumes the heat sum required for a certain variety of a crop to reach maturity is constant. This heat sum requirement is known as the varietal constant (Brooker, Gray, Ingram).

Once the heat sum units required for each vegetable have been ascertained, then how many and which vegetables will fit into a sequential cropping scheme can be determined. The beginning and ending dates for a

designated growing season depend upon the specified probability levels of not experiencing a freeze. For example, if a 90 percent frost-free probability was chosen, it will be a shorter season in terms of days than if a 50 percent probability was chosen. The potential growing season is expanded when a grower increases his willingness to accept risk of a freeze. By using historical heat unit data, it can be estimated how many heat units are available between specified dates at a particular location represented by that weather station. This will then allow the determination of sequences that are possible for an individual farmer (Brooker, Gray).

Neither way of determining growing season length gives a precise number of days to maturity due to the number of variables that are involved, but the heat unit method does take the important heat variable into account. However it does not take into account other variables such as water, fertility of the soil, and extreme heat. When approximating the number of days to maturity using heat units, at least one significant variable is taken into account. And with today's technology the ability to control some of the others such as water and fertility is possible.

One of the greatest criticisms of the heat unit system is that it does not take into account factors involved in plant growth other than heat. Plant growth results from the interaction of the plant with temperature, moisture, light intensity, photo period, fertility level and others. Any one of these factors can be limiting, but the heat unit system only takes temperature into account (Seaton).

Another criticism of the heat unit system is that it does not take into consideration the upper limit of the temperature growth relationship.

Plants have both lower and upper temperatures at which they will die. However studies have determined that at some temperature before the upper temperature is reached the plant will stop growing (Newman, *et al.*).

Once it has been determined what sequences can fit in the growing season, those that are compatible need to be identified. For the best results in a triple or double cropping sequence there should not be two *brassicaceae* planted in the same field in the same year. The same rule is true for *cucurbitaceae* and beans also. One reason for these constraints is to keep disease residues to a minimum because the same plant family is susceptible to the same diseases. Another reason is because plants from the same families tend to drain the same nutrients from the soil (Coffey).

However, it is possible to grow them in the same season with the assumptions that the farmer has a good disease control and fertilization program. Growing vegetables of the same family in the same season also assumes that the farmer uses a rotation scheme that puts the land in service every other year at the maximum (Coffey).

CHAPTER III

PROCEDURE

A. MARKET WINDOW ANALYSIS FOR TENNESSEE

The first step in the market window analysis was the selection of vegetables to be examined. This process was based on physical production attributes and availability of historical price data. The absence of price data forced the exclusion of some vegetables with good production or sales potential. Identification of vegetables that have appropriate production potential required input from plant scientists.

The second step was to determine the feasible production period for these crops. Because the feasible growing periods depend on climate and biological constraints as well as production and marketing constraints, the beginning and ending dates of potential growing periods varied with location due to the diversity of Tennessee's topography. The presumption was made that there would not be any sales or harvests until several weeks after the last freezing temperature in the spring and that sales would end after the first freeze in the fall. Therefore, the longest growing period for any of the vegetables in the four designated locations determined how many weeks of price data were needed.

The third step in the market window analysis was to define a target market for the selected vegetables. For the Tennessee region, four terminal markets were selected to represent markets in all four directions. These four destinations are Atlanta, Baltimore, Chicago, and

Cincinnati.

Price data from the four selected wholesale terminal markets were used to obtain average prices per week for U.S. number 1. produce. Production costs were obtained from planning manuals from the Tennessee Extension Service (Jenkins, *et al.*, 1988). Price variances and production costs were used to help determine the level of price-risk confronting farmers. Determining the level of price-risk was accomplished by calculating a coefficient of variation for average weekly prices of the crops during the targeted harvesting periods. Coefficients of variation were used to provide a ranking of the risk for each crop.

B. STANDARD PLANTING DATES

After the average prices by week were determined, the standard planting dates were used to determine expected net returns from each vegetable. Once the net returns and associated risks were determined, they were compared to the other two options of the growers--growing for market windows and sequencing crops in multiple cropping schemes.

C. TARGETING HARVEST FOR MARKET WINDOWS

The next step was to identify which crops could be grown so that harvest would occur during the market windows. Net returns from these schemes were determined. These net returns were then compared to the net returns from the use of standard planting dates. Market window targeting was done in the same manner as the sequencing, as far as determining the

time for planting and harvesting.

D. MULTIPLE CROPPING SCHEMES

The sequences for multiple cropping were specified by first determining which crops have potential market windows. Once those were determined, then the sequences that matched up with the windows were also determined. Various cropping sequences that fit the market windows were compared with respect to potential return and risk. These projected returns were compared with projected returns from planting on the standard planting dates, and the returns for market window target dates.

To determine the potential for multiple sequential cropping in Knoxville and Tennessee's four climatological divisions, the amount of heat units required for a plant to be grown was determined. Since relatively little published data exist on the required heat units for vegetables, a reasonable approximation of the heat unit requirements was formed.

The heat unit requirements for each vegetable are important because they will determine whether or not a sequence of crops in a specific area of Tennessee will be physically feasible. Therefore, in using the heat unit data from Knoxville and the four representative locations in Tennessee, it was possible to determine what type of triple or double cropping sequences fit into the growing periods of these four locations.

The heat units required for each of the vegetables were determined in the following manner. First, for each vegetable the recommended planting date was found for the area. Second, the length of time required

for each vegetable to reach maturity was designated. Third, the length of the average harvest season was determined for each crop. These dates were necessary for the calculation of the approximate number of heat units required for production and harvesting of the vegetables. Finally, the varietal constant for each vegetable was determined by calculating the average daily heat units available between the recommended planting date and the last harvest date.

After calculating the required average heat units (varietal constant) for each vegetable, it was possible to determine the crop sequences for multiple cropping that were adoptable in Knoxville and the four growing locations. When determining the possible sequences for the four divisions in Tennessee, it was assumed that growers had good disease control, fertilization, and rotation programs. Therefore, plants of the same family could be grown one after the other in the same season.

E. EVALUATION OF ALTERNATIVE SCENARIOS

Evaluation of alternative production schemes involved using the price and temperature deviations to determine what sequences would be the safest or the most profitable sequences. The gross and net revenues were found using the average price data for the weeks in which the vegetables in the sequence were harvested. The harvest dates were determined by finding the highest possible price for the vegetables in a time frame that would allow the sequence to be completed during the overall potential growing period. The results illustrate what could occur from production of selected sequences of vegetables during one growing season. Also, production risk

using the temperature data was taken into consideration for the vegetables that might be grown in a time period that is not as favorable as the standard growing period. This was accomplished by reducing the units of production for the crop that could be affected by the climate. The crops that would most likely be adversely affected by the climate should be the warm season crops. The earlier these crops are planted the lower the yield for the vegetables could be. The evaluation involved reducing the yield 25 percent for the vegetables that could be adversely affected.

CHAPTER IV

RESULTS

A. MARKET WINDOWS

Based on production potential and the availability of price data, nine vegetables were selected--snapbeans, broccoli, cabbage, sweet corn, cucumbers, okra, green peppers, yellow squash, and tomatoes. These vegetables were selected with the help of plant scientists at the University of Tennessee (Coffey and Rutledge, 1989). The products were selected on the basis of two considerations. The first concern relates to the potential to be grown in Tennessee. Second, there was a concern for the availability of price data over a 10 year period for the targeted wholesale markets.

To accomplish the proposed analysis of multiple cropping sequences or targeted harvest periods, the heat unit system of measuring the required growing period areas was used. The average daily heat units for these vegetables for the past thirty years at the Knoxville weather station were used to estimate the varietal constant for each vegetable for the Knoxville area.

With help from Dr. David Coffey of the Plant and Soil Science Department at the University of Tennessee, it was determined when farmers in the Knoxville area would typically plant each of the nine vegetables (Coffey, 1990). Beginning with that planting date, the average harvest date was specified (Table 1).

Table 1. Length Of Vegetable Seasons When Standard Planting Dates Are Used, Knoxville, TN.

Vegetable	Planting Date	Week	Begin Harvest	Week	End Harvest	Days to Maturity
Broccoli	March 22	12	May 22	21	May 28	67
Cabbage	March 22	12	May 24	21	May 30	69
Beans	April 15	15	June 7	23	June 13	59
Corn	April 1	13	June 21	25	June 27	87
Cucumbers	May 15	20	July 5	27	July 25	71
Squash	May 15	20	July 1	26	July 21	67
Okra	May 5	18	July 25	30	August 28	115
Peppers(TP)	May 15	20	July 5	27	August 1	78
Tomatoes(TP)	April 10	15	June 5	23	July 9	90

(TP) Transplanted plants.

The vegetables selected for analysis in this study can be divided into four groups based on growing temperature threshold levels. These threshold levels are 40, 45, 50 and 55 degrees fahrenheit. The threshold temperatures were the starting point in determining the needed varietal constants. The varietal constants were determined using average daily heat unit data for the Knoxville Weather Service Office. By using this daily heat unit data and the anticipated growing season based on the standard planting and harvesting dates, the approximate varietal constants were determined. These values ranged from 1,255 heat units for tomatoes to 2,191 for okra (Table 2).

The specified maximum available production/marketing period for all vegetables in this analysis begins with week 14 and ends with week 45, based on the Knoxville WSO data. This period was identified by accepting the condition that the probability of experiencing a freezing temperature was less than 25 percent. At the 75 percent probability level, a season ending freeze will occur in week 45 for cool season crops. With this same

Table 2. Threshold Temperatures And Estimated Varietal Constants, Knoxville, TN.

Vegetable	Threshold Temperature	Estimated Heat Units Required
Broccoli	40 Degrees Fahrenheit	1,421 Heat Units
Cabbage	40 Degrees Fahrenheit	1,479 Heat Units
Beans	45 Degrees Fahrenheit	1,272 Heat Units
Corn	50 Degrees Fahrenheit	1,442 Heat Units
Cucumbers	50 Degrees Fahrenheit	1,699 Heat Units
Squash	50 Degrees Fahrenheit	1,587 Heat Units
Okra	55 Degrees Fahrenheit	2,191 Heat Units
Peppers	55 Degrees Fahrenheit	1,502 Heat Units
Tomatoes	55 Degrees Fahrenheit	1,255 Heat Units

Sources of threshold temperatures: Lorenz and Maynard[1980], and Hopp, R. J., Et. Al.[1960].

75 percent level of confidence, the grower can begin planting during week 14 for cool season crops. Although week 14 is the date when planting can start, harvesting will not start for several weeks later depending on the variety of vegetable. The available growing season for warm season crops is obviously shorter, therefore, if the weeks from 14 through 45 are used, all possible vegetables will have their potential growing periods taken into account. The potential growing season could be extended if the level of risk for experiencing a freeze is set at a level higher than 25 percent.

The wholesale terminal markets chosen for this analysis were Atlanta, Baltimore, Cincinnati, and Chicago. They were chosen due to their proximity to Tennessee so they represent potential markets for vegetables grown in the state.

Production costs were taken from the enterprise budgets published by the Tennessee Agriculture Extension Service (Jenkins, et al., 1988) for the year 1988. These variable and fixed costs per unit were added to

shipping and marketing costs in order to determine total production and marketing costs. The marketing cost was set at 10 percent of the mean wholesale price at each terminal market (Snell, 1990). Shipping cost varied by destination and type of vegetable transported. In Table 3 an example of the estimation of the total cost of supplying green beans to each of the four wholesale markets is presented.

Price data for the years 1979-1989 were used to determine a weekly mean price for each of the nine vegetables. The price data were adjusted by the Prices Received by Farmers Index (Agricultural Statistics, 1988 and Agricultural Outlook, 1990) with 1988 being the base year. That was done to take the effects of inflation out of the data. Also, prices used in the analysis are for U.S. Number 1. products. Prices for lower grades may result in price lines considerably lower than the top-grade prices presented in Figures 1 - 36*. Along with the mean price per week, a weekly price plus and minus one standard deviation was also calculated. These data are presented in Figures 1-36. There are four figures for each vegetable crop with each figure representing one of the four terminal markets prices. These figures also give the production cost for Tennessee farmers, which includes marketing and shipping costs. In any of the figures, when the mean price line for a particular week is above the production cost line, a Tennessee farmer should be able to operate at a profit, on the average, for that week.

In Figure 1, the Atlanta price for snapbeans throughout the whole season was above the production cost. The price line that is one standard

* All figures may be found in the appendix.

Table 3. Production, Marketing, And Shipping Costs Per Unit For Snapbeans, Knoxville, TN^a.

Week	Marketing Cost @	Shipping Point	Shipping Cost	Production Cost	Total Cost
25	\$1.24	Atlanta	\$.75	\$3.14	\$5.13
25	\$1.06	Baltimore	\$1.25	\$3.14	\$5.45
25	\$1.35	Chicago	\$1.25	\$3.14	\$5.74
25	\$1.40	Cincinnati	\$.75	\$3.14	\$5.29

@ Estimated at 10 percent of price. The bean price for week 25 Atlanta equals \$12.44. The bean price for week 25 Baltimore is \$10.66. The bean price for week 25 Chicago is \$13.52. The bean price for week 25 Cincinnati is \$14.04. * This is an example using shipping costs for the year 1990 and production costs for the year 1988.

deviation below the mean price line was also above the production cost line for the entire period. This would mean that a grower can be sure that at least 67 percent of the time, on average, price should be above cost. Since each vegetable grower will have a slightly different cost of production, each would need to calculate his own cost of production to compare with the weekly price data.

For Baltimore, the minus-one standard deviation line drops below the production cost line four times (Figure 2). At these places one can not be as sure as in Figure 1. that the price for U.S. Number 1 snapbeans will be above production costs. The periods of time that the minus one standard deviation line was below the cost line were most likely when supplies were plentiful in the summer months. The price lines for snapbeans in Chicago and Cincinnati were similar to the prices in Atlanta.

Broccoli is a cool season crop and has a different price trend than snapbeans (Figures 5-8). For broccoli growers there was more price-risk in the earlier part of spring when supplies are usually more plentiful. In the hot summer months when broccoli does not thrive, the price-risk

should be lower because the minus one standard deviation line is consistently above the cost line. In Baltimore and Chicago, the average price line is below production cost in early spring.

Cabbage is another cool season crop that has its average price peak early in the first half of the year (Figures 9-12). The average price for Atlanta and Cincinnati stays well above production costs for the whole season. Both Baltimore and Chicago have two week periods when the average price drops below production costs. All of these sub-production cost prices came during the middle of the season.

Sweet corn in Figures 13 through 16 showed potential for higher prices in the early part of the year, but systematically dropped in price during the summer months at all four terminal markets, which made corn a high price risk for growers in Tennessee. In Baltimore and Chicago, the mean price for corn stayed below the cost line for several weeks in the middle of the season.

The average weekly price of cucumbers for Atlanta and Cincinnati was continuously above production costs (Figures 17-20). When cucumbers were "out-of-season" in the early spring, prices at all four terminal markets were high. During week 32 when shipping to Baltimore and week 33 and 34 when shipping to Chicago, the average price does fall below production costs. In both cases the minus-one standard deviation line is, for the most part, never above production costs during the middle of the season.

Okra had a wide range of fluctuating average prices for Atlanta, but even the minus-one standard deviation line stayed above the production cost line (Figures 21-24). Baltimore's price data were insufficient to produce a complete graph, and the information on Figure 22 reveals that.

The average prices for Cincinnati did not fluctuate as much as Atlanta's, and the minus-one standard deviation line also stayed well above the production cost line all season.

All four terminal markets for green peppers showed wide fluctuations in prices for the first 25 weeks of the year, then seemed to settle down during the summer months (Figures 25-28). Pepper prices are high enough in Atlanta, Chicago and Cincinnati to be at least 67 percent sure that price will cover production costs.

Yellow squash is another vegetable with consistent prices that allow for it to be grown and sold for more than it costs to produce (Figures 29-31). At the terminal markets in Atlanta and Cincinnati, a vegetable grower can produce squash being 67 percent sure that on average throughout his whole season he can at the least cover all his production costs. In Baltimore though, there is a one week period when the average price does drop below production cost. In Chicago the average price stays above the production cost for the whole season. But, at the 67 percent confidence level, the average price is not above the production cost for all weeks during the season.

Tomatoes, had similar price patterns in the four terminal markets. The price levels for these markets seemed to vary somewhat, but the peaks and valleys occurred around the same weeks. Baltimore had the highest overall average price throughout the season.

In Figures 37-45 the 11-year average weekly prices on all four terminal markets are shown on the same figure for each vegetable. According to the theory of one-price, the only difference in the prices for vegetables of the same quality between each terminal market during the

same week should be the cost of transporting that vegetable (Markusen, J. and Melvin J., 1988). This means that none of the price lines on the graphs should ever be separated by more than the cost of shipping the vegetable from the origin to each terminal market.

Snapbeans in Chicago and Baltimore started out on week 12 at the same high price, but by week 33 over \$8.00 separated the two prices (Figure 37). Theoretically, vegetable growers shipping to Baltimore should have started shipping to Chicago instead. This would continue until the two prices equalized, excluding shipping costs. This demonstrates the potential benefit from searching for a higher paying market instead of just shipping to the one that is closest to them. Okra was another vegetable that exhibited considerable inconsistency in average weekly prices in the four terminal markets (Figure 42). Cabbage prices also varied by fairly large amounts among the four markets (Figure 39).

The average weekly prices for broccoli, sweet corn, and cucumbers were close and moved in unison (Figures 38, 40, 41). The prices of broccoli and corn do not vary market to market by as much as the extra shipping cost. Average weekly prices of peppers, squash, and tomatoes moved in close unison over the 36-week period.

B. STANDARD PLANTING DATES

The expected returns using standard planting dates for the nine selected crops were determined by using the mean price during the standard harvest period of the crop. Crop yields were set at the levels presented in Table 4 from the Extension Vegetable Planning Manual for 1988.

Table 4. Average Yield Per Acre For Selected Vegetable Crops.

Vegetable	Units Per Acre Of U.S. Number 1. Produce
Snapbeans	130 bushels
Broccoli	225 14-s boxes
Cabbage	450 50 lb. bags
Corn	180 5 dz. crates
Cucumbers	263 bushels
Okra	400 half bushels
Green peppers	356 bushels
Yellow squash	600 half bushels
Tomatoes	808 25 lb. boxes

As noted in the planning manual, these yields do not represent average yields obtained by growers. These yields are projected for experienced growers using recommended production practices.

The 11-year average weekly price, standard deviation, and the production cost are presented in Table 5. Whether a crop will make a profit on average during the designated harvest period can be determined by subtracting the production cost for a vegetable from its average price. If the mean price is higher than production costs then the crop will produce a profit on average. Several crops like snapbeans, cabbage, and okra have a mean price that is more than double the production cost. Others, like squash sold in Baltimore have a higher production cost than mean price.

Average gross returns and average net returns were determined for the weeks in which the vegetables were harvested (Table 6). The coefficient of variation for the price during the harvest period can be used for a relative ranking of price-risk. The coefficient of variation is equal to the standard deviation divided by the mean price, then multiplied by 100. A coefficient of variation of 35 or more is an indication of high price

Table 5. Mean Prices, Standard Deviations, And Production Cost When Standard Planting Dates Are Used, Knoxville, TN.

Vegetable	Wholesale Market	Harvest Week(s)	Mean Price	Standard Deviation	Production Cost
-----Dollars per unit-----					
Snapbeans	Atlanta	23	11.78	2.54	5.06
	Baltimore	23	13.32	5.25	5.72
	Chicago	23	16.79	4.95	6.06
	Cincinnati	23	13.96	4.20	5.28
Broccoli	Atlanta	21	8.88	1.42	8.24
	Baltimore	21	8.44	1.12	8.95
	Chicago	21	8.63	1.34	8.97
	Cincinnati	21	9.79	1.46	8.33
Cabbage	Atlanta	21	6.90	2.81	3.89
	Baltimore	21	7.64	2.99	4.71
	Chicago	21	8.62	2.78	4.81
	Cincinnati	21	8.57	2.80	4.05
Corn	Atlanta	25	7.33	1.75	6.06
	Baltimore	25	8.70	2.76	6.70
	Chicago	25	8.99	1.53	6.72
	Cincinnati	25	8.90	1.88	6.22
Cucumbers	Atlanta	27-29	11.64	3.06	8.14
	Baltimore	27-29	11.27	3.32	8.51
	Chicago	27-29	11.79	3.16	8.65
	Cincinnati	27-29	12.16	3.03	8.19
Okra	Atlanta	30-34	7.11	1.12	5.13
	Baltimore	30-34	11.69	1.08	5.39
	Chicago	30-34	11.12	2.97	6.03
	Cincinnati	30-34	12.56	2.20	5.69
Peppers	Atlanta	27-30	10.67	2.61	5.87
	Baltimore	27-30	9.88	1.97	6.29
	Chicago	27-30	11.61	1.92	6.46
	Cincinnati	27-30	11.26	2.55	5.93
Squash	Atlanta	26-28	7.93	1.66	3.92
	Baltimore	26-28	4.01	1.13	4.02
	Chicago	26-28	6.50	1.66	4.28
	Cincinnati	26-28	6.29	0.83	3.75
Tomatoes	Atlanta	23-27	10.08	2.62	8.06
	Baltimore	23-27	10.71	3.23	8.61
	Chicago	23-27	8.82	1.83	8.43
	Cincinnati	23-27	10.05	2.09	8.06

Table 6. Returns Per Acre When Standard Planting Dates Are Used.

Vegetable	Wholesale Market	Harvest Week(s)	Average Gross Return	Average Net Return	Coef. of Var. @
Snapbeans	Atlanta	23	\$1,531.40	\$873.60	21.56
	Baltimore	23	\$1,731.60	\$988.00	39.33
	Chicago	23	\$2,182.70	\$1,394.90	29.48
	Cincinnati	23	\$1,814.80	\$1,128.40	30.08
Broccoli	Atlanta	21	\$1,998.00	\$144.00	15.99
	Baltimore	21	\$1,899.00	\$-114.75	13.27
	Chicago	21	\$1,941.75	\$-76.50	15.52
	Cincinnati	21	\$2,202.75	\$328.50	14.91
Cabbage	Atlanta	21	\$3,105.00	\$1,354.50	40.72
	Baltimore	21	\$3,438.00	\$1,318.50	39.13
	Chicago	21	\$3,879.00	\$1,714.50	32.25
	Cincinnati	21	\$3,856.50	\$2,304.00	32.67
Corn	Atlanta	25	\$1,319.40	\$228.60	23.87
	Baltimore	25	\$1,566.00	\$360.00	31.72
	Chicago	25	\$1,618.20	\$408.60	17.01
	Cincinnati	25	\$1,602.00	\$482.40	21.12
Cucumbers	Atlanta	27-29	\$3,061.32	\$920.50	26.28
	Baltimore	27-29	\$2,964.01	\$725.88	29.45
	Chicago	27-29	\$3,100.77	\$825.82	26.80
	Cincinnati	27-29	\$3,198.08	\$1,044.11	24.91
Okra	Atlanta	30-34	\$2,844.00	\$792.00	15.75
	Baltimore	30-34	\$4,676.00	\$2,520.00	9.23
	Chicago	30-34	\$4,448.00	\$2,036.00	26.70
	Cincinnati	30-34	\$5,024.00	\$2,748.00	17.51
Peppers	Atlanta	27-30	\$3,798.52	\$1,708.80	24.46
	Baltimore	27-30	\$3,517.28	\$1,278.04	19.93
	Chicago	27-30	\$4,133.16	\$1,833.40	16.53
	Cincinnati	27-30	\$4,008.56	\$1,897.48	22.64
Squash	Atlanta	26-28	\$4,758.00	\$2,406.00	20.93
	Baltimore	26-28	\$2,406.00	\$-6.00	28.17
	Chicago	26-28	\$3,900.00	\$1,332.00	25.53
	Cincinnati	26-28	\$3,774.00	\$1,524.00	13.19
Tomatoes	Atlanta	23-27	\$8,144.64	\$1,632.16	25.99
	Baltimore	23-27	\$8,653.68	\$1,696.80	30.15
	Chicago	23-27	\$7,126.56	\$315.12	20.74
	Cincinnati	23-27	\$8,120.40	\$1,607.92	20.79

@ A coefficient of variation for average product prices over the designated harvesting period.

risk. A coefficient of variation of 20 to 35 is defined as moderate risk, and one of less than 20 is considered low risk (Venturella, *et al.*, 1988).

The standard planting dates resulted in most of the crops exhibiting a positive net return. Broccoli did not produce a result in a positive average net return at Baltimore and Chicago. The average net returns for squash was negative for Baltimore. While squash shipped to Baltimore lost \$6.00 per acre, squash shipped to the other three terminal markets resulted in an average net return of over \$1,500.00 per acre. Cincinnati yielded an average net return of \$1,524.00. Cincinnati's terminal market also had the lowest price-risk for squash with a coefficient of variation for average weekly price of 13.19. Hence, squash sold in Cincinnati fits in the low risk category. Squash sold in Atlanta made more money on average than what was sold in Cincinnati, but its price-risk was higher with a coefficient of variation of 20.93, defined as a moderate risk.

The other vegetable with negative average net returns was broccoli shipped to Baltimore and Chicago. In Baltimore broccoli lost an average of \$114.75 per acre. In Chicago broccoli lost an average of \$76.50 per acre. Broccoli at all four terminal markets had low coefficients of variation. Although this did indicate low price-risk, the incomes for this vegetable during the standard harvest period are also low. Cincinnati, with the best net return, only yielded an average of \$328.50 per acre.

The highest average net income of the nine vegetables was for okra sold at the terminal market in Cincinnati. An average net return of \$2,748.00 was calculated for Cincinnati. The next highest was also for okra sold in Baltimore, resulting in \$2,520.00 per acre in average net

returns. The highest coefficient of variation, 40.72, was for cabbage sold in Atlanta. The lowest coefficient of variation was for okra sold in Baltimore, but due to the lack of available data for okra sold in Baltimore (only six weeks) it may not really be the vegetable with the lowest price risk over the last eleven years. Squash is the vegetable with the lowest coefficient of variation (13.19) that can be compared with the other vegetables. Out of the nine vegetables sold at the four terminal markets, 11 fit in the low-risk coefficient of variation category (including Baltimore okra). Only three were in the high risk category, and the rest were a moderate risk.

C. TARGET MARKET PLANTING

For the target-market schedule of planting and harvesting dates, more explanation is needed. First, it had to be determined when each of the nine vegetables could be planted in Tennessee. For this, a 75 percent probability of a freeze free season was chosen. Due to the different varieties of vegetables in the study, some of the vegetables could have earlier planting dates than others. The cool season crops were specified to be able to be planted when the probability of not experiencing a 28-degrees Fahrenheit temperature reached the 75 percent level. The warm season crops must be planted after the probability of not experiencing a 32 degrees Fahrenheit temperature reached the 75 percent level. The data for Knoxville WSO is shown in Table 7.

The next step was to determine how long it would take for each of the nine crops to be harvestable. This was accomplished by use of the average

Table 7 . Potential Seasons For Vegetables With A 25 Percent Probability Of A Crop Damaging Temperature, Knoxville, TN.

Vegetable	Type Crop	First Planting	Week	Last Harvest	Week
Broccoli	Cool ^a	April 5	14	November 9	45
Cabbage	Cool ^a	April 5	14	November 9	45
Beans	Warm ^b	April 8	15	October 30	44
Corn	Warm ^b	April 8	15	October 30	44
Cucumbers	Warm ^b	April 8	15	October 30	44
Squash	Warm ^b	April 8	15	October 30	44
Okra	Warm ^b	April 8	15	October 30	44
Peppers	Warm ^b	April 8	15	October 30	44
Tomatoes	Warm ^b	April 8	15	October 30	44

^a Crop damaging temperature defined to be 28 degrees Fahrenheit or lower.

^b Crop damaging temperature defined to be 32 degrees Fahrenheit or lower.

daily heat units and the varietal constant required for each crop. The estimated varietal constants were presented in Table 2. Using temperature data from weather stations at Knoxville WSO, Columbia, Covington, Greeneville, and Monteagle, the earliest date that a crop could be harvested was determined. Using the first planting dates and the last harvest dates in Table 7, the potential harvest period for each vegetable can be estimated. In order to do this, the first planting date for a crop must be used. The daily heat units are added together from the first planting date until the varietal constant for each vegetable is reached. The initial potential harvest date is determined by first finding the day on which the varietal constant for each vegetable was reached. Then one can subtract the days of the harvest period from the date the varietal constant was reached in order to determine the initial harvest date for each vegetable. The last potential day for fall harvest is when the identified crop damaging temperature occurs for each vegetable. For example, a cool season crop ends its season on November 9 and a warm

season crops ends on October 30 (Table 7).

Once the potential harvest periods were determined, the average gross returns and average net returns were estimated. The maximum potential harvest periods were labeled on Figures 1-36. Tables 8 and 9 show the price and cost data used to determine the results in Tables 10 and 11. In Tables 8, 9, 10, and 11 the harvesting periods were set for when the highest average price occurs in each city during that particular potential harvest period. If the harvest period was one week, the highest average weekly price during the potential harvesting period was used in determining the net return for that product in that city. If the harvest period was three to five weeks then the highest possible harvest period average price for a multi-consecutive week period was used. The results are listed in Table 10 and 11.

In Tables 10 and 11 all products show positive net returns. Most of these products show substantial increases in net income due to the shifting of the harvest period. Some were already at their highest point when the standard planting dates were used. An example of this would be snap beans sold at the Baltimore terminal market with an net income of \$ 988.00.

The highest average net income for any vegetable using the target harvest system was for squash when shipped to Atlanta. If squash were sold during weeks 39-41 in Atlanta it would produce an average net income of \$3,684.00. Not only did Atlanta have high net returns for squash, but the other three terminal markets did as well.

Most of the vegetables in the target harvest system had low net incomes when shipped to Baltimore. Baltimore was consistently below the

Table 8. Mean Prices, Standard Deviations, And Production Cost When Target Harvest Dates Are Used.^a

Vegetable	Wholesale Market	Harvest Week(s)	Mean Price	Standard Deviation	Production Cost
-----Dollars per unit-----					
Snapbeans	Atlanta	41	12.92	3.65	5.18
	Baltimore	23	13.32	5.24	5.72
	Chicago	24	17.00	2.70	6.09
	Cincinnati	24	14.16	3.40	5.30
Broccoli	Atlanta	41	10.56	1.86	8.41
	Baltimore	41	11.10	2.07	9.22
	Chicago	41	10.67	2.02	9.17
	Cincinnati	41	11.43	1.71	8.50
Cabbage	Atlanta	24	7.12	3.02	3.91
	Baltimore	22	7.06	3.09	4.65
	Chicago	22	9.31	3.79	4.88
	Cincinnati	24	8.89	4.20	4.08
Corn	Atlanta	26	8.21	1.58	6.15
	Baltimore	25	8.70	2.76	6.70
	Chicago	42	10.10	1.54	6.81
	Cincinnati	42	9.68	1.17	6.29
Cucumber	Atlanta	25-27	12.18	3.91	8.19
	Baltimore	25-27	10.46	2.98	8.61
	Chicago	25-27	13.19	4.01	8.79
	Cincinnati	25-27	13.68	3.18	8.34
Okra	Atlanta	38-42	11.21	2.97	5.54
	Baltimore	38-42	12.86	0.80	5.70
	Chicago	38-42	12.83	3.46	6.18
	Cincinnati	32-36	12.99	2.03	5.60
Peppers	Atlanta	29-32	11.17	2.31	5.92
	Baltimore	25-28	10.69	2.92	6.37
	Chicago	25-28	12.62	3.28	6.57
	Cincinnati	25-28	12.05	3.59	6.01
Squash	Atlanta	39-41	10.29	2.94	4.15
	Baltimore	40-42	9.53	3.76	4.54
	Chicago	40-42	9.25	3.40	4.55
	Cincinnati	40-42	9.81	3.22	4.11
Tomatoes	Atlanta	24-28	10.15	2.57	8.07
	Baltimore	38-42	11.62	2.62	8.71
	Chicago	38-42	9.23	2.16	8.48
	Cincinnati	23-27	10.05	2.09	8.06

^a See Table 4. for production units.

Table 9. Mean Prices, Standard Deviations, And Production Cost When Target Harvest Dates Are Used For The Four Growing Regions Of Tennessee, And Produce Is Shipped To The Atlanta Wholesale Market.^a

Vegetable	Growing Region	Harvest Week(s)	Mean Price	Standard Deviation	Production Cost
-----Dollars per unit-----					
Tomatoes	Columbia	24-28	10.15	2.57	8.07
	Covington	24-28	10.15	2.57	8.07
	Greeneville	25-29	9.97	2.37	8.05
	Monteagle	24-28	10.15	2.57	8.07

^a See Table 4. for production units

Table 10. Returns Per Acre When Target Market Planting Dates Are Used.^a

Vegetable	Wholesale Market	Harvest Week(s)	Average Gross Return	Average Net Return	Coef. of Var.
Snapbeans	Atlanta	41	\$1,679.60	\$1,006.20	28.25
	Baltimore	23	\$1,731.60	\$988.00	39.33
	Chicago	24	\$2,210.00	\$1,418.30	15.88
	Cincinnati	24	\$1,840.80	\$1,151.80	24.01
Broccoli	Atlanta	41	\$2,376.00	\$483.75	17.61
	Baltimore	41	\$2,497.50	\$423.00	18.64
	Chicago	41	\$2,400.75	\$337.50	18.93
	Cincinnati	41	\$2,571.75	\$659.25	14.96
Cabbage	Atlanta	24	\$3,204.00	\$1,444.50	42.41
	Baltimore	22	\$3,177.00	\$1,084.00	43.76
	Chicago	22	\$4,189.50	\$1,993.50	40.70
	Cincinnati	24	\$4,000.50	\$2,164.50	47.24
Corn	Atlanta	26	\$1,477.80	\$370.80	19.24
	Baltimore	25	\$1,566.00	\$360.00	31.72
	Chicago	42	\$1,818.00	\$592.20	15.24
	Cincinnati	42	\$1,742.40	\$610.20	12.08
Cucumber	Atlanta	25-27	\$3,203.34	\$1,049.00	32.10
	Baltimore	25-27	\$2,750.98	\$486.55	28.48
	Chicago	25-27	\$3,468.97	\$1,157.20	30.40
	Cincinnati	25-27	\$3,597.84	\$1,404.42	23.24
Okra	Atlanta	38-42	\$4,484.00	\$2,268.00	26.49
	Baltimore	38-42	\$5,144.00	\$2,864.00	6.22
	Chicago	38-42	\$5,132.00	\$2,660.00	26.96
	Cincinnati	32-36	\$5,196.00	\$2,956.00	15.62
Peppers	Atlanta	29-32	\$3,976.52	\$1,869.00	20.68
	Baltimore	25-28	\$3,805.64	\$1,537.92	27.31
	Chicago	25-28	\$4,492.72	\$2,153.80	25.99
	Cincinnati	25-28	\$4,289.80	\$2,150.24	29.79
Squash	Atlanta	39-41	\$6,174.00	\$3,684.00	28.57
	Baltimore	40-42	\$5,718.00	\$2,994.00	39.45
	Chicago	40-42	\$5,550.00	\$2,820.00	36.75
	Cincinnati	40-42	\$5,886.00	\$3,420.00	32.82
Tomatoes	Atlanta	24-28	\$8,201.20	\$1,680.64	25.32
	Baltimore	38-42	\$9,388.96	\$2,351.28	22.54
	Chicago	38-42	\$7,457.84	\$606.00	23.40
	Cincinnati	23-27	\$8,120.40	\$1,607.92	20.79

^a See Table 4. for production units per acre.

Table 11. Returns Per Acre When Target Market Planting Dates Are Used For The Four Growing Regions Of Tennessee When Produce Is Shipped To The Atlanta Wholesale Market.*

Vegetable	Growing Region	Harvest Week(s)	Average Gross Return	Average Net Return	Coef. of Var.
Tomatoes	Columbia	24-28	\$8,201.20	\$1,680.64	25.32
	Covington	24-28	\$8,201.20	\$1,680.64	25.32
	Greeneville	25-29	\$8,055.76	\$1,551.36	23.77
	Monteagle	24-28	\$8,201.20	\$1,680.64	25.32

* See Table 4. for production units per acre.

other three terminal markets in average price. In some cases Baltimore would not even bring half the price of other terminal markets, such as in the case of cucumbers.

The coefficients of variation listed in tables 10 and 11 show the relative ranking of risk between the terminal markets and their vegetables. The coefficients of variation were increased in some cases from the standard planting dates and reduced in others. The highest coefficient of variation went up from 40.72 for Atlanta cabbage in Table 6 to 47.24 for Cincinnati cabbage in Table 10. The lowest coefficient of variation was 6.22 for okra in the Baltimore wholesale market. The next lowest coefficient of variation is 12.08 for corn sold in Cincinnati.

In Table 11, the net returns for tomatoes based on the regions of Tennessee are shown. Tomatoes were used to represent what can happen in the different climatic regions of Tennessee because they are Tennessee's number one vegetable crop. Heat unit data and planting dates based on a 75 percent freeze confidence level were used to determine the different harvest periods for these four regions. This was done to demonstrate what

the effects of varying climate can have on what market window a grower can aim for. Three of the four regions had the same five week market window, even though the potential harvest periods were different due to the varying climate. This is demonstrated in Figures 36a-36d. It just happened that the highest price period for three of the four regions occurred during the same five week period.

When the planting dates and harvesting dates are shifted away from the ideal dates, it stands to reason that there should be some other risks involved. When targeting harvest dates in order to receive a higher price, a farmer should know what production risks he is also accepting. Tables 12 and 13 show the level of frost risk for when the vegetables were planted. Probabilities are shown in the percentage of the years that a frost can be expected to kill the crop mentioned when it is planted for the targeted harvest date. Over half of the vegetables planted for a targeted harvest date had a 25 percent killing freeze risk associated with them. Only 16 had a risk of less than 10 percent.

D. SEQUENTIAL CROPPING FOR MARKET WINDOWS

For a sequential cropping schedule of all of the alternative sequences using double and triple crop sequences for the nine vegetables, the possibilities would be numerous. The number of sequences for triple and double cropping was reduced to ten, to demonstrate the technique being used rather than emphasizing the results of all possible outcomes. The sequences were picked to have every vegetable used in at least one sequence. The following sequences in Table 14 are some of the

Table 12. Vegetable Killing Freeze Probabilities.

Vegetable	City	Harvest Week(s)	Vegetable Killing Freeze Probability
Snapbeans ^a	Atlanta	41	Less than 10 %
	Baltimore	23	25 %
	Chicago	24	Less than 10 %
	Cincinnati	24	Less than 10 %
Broccoli ^b	Atlanta	41	Less than 10 %
	Baltimore	41	Less than 10 %
	Chicago	41	Less than 10 %
	Cincinnati	41	Less than 10 %
Cabbage ^b	Atlanta	24	Less than 10 %
	Baltimore	22	25 %
	Chicago	22	25 %
	Cincinnati	24	Less than 10 %
Corn ^a	Atlanta	26	Less than 10 %
	Baltimore	25	25 %
	Chicago	42	25 %
	Cincinnati	42	25 %
Cucumber ^a	Atlanta	25-27	25 %
	Baltimore	25-27	25 %
	Chicago	25-27	25 %
	Cincinnati	25-27	25 %
Okra ^a	Atlanta	38-42	25 %
	Baltimore	38-42	25 %
	Chicago	38-42	25 %
	Cincinnati	32-36	Less than 10 %
Peppers ^a	Atlanta	29-32	Less than 10 %
	Baltimore	25-28	25 %
	Chicago	25-28	25 %
	Cincinnati	25-28	25 %
Squash ^a	Atlanta	39-41	Less than 10 %
	Baltimore	40-42	25 %
	Chicago	40-42	25 %
	Cincinnati	40-42	25 %
Tomatoes ^a	Atlanta	24-28	Less than 10 %
	Baltimore	38-42	25 %
	Chicago	38-42	25 %
	Cincinnati	23-27	25 %

^a designates that below 32 degrees Fahrenheit will kill the crop.

^b designates that below 28 degrees Fahrenheit will kill the crop.

Table 13. Tomato Killing Freeze Probabilities For Different Growing Regions Of Tennessee

Vegetable	City	Harvest Week(s)	Vegetable Killing Freeze Probability
Tomatoes	Columbia	24-28	Less than 10
	Covington	24-28	Less than 10 %
	Greeneville	25-29	25 %
	Monteagle	24-28	25 %

Table 14. Ten Double and Triple Vegetable Crop Sequences Selected For Comparison, Knoxville, TN.

	First	Second	Third
Triple			
	Broccoli	Tomatoes	Cabbage
	Cabbage	Squash	Broccoli
	Beans	Corn	Broccoli
Double			
	Corn	Broccoli	
	Tomatoes	Cabbage	
	Okra	Broccoli	
	Squash	Broccoli	
	Peppers	Broccoli	
	Cucumbers	Broccoli	
	Beans	Tomatoes	

possibilities before it is determined whether or not they can fit into the potential growing seasons of Tennessee.

Using the same techniques that were used in determining the target harvest periods the harvest periods for the sequenced vegetables were found. Starting with the potential harvest periods listed in Figures 1-36, the potential harvest dates for each vegetable during its part of the

sequence was found. The time for each harvest was determined using the heat unit system. This time, though, a second and sometimes third crop had to be taken into account during the potential harvest period. When the second crop's harvest period was determined, a two week delay was added to the beginning harvest date in order to take into account the detrimental effect of too much heat on the plants in June and July. Then after the two week delay the highest prices were taken for the time period shortly after the delay that would still allow for another crop to be grown in the potential harvest period if a three crop sequence was being used.

Tables 15, 16, and 17 represent the results of this analysis as Table follows. Tables 15 and 16 show the sequences of vegetables to be grown. Then beside the sequences on the same table the terminal markets, weeks harvested, products, product prices, standard deviations, and production costs are presented across the table. Table 17 shows the average gross and net returns for each sequence at each terminal market.

In Table 17 all sequences show positive average net returns. This does not mean though, that each individual crop has a positive average net return. For example, even though the sequence beans-corn-broccoli shows a positive average net return for Baltimore, the net return for corn was negative. This can be seen in Table 15 where the average production cost is greater than the mean price for Baltimore corn during the harvest period, week 32.

When analyzing the broccoli-tomato-cabbage sequence, a difference in average net revenue can be seen in not only the different terminal markets, but also in the five different production areas (Table 17).

Table 15. Mean Prices, Standard Deviations, And Production Cost For Specified Sequences In The Knoxville Area.

Sequence	Wholesale Market	Week(s)	Vegetable	Mean Price	Standard Deviation	Production Cost
				-----Dollars per unit-----		
Cabbage-Squash-Broccoli	Atlanta	24	Cabbage	7.12	3.02	3.91
	Baltimore	22	Cabbage	7.06	3.09	4.65
	Chicago	22	Cabbage	9.31	3.79	4.88
	Cincinnati	24	Cabbage	8.89	4.20	4.08
	Atlanta	32-34	Squash	9.35	1.25	4.06
	Baltimore	32-34	Squash	5.64	2.19	4.19
	Chicago	32-34	Squash	5.87	1.28	4.21
	Cincinnati	32-34	Squash	6.33	0.91	3.75
	Atlanta	41	Broccoli	10.56	1.86	8.41
	Baltimore	41	Broccoli	11.10	2.07	9.22
	Chicago	41	Broccoli	10.67	2.02	9.17
	Cincinnati	41	Broccoli	11.43	1.71	8.50
Beans-Corn-Broccoli	Atlanta	25	Beans	12.44	3.81	5.13
	Baltimore	23	Beans	13.32	5.38	5.72
	Chicago	24	Beans	17.00	2.70	6.09
	Cincinnati	24	Beans	14.16	3.40	5.30
	Atlanta	32	Corn	6.64	0.97	5.99
	Baltimore	32	Corn	5.94	1.25	6.42
	Chicago	35	Corn	6.45	1.56	6.47
	Cincinnati	32	Corn	6.54	1.24	5.98
	Atlanta	41	Broccoli	10.56	1.86	8.41
	Baltimore	41	Broccoli	11.10	2.07	9.22
	Chicago	41	Broccoli	10.67	2.02	9.17
	Cincinnati	41	Broccoli	11.43	1.71	8.50
Corn-Broccoli	Atlanta	26	Corn	8.21	1.58	6.15
	Baltimore	25	Corn	8.70	2.83	6.70
	Chicago	26	Corn	9.54	1.45	6.78
	Cincinnati	26	Corn	9.57	1.67	6.28
	Atlanta	41	Broccoli	10.56	1.86	8.41
	Baltimore	41	Broccoli	11.10	2.07	9.22
	Chicago	41	Broccoli	10.67	2.02	9.17
	Cincinnati	41	Broccoli	11.43	1.71	8.50
Tomatoes-Cabbage	Atlanta	24-28	Tomatoes	10.15	2.57	8.07
	Baltimore	23-27	Tomatoes	10.71	3.23	8.61
	Chicago	24-28	Tomatoes	8.90	1.81	8.44
	Cincinnati	24-28	Tomatoes	10.04	1.98	8.06
	Atlanta	37	Cabbage	6.20	1.97	3.82
	Baltimore	37	Cabbage	5.42	1.80	4.49
	Chicago	37	Cabbage	5.31	1.86	4.48
	Cincinnati	38	Cabbage	6.19	1.85	3.81
Okra-Broccoli	Atlanta	30-34	Okra	7.11	1.12	5.11
	Baltimore	30-34	Okra	11.69	1.08	6.13
	Chicago	30-34	Okra	11.65	2.68	5.99
	Cincinnati	30-34	Okra	12.39	2.04	5.65
	Atlanta	41	Broccoli	10.56	1.86	8.41
	Baltimore	41	Broccoli	11.10	2.07	9.22
	Chicago	41	Broccoli	10.67	2.02	9.17
	Cincinnati	41	Broccoli	11.43	1.71	8.50
Squash-Broccoli	Atlanta	24-26	Squash	8.08	2.15	3.93
	Baltimore	24-26	Squash	4.59	1.15	4.08
	Chicago	24-26	Squash	7.67	2.27	4.39
	Cincinnati	24-26	Squash	7.06	1.14	3.83
	Atlanta	41	Broccoli	10.56	1.86	8.41
	Baltimore	41	Broccoli	11.10	2.07	9.22
	Chicago	41	Broccoli	10.67	2.02	9.17
	Cincinnati	41	Broccoli	11.43	1.71	8.50

Continued on next page

Table 15.-continued.

Sequence	City	Week(s)	Vegetable	Mean Price	Standard Deviation	Production Cost
-----Dollars per unit-----						
Peppers-Broccoli	Atlanta	25-28	Peppers	10.06	2.64	5.86
	Baltimore	25-28	Peppers	10.69	2.92	6.38
	Chicago	25-28	Peppers	12.62	3.28	6.57
	Cincinnati	25-28	Peppers	12.05	3.59	6.01
	Atlanta	41	Broccoli	10.56	1.86	8.41
	Baltimore	41	Broccoli	11.10	2.07	9.22
	Chicago	41	Broccoli	10.67	2.02	9.17
	Cincinnati	41	Broccoli	11.43	1.71	8.50
Cucumbers-Broccoli	Atlanta	25-27	Cucumbers	12.18	3.91	8.19
	Baltimore	25-27	Cucumbers	11.36	3.28	8.61
	Chicago	25-27	Cucumbers	13.19	4.01	8.79
	Cincinnati	25-27	Cucumbers	13.68	3.18	8.34
	Atlanta	41	Broccoli	10.56	1.86	8.41
	Baltimore	41	Broccoli	11.10	2.07	9.22
	Chicago	41	Broccoli	10.67	2.02	9.17
	Cincinnati	41	Broccoli	11.43	1.71	8.50
Beans-Tomatoes	Atlanta	25	Beans	12.44	3.81	5.13
	Baltimore	23	Beans	13.32	5.38	5.72
	Chicago	24	Beans	17.00	2.70	6.09
	Cincinnati	24	Beans	14.16	3.40	5.30
	Atlanta	38-42	Tomatoes	10.02	1.85	8.05
	Baltimore	38-42	Tomatoes	11.62	2.62	8.71
	Chicago	38-42	Tomatoes	9.23	2.16	8.48
	Cincinnati	29-33	Tomatoes	9.62	2.05	8.01

Table 16. Mean Prices, Standard Deviations, And Production Cost For A Broccoli-Tomato-Cabbage Sequence.

Production Location	Wholesale Market	Week(s)	Vegetable	Mean Price	Standard Deviation	Production Cost
-----Dollars per unit-----						
Knoxville	Atlanta	22	Broccoli	8.07	1.27	8.23
	Baltimore	23	Broccoli	9.51	1.99	9.06
	Chicago	23	Broccoli	9.44	2.48	9.05
	Cincinnati	22	Broccoli	9.68	1.31	8.32
	Atlanta	28-32	Tomatoes	9.05	1.90	7.95
	Baltimore	29-33	Tomatoes	10.04	2.67	8.55
	Chicago	28-32	Tomatoes	8.67	2.09	8.42
	Cincinnati	28-32	Tomatoes	9.78	2.05	8.03
	Atlanta	40	Cabbage	5.78	1.49	3.77
	Baltimore	42	Cabbage	4.98	1.30	4.44
	Chicago	43	Cabbage	5.22	1.07	4.47
	Cincinnati	40	Cabbage	5.93	1.44	3.79
Columbia	Atlanta	23	Broccoli	8.07	1.27	8.23
	Baltimore	23	Broccoli	9.51	1.99	9.06
	Chicago	23	Broccoli	9.44	2.48	9.05
	Cincinnati	23	Broccoli	9.91	1.14	8.35
	Atlanta	29-33	Tomatoes	8.85	1.70	7.93
	Baltimore	30-34	Tomatoes	9.90	2.72	8.54
	Chicago	29-33	Tomatoes	8.81	2.25	8.43
	Cincinnati	29-33	Tomatoes	9.61	2.28	8.01
	Atlanta	39	Cabbage	5.80	1.49	3.77
	Baltimore	39	Cabbage	5.05	1.29	4.45
	Chicago	39	Cabbage	4.99	1.64	4.44
	Cincinnati	39	Cabbage	6.14	1.68	3.81
Covington	Atlanta	21	Broccoli	8.88	1.42	8.24
	Baltimore	20	Broccoli	8.87	1.62	8.99
	Chicago	20	Broccoli	8.82	1.29	8.99
	Cincinnati	20	Broccoli	9.90	1.38	8.35
	Atlanta	26-30	Tomatoes	9.57	2.27	8.01
	Baltimore	26-30	Tomatoes	10.14	2.24	8.57
	Chicago	26-30	Tomatoes	8.84	1.78	8.44
	Cincinnati	26-30	Tomatoes	10.02	2.00	8.06
	Atlanta	39	Cabbage	5.80	1.64	3.78
	Baltimore	39	Cabbage	5.05	1.29	4.45
	Chicago	39	Cabbage	4.99	1.64	4.44
	Cincinnati	39	Cabbage	6.14	1.68	3.81
Greeneville	Atlanta	23	Broccoli	9.05	1.45	8.26
	Baltimore	23	Broccoli	9.51	1.99	9.06
	Chicago	23	Broccoli	9.44	2.48	2.48
	Cincinnati	23	Broccoli	9.91	1.14	8.35
	Atlanta	30-34	Tomatoes	8.51	1.42	7.90
	Baltimore	30-34	Tomatoes	9.90	2.72	8.54
	Chicago	30-34	Tomatoes	8.65	2.33	8.42
	Cincinnati	30-34	Tomatoes	9.23	2.14	7.98
	Atlanta	39	Cabbage	5.80	1.64	3.78
	Baltimore	39	Cabbage	5.05	1.29	4.45
	Chicago	39	Cabbage	4.99	1.64	4.44
	Cincinnati	39	Cabbage	6.14	1.68	3.81
Monteagle	Atlanta	23	Broccoli	9.05	1.45	8.26
	Baltimore	23	Broccoli	9.51	1.99	9.06
	Chicago	23	Broccoli	9.44	2.48	9.05
	Cincinnati	23	Broccoli	9.91	1.14	8.35
	Atlanta	30-34	Tomatoes	8.51	1.42	7.90
	Baltimore	30-34	Tomatoes	9.90	2.72	8.54
	Chicago	30-34	Tomatoes	8.65	2.33	8.42
	Cincinnati	30-34	Tomatoes	9.23	2.14	7.98
	Atlanta	39	Cabbage	5.80	1.64	3.78
	Baltimore	39	Cabbage	5.05	1.29	4.45
	Chicago	39	Cabbage	4.99	1.64	4.44
	Cincinnati	39	Cabbage	6.14	1.68	3.81

Table 17. Gross And Net Returns For Crop Sequences.

Sequence	Production Location	City	Gross Returns	Net Returns
			-----Dollars-----	
Cabbage-Squash-Broccoli	Knoxville	Atlanta	11,190.00	5,102.25
		Baltimore	9,058.50	2,377.50
		Chicago	10,112.25	3,327.00
		Cincinnati	10,370.25	4,371.75
Beans-Corn-Broccoli	Knoxville	Atlanta	5,188.40	1,551.05
		Baltimore	5,298.30	1,324.60
		Chicago	5,771.75	1,752.20
		Cincinnati	5,589.75	1,911.85
Corn-Broccoli	Knoxville	Atlanta	3,853.80	854.55
		Baltimore	4,063.50	783.00
		Chicago	4,117.85	834.30
		Cincinnati	4,294.35	1,251.45
Tomatoes-Cabbage	Knoxville	Atlanta	10,991.20	2,751.64
		Baltimore	11,092.68	2,115.30
		Chicago	9,580.70	745.18
		Cincinnati	10,897.82	2,670.84
Okra-Broccoli	Knoxville	Atlanta	5,220.00	1,283.75
		Baltimore	7,173.50	2,647.00
		Chicago	7,060.75	2,601.50
		Cincinnati	7,527.75	3,355.25
Squash-Broccoli	Knoxville	Atlanta	7,224.00	2,973.75
		Baltimore	5,251.50	729.00
		Chicago	7,002.75	2,305.50
		Cincinnati	6,807.75	2,597.25
Peppers-Broccoli	Knoxville	Atlanta	6,149.60	2,171.19
		Baltimore	6,303.14	1,957.36
		Chicago	6,893.47	2,491.30
		Cincinnati	6,861.55	2,809.49
Cucumbers-Broccoli	Knoxville	Atlanta	5,579.34	1,533.12
		Baltimore	5,485.18	1,146.25
		Chicago	5,869.72	1,494.70
		Cincinnati	6,169.59	2,063.67
Beans-Tomatoes	Knoxville	Atlanta	9,713.36	2,542.06
		Baltimore	11,120.56	3,339.28
		Chicago	9,667.84	2,024.30
		Cincinnati	9,613.76	2,452.68
Broccoli-Tomato-Cabbage	Knoxville	Atlanta	11,729.15	1,757.30
		Baltimore	12,493.07	1,548.17
		Chicago	11,478.36	627.25
		Cincinnati	12,748.74	2,683.00
	Columbia	Atlanta	11,797.05	1,830.11
		Baltimore	12,411.45	1,470.13
		Chicago	11,487.98	642.29
		Cincinnati	12,757.63	2,692.30
	Covington	Atlanta	12,340.56	2,313.48
		Baltimore	12,461.37	1,511.56
		Chicago	11,372.72	532.45
		Cincinnati	13,086.66	2,980.93
	Greeneville	Atlanta	11,522.33	1,579.63
		Baltimore	12,411.45	1,470.13
		Chicago	11,358.70	521.09
		Cincinnati	12,450.59	2,409.50
	Monteagle	Atlanta	11,522.33	1,579.63
		Baltimore	12,411.45	1,470.13
		Chicago	11,358.70	521.09
		Cincinnati	12,450.59	2,409.50

Cincinnati provides the highest average net revenue for the sequence in the Knoxville production area with \$2,683.00. The lowest average net revenue was \$627.25 in Chicago. The difference in the two average net incomes is due to the difference in average price and marketing and Table shipping costs. Vegetables sold in Cincinnati resulted in the highest net returns of all five production regions. The overall highest average net revenue came from the Covington production region for vegetables sold in Cincinnati. It had an average net revenue of \$2,980.93 for all three crops. The lowest average net revenue was for Monteagle and Greeneville when shipping to Chicago, \$521.09.

The highest overall average net revenue for any sequence came from the cabbage-squash-broccoli sequence with the vegetables being shipped to Atlanta. It had an average net revenue of \$5,102.25. In this sequence all three crops had positive average net returns. Prices at Cincinnati resulted in the second highest average net revenue for a double or triple crop sequence.

The sequence that made the lowest net return for the average of all four terminal markets, was the corn-broccoli sequence. In Figures, 5-18 and 13-16, it is evident that during Tennessee's potential harvest period the price stays close to the production cost in most weeks.

Due to the low average price of tomatoes at the Chicago terminal market, the sequences that have tomatoes in them are lower at this wholesale market than at the other three. If the farmer has the ability and brokers that will allow him to ship to a different terminal market for each vegetable, then a grower would be able to make considerably more than the average net revenues stated in Table 17 by shipping each crop to the

market with the history of having higher prices. Although this table does not present this information in the form of average net returns, it can be determined by comparing price to production cost in Tables 15, and 16. If the farmer picks the terminal markets with the largest positive difference after subtracting production cost from price, he will be able to sell his produce for the greatest average profit.

E. COMPARING PLANTING STRATEGIES

All three of the planting strategies have advantages and disadvantages for the Tennessee farmer. If a Tennessee farmer has a small amount of land, he may be able to use sequential cropping to enhance annual net revenue. The sequential cropping strategies resulted in Tennessee farmers being able to make up to \$5,102.25 on average per acre. This is the highest income of any of the three planting techniques. This income also comes from some vegetables that are adapted to the cool weather of the spring and fall, which means they would be relatively safe to target the harvest dates within the sequence. The sequence starts with cabbage in the spring and ends with broccoli in the fall. Both of these vegetables should not have their production adversely affected by cool weather conditions. Squash is safely placed in the middle of the growing season when it grows without being adversely affected by the heat.

This one sequence can be compared with squash in the target market planting dates and okra in the standard planting dates. Squash grown for the target market in Atlanta can make \$3,684.00 per acre on the average. But along with the high income per acre comes several risks. The net

income from selling in Atlanta comes with a moderate price risk according to the coefficient of variation of 28.57. This price risk though is not bad when compared with the price risk involved when selling squash in Baltimore and Chicago, which are both in the high risk category and provided less net revenue on average. Another risk that must be considered by vegetable farmers planting at this time is the production risk. One interesting fact is that, even though Atlanta has the better price it also has a lower production risk when referring to freeze damage. This is because it can be harvested one week earlier and still receive the highest price of the season when compared with the other three terminal markets. Harvesting the product one week earlier in this case lowers the freeze risk from 25 percent to below ten percent.

If a farmer has limited resources and cannot afford to take the price and production risk that another farmer might be able to, then he can plant when its the safest time and receive the safest price. The highest net income from the standard planting dates came from okra. This product can bring in an average of \$2,748.00 in net revenue when sold at the Cincinnati terminal market. This income not only comes with a very low freeze risk, but also comes with a low price risk. Its coefficient of variation is 17.51, which puts it in the low risk category.

The standard planting dates for all vegetables seem to be safer concerning price risk. The weekly average prices, based on harvest results from the use of standard planting dates, result in only three crops that are in the high risk category using the coefficient of variation as the indicator. On the other hand, weekly average prices during the prescribed harvest period for the target market strategy

resulted in eight of the nine vegetables being in the high risk category.

F. PRODUCTION RISK IN SEQUENCING DUE TO YIELD LOSS

Another risk that vegetable growers must face with sequential cropping is a production risk associated with growing a vegetable at a time that may be less favorable due to adverse weather conditions. This could occur when a vegetable plant may be damaged but not destroyed. As a result of the damage or unfavorable weather, yields will be reduced. To account for what can happen to a farmer growing a sequence of vegetables that could be affected this way, a reduction in the average yield can help show other possible outcomes. The vegetables that are most likely to have this risk associated with them are the first ones grown in a double sequence, or the first and last ones grown in a triple sequence. The cool season crops are not as likely to be affected as the warm season crops planted in the early part of the year. The crops chosen to demonstrate possible changes in net revenues for sequences are the warm season crops planted at the beginning or end of a sequence. One further stipulation was the crop must also be planted in 75 percent or greater freeze-free time period.

The production level of all the crops that fit this category was reduced by 25 percent. This led to a change in total net revenue due to the change in per unit costs and the change in net revenue per vegetable crop (Table 18).

Some of the sequences identified as possibly being affected by a reduction in yield due to adverse weather in the spring and fall still

Table 18. Gross And Net Returns For Vegetable Sequences With Yield Reduced 25 percent, Knoxville, TN.

Crop	Wholesale Market	Gross Returns	Net Returns
-----Dollars-----			
Beans ^a -Corn-Broccoli	Baltimore	4,865.40	990.82
Tomatoes ^a -Cabbage	Baltimore	8,929.26	1,072.72
Squash ^a -Broccoli	Atlanta	6,012.00	2,108.25
	Baltimore	4,563.00	409.50
	Chicago	5,852.25	1,570.50
	Cincinnati	5,748.75	1,869.75
Peppers ^a -Broccoli	Atlanta	5,206.20	1,495.68
	Baltimore	5,351.73	1,320.12
	Chicago	5,770.29	1,699.20
	Cincinnati	5,789.10	2,018.28
Cucumbers ^a -Broccoli	Atlanta	4,778.50	921.64
	Baltimore	4,738.26	618.27
	Chicago	5,002.47	856.26
	Cincinnati	5,270.13	1,363.43
Beans ^a -Tomatoes ^a	Atlanta ^b	7,689.32	1,526.00
	Baltimore ^c	8,340.42	1,781.38
	Chicago ^b	7,803.38	1,254.68

^a Yield for this crop was reduced by 25 percent. ^b Only Tomatoes were reduced when selling to this market. ^c Both vegetables were reduced.

resulted in positive net returns. The squash-broccoli sequence still resulted in \$2,108.25 at the Atlanta market, even after a 25 percent reduction in the yield level of squash. Without the 25 percent reduction, this sequence had an average income of over \$2,900.00.

Although the decrease in production for some vegetables in a sequence did not cause the sequence to have a negative net return, it did have that effect on several of the individual crops. In these cases it would be more reasonable for farmers to look at their own situation and decide what

their average yield would be if they grew in these unfavorable time periods.

CHAPTER V

IMPLICATIONS AND CLOSING REMARKS

A. IMPLICATIONS

When determining whether or not vegetable growing in Tennessee can be considered a possible alternative to other agronomic crops several things must be taken into consideration. One consideration is the consistency of yearly net returns. According to the price data in this study, average weekly prices are above estimated production costs. The enterprise budgets published by the University of Tennessee Extension Service, which assume the use of good management skills, were used in this analysis. Individual farmer's skill levels will vary. A strong assumption in this study was that the farmer has the ability to grow the crop and produce the average yield of high quality produce specified in these budgets. Another assumption was that farmers would be skilled at marketing their produce.

The traditional way of growing crops involves planting during a time period that the farmer feels will allow plant growth at the risk level he perceives to be reasonable. The information in this study should be useful to farmers because of the comparison of net revenues obtained from following "standard" planting dates versus planting at a time to harvest during a targeted market window or planting two or three vegetables in sequence during one growing season.

Vegetable growers should be aware of the price variation of vegetables during their harvesting period. They can look at the average prices and standard deviation of vegetables during the identified harvest period. The average price demonstrates to the growers the possible benefits of producing for a target market. One other thing the market window portion of the study demonstrated was the price risk associated with the average prices. The larger the standard deviation, the more risk associated with the price. The vegetable farmer needs to recognize that the wholesale price fluctuates greatly during a season. Even though the 11-year average price may be attractive, the variability could result in a loss for many of the years.

The second thing that would be beneficial for the vegetable farmers to see is the income generated by the target harvesting as opposed to the income from planting at "standard" planting dates. The target harvesting showed potential for increased incomes when compared with net returns from use of standard planting dates. Ranking of risk is provided by the price coefficient of variation this is a comparison of any of the crops whether they are produced for target markets or produced following standard harvesting dates. It provides additional insight to a grower regarding the level of risk being accepted with respect to price.

The final phase of this study demonstrated how sequential cropping could affect the income of a vegetable farmer. This would logically seem to have more significance for the farmers with limited land resources because they could make more complete use of this resource. The land owners that have idle land could also look at sequential cropping if they have other uses for the rest of their land, or prefer to concentrate on

one crop at a time. Sequential cropping showed a benefit in terms of total net income from sequencing of crops. The largest net income per acre in the study came from a sequentially planted set of crops. This result is not quite as obvious as it may seem. Some people might think that just because a farmer is planting three crops that he should make more money than if he plants just one, but this is not always the case. With the wide variation in average prices for vegetables from week to week, a farmer can make money if he harvests one week and lose money if he was to harvest the following week. So when a farmer plants in a sequence, the harvest options are limited to what the growing sequence will allow. When sequencing crops he may be able to "hit" one of the two or three crops at its highest point in price, but harvest another at a low point. This might mean that he could lose money on one of his crops but make money on the others. The sequence selection is important to all farmers because some may be less able to accept low or negative returns during any one production year. A financially secure grower may be willing to accept the risk in anticipation of reaping potentially high returns. The farmer who has plenty of land and other limited resources may not benefit from sequential cropping as much because there is probably no sequence that would allow him to receive the highest price per acre on each crop during his potential harvest period. When a farmer has plenty of land and other limited resources he could target every crop he wants to grow for a harvest period with the historically highest average price.

Along with all the facts that this study brought to the attention of the Tennessee farmer, it also brought out other possible options a farmer might use to further increase income. This additional marketing option

requires some new assumptions. One of the assumptions made when calculating the net returns to farmers for the cropping sequences was that the farmer must ship all of the crops to one terminal market. Differences in prices between terminal markets during the same time periods could allow the farmer to decide whether or not it is worth the extra effort to ship each vegetable of the sequence to the highest paying market. For the farmer to ship to more than one terminal market, he must have the ability to deal with several different brokers and be able to transport to the separate locations. Examination of the price data should assist the farmer in estimating, given a specific production level for each crop, average net income for selected markets. The absolute value of the estimated net returns to the various planting scenarios examined in this study are not as important as the relative differences between the specified alternatives.

B. LIMITATIONS

As with any research, there are limitations to this work. One of the most important limitations of this research is that average prices are being used to estimate net incomes. The average price is not able to show how many years a farmer may or may not reach the average price. Another limitation is that the production costs in this study are fixed. In actuality production costs are not fixed, and neither are input prices during the growing season. This study is able to show what the differences in income could be between different crops and sequences, because the same techniques are being applied to all crops and sequences.

C. FUTURE RESEARCH

For future projects focusing on the profitability of vegetable production, several issues could be examined. First, instead of using average prices to determine net returns, a stochastic component could be added to give more realistic outcomes for the estimated net income a farmer might receive. Along with fluctuating weekly prices, a random weather variable could be introduced. The random weather variable could show the farmer the risk he is accepting if he plants his vegetables on a particular day. Another issue that might be examined is fluctuations in production costs during one year and from year to year.

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APPENDIX

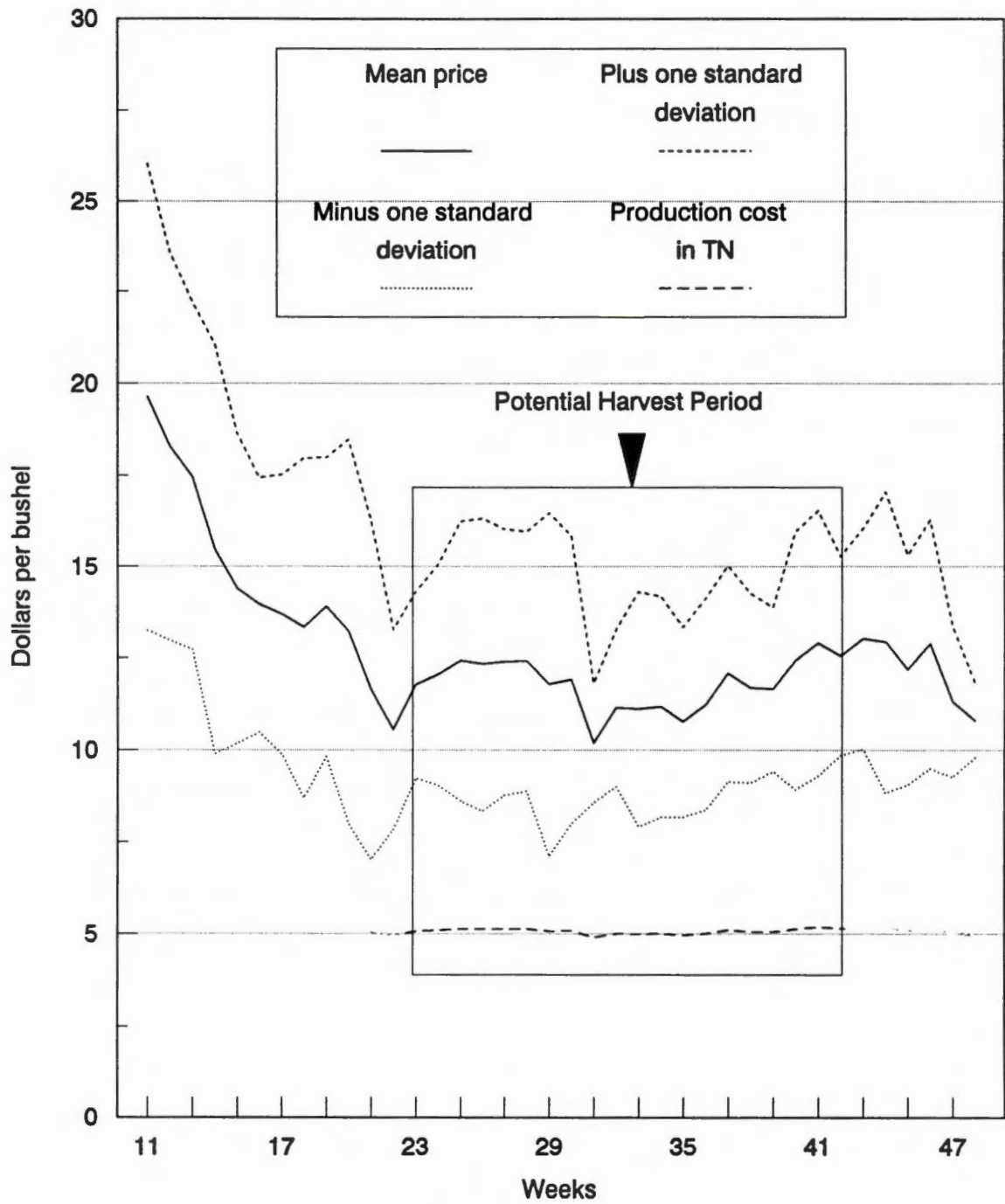


Figure 1. - Snapbeans: Atlanta, GA, Average
Wholesale Market Price, 1979-1989.

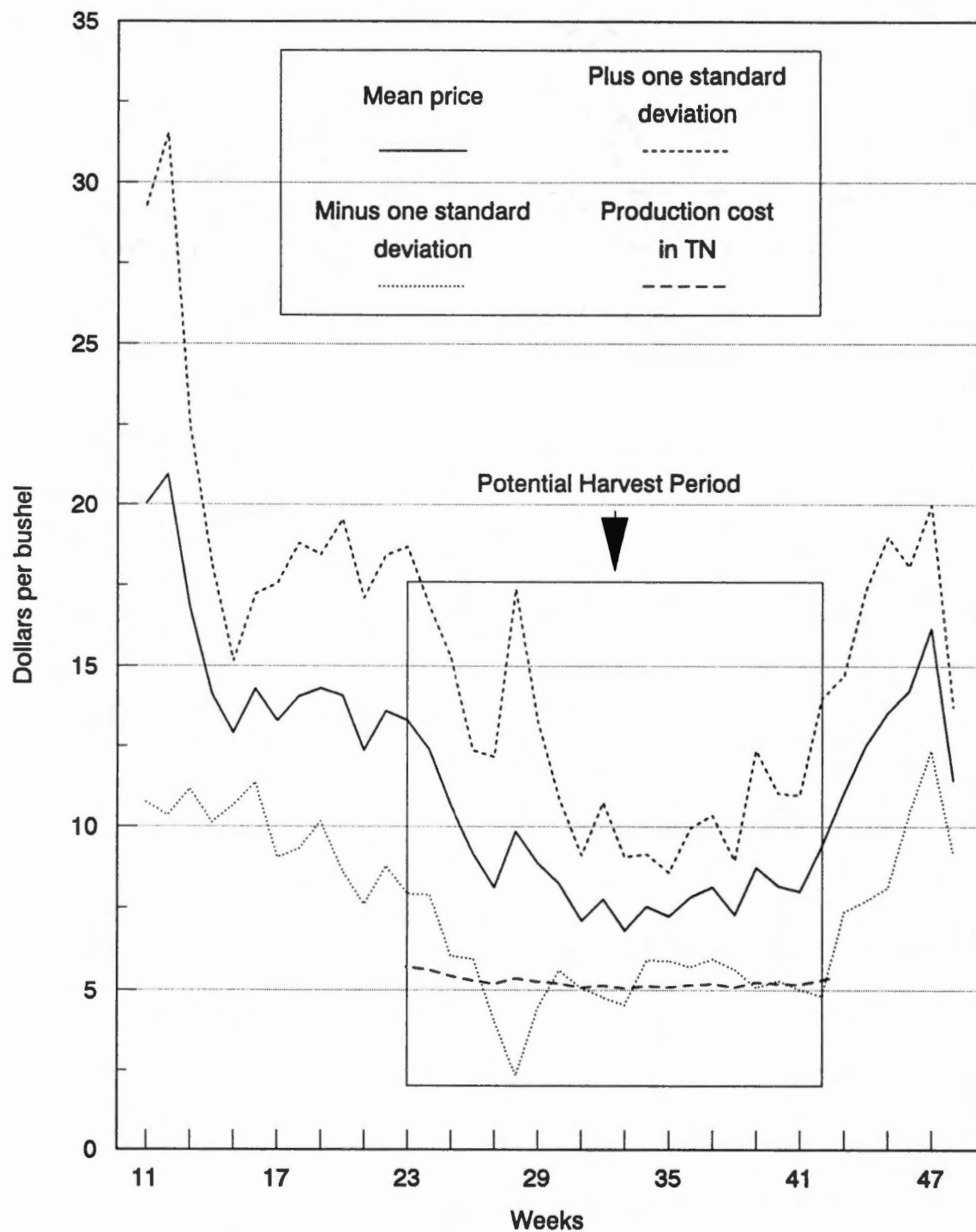


Figure 2. - Snapbeans: Baltimore, MD, Average
Wholesale Market Price, 1979-1989.

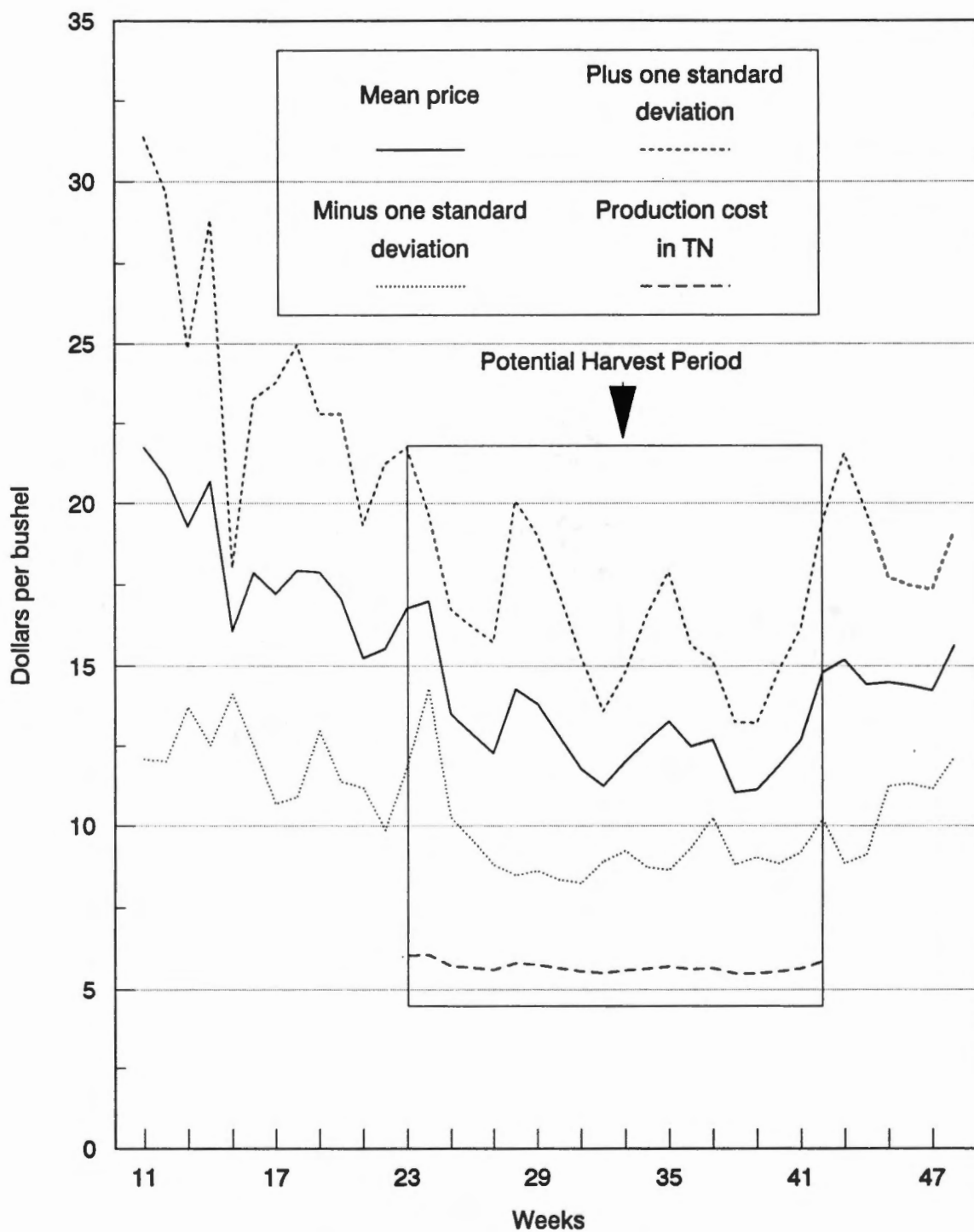


Figure 3. - Snapbeans: Chicago, IL, Average

Wholesale Market Price, 1979-1989

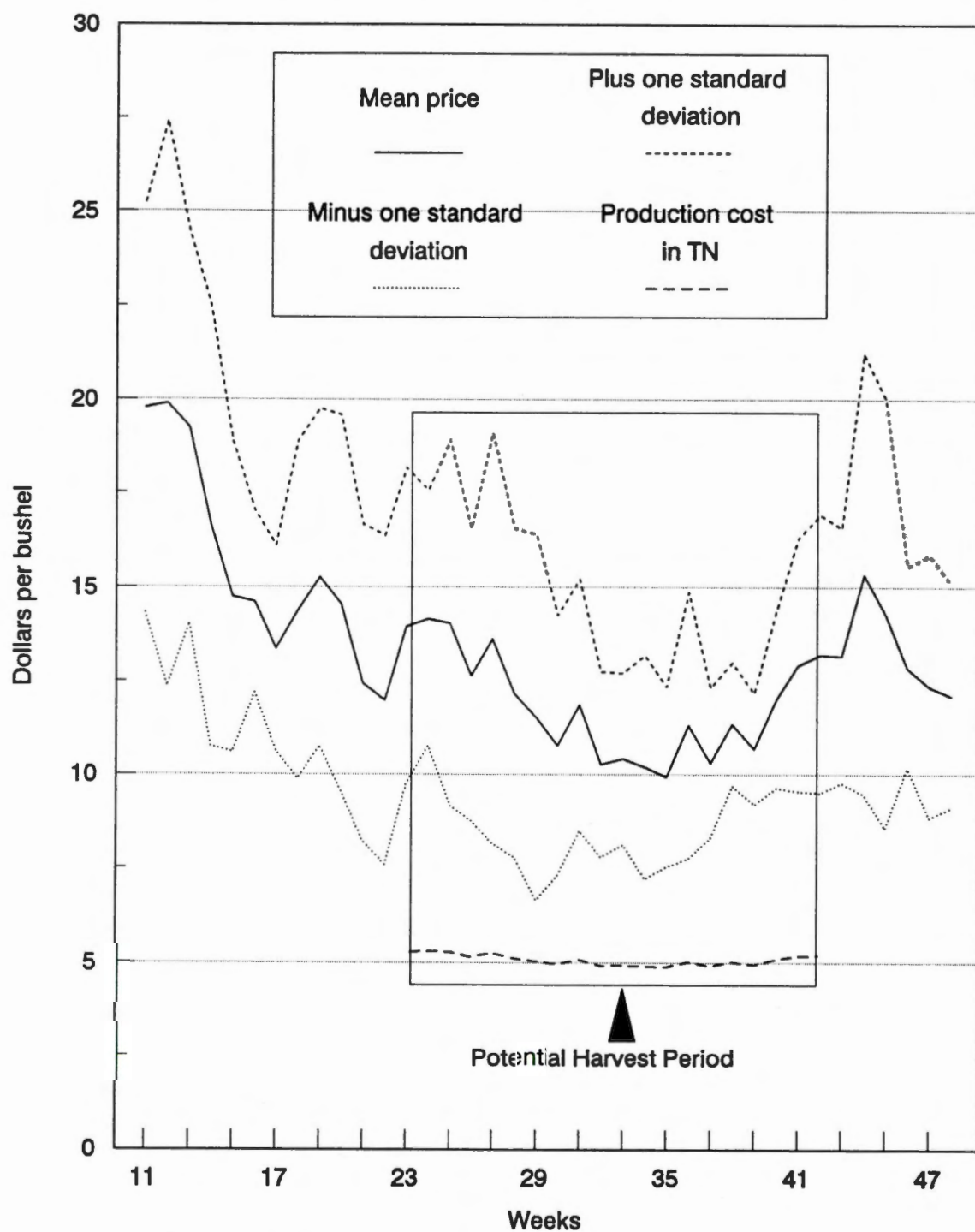


Figure 4. - Snapbeans: Cincinnati, OH, Average
Wholesale Market Price, 1979-1989.

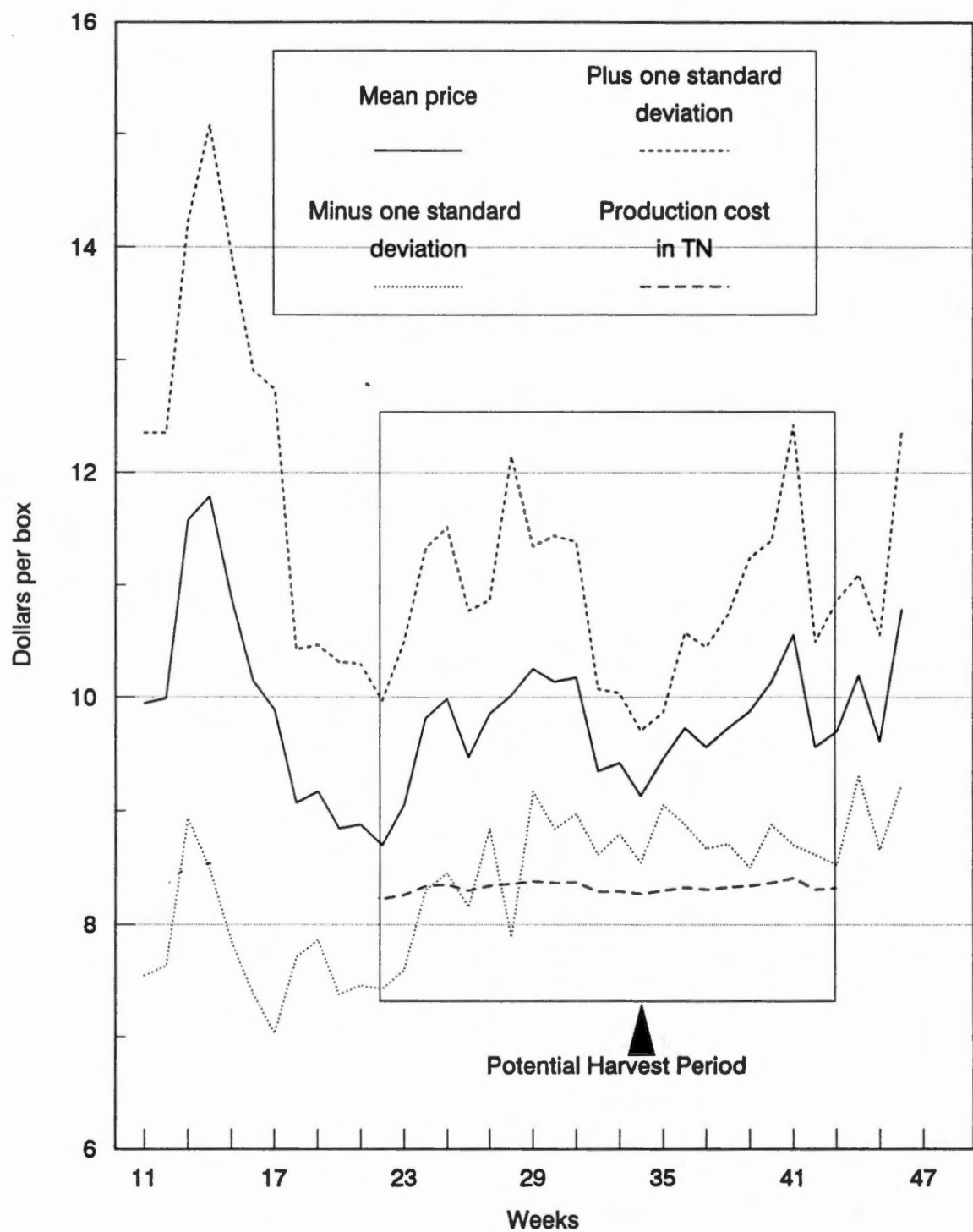


Figure 5. - Broccoli: Atlanta, GA, Average
Wholesale Market Price, 1979-1989.

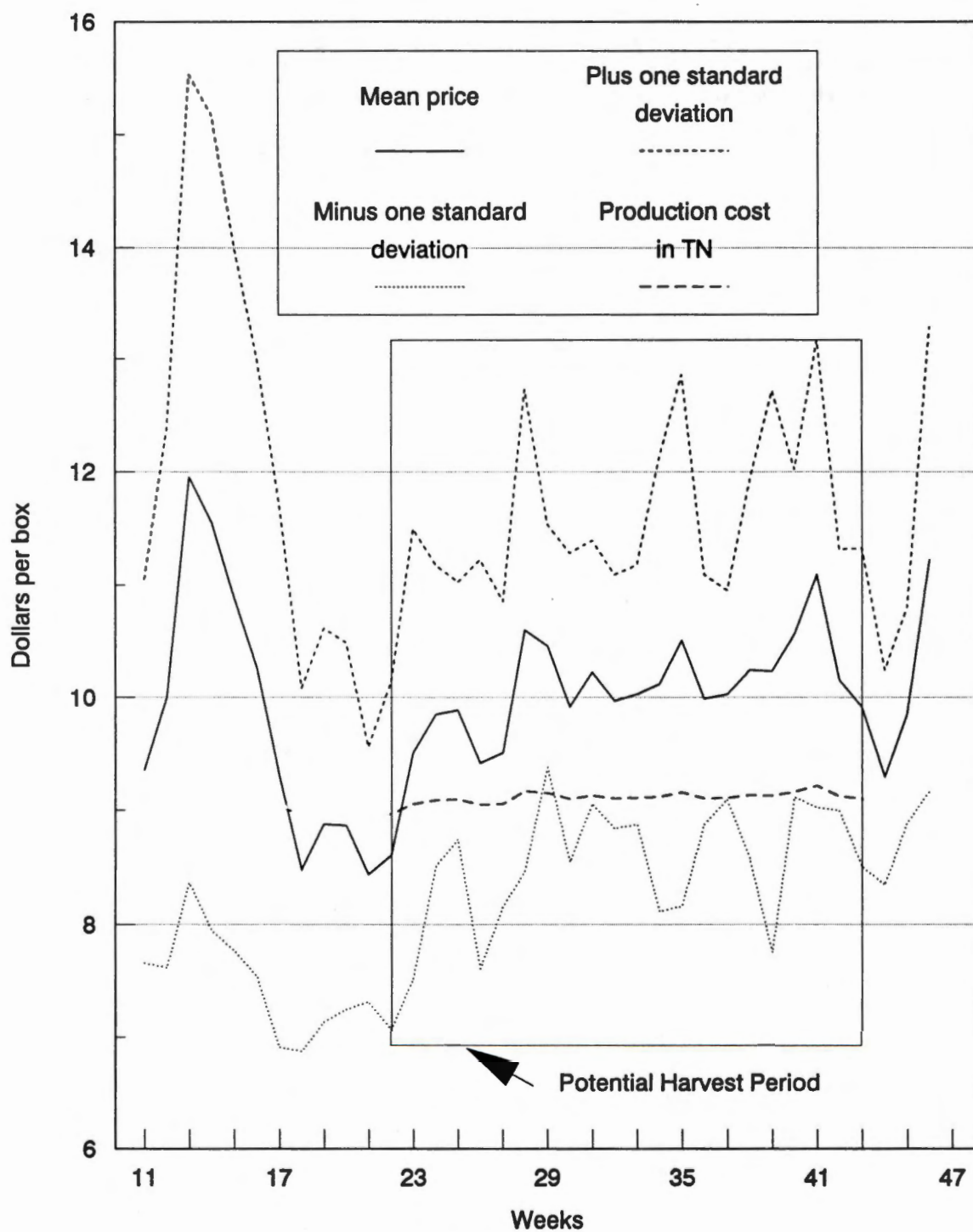


Figure 6. - Broccoli: Baltimore, MD, Average
Wholesale Market Price, 1979-1989.

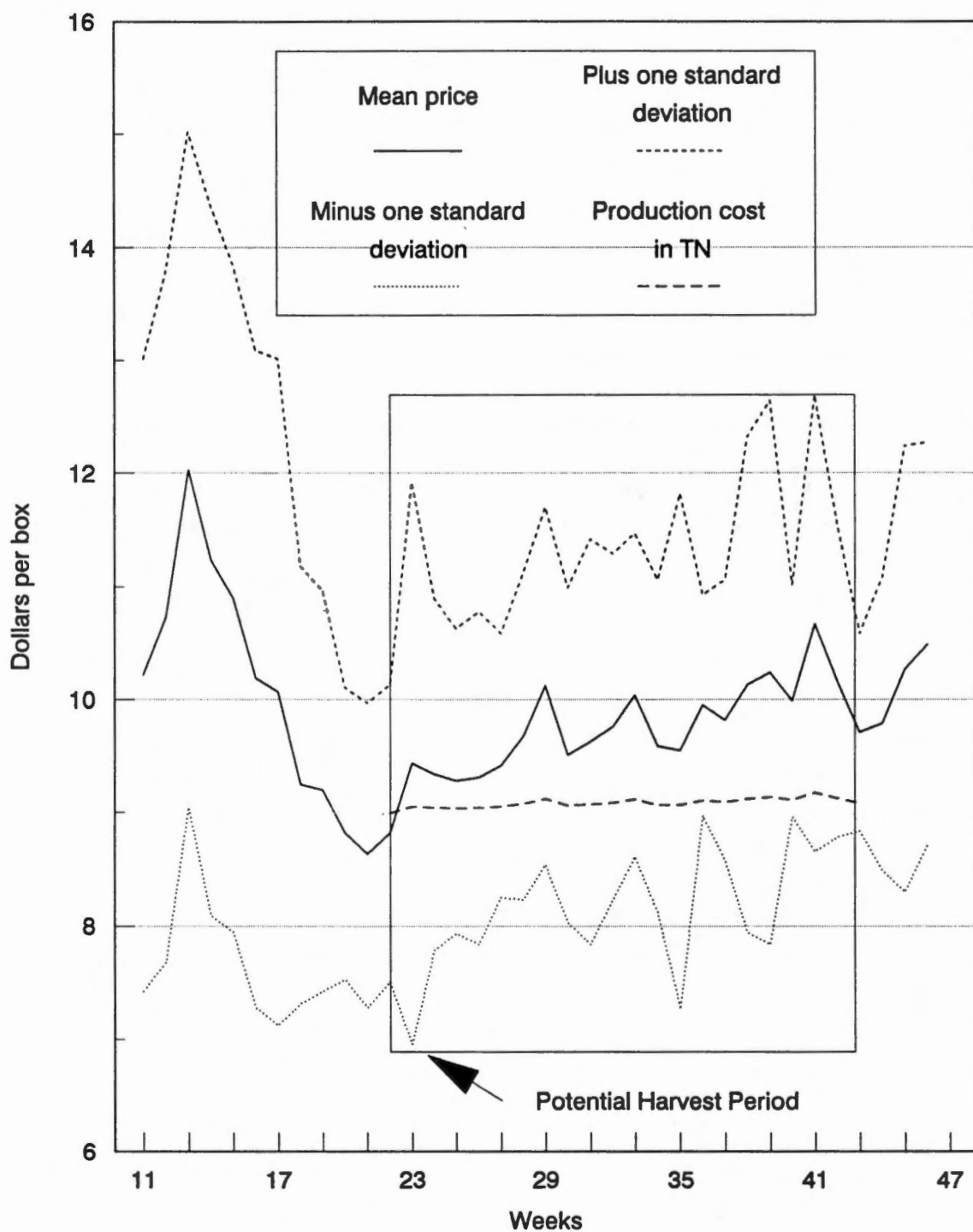


Figure 7. - Broccoli: Chicago, IL, Average
Wholesale Market Price, 1979-1989.

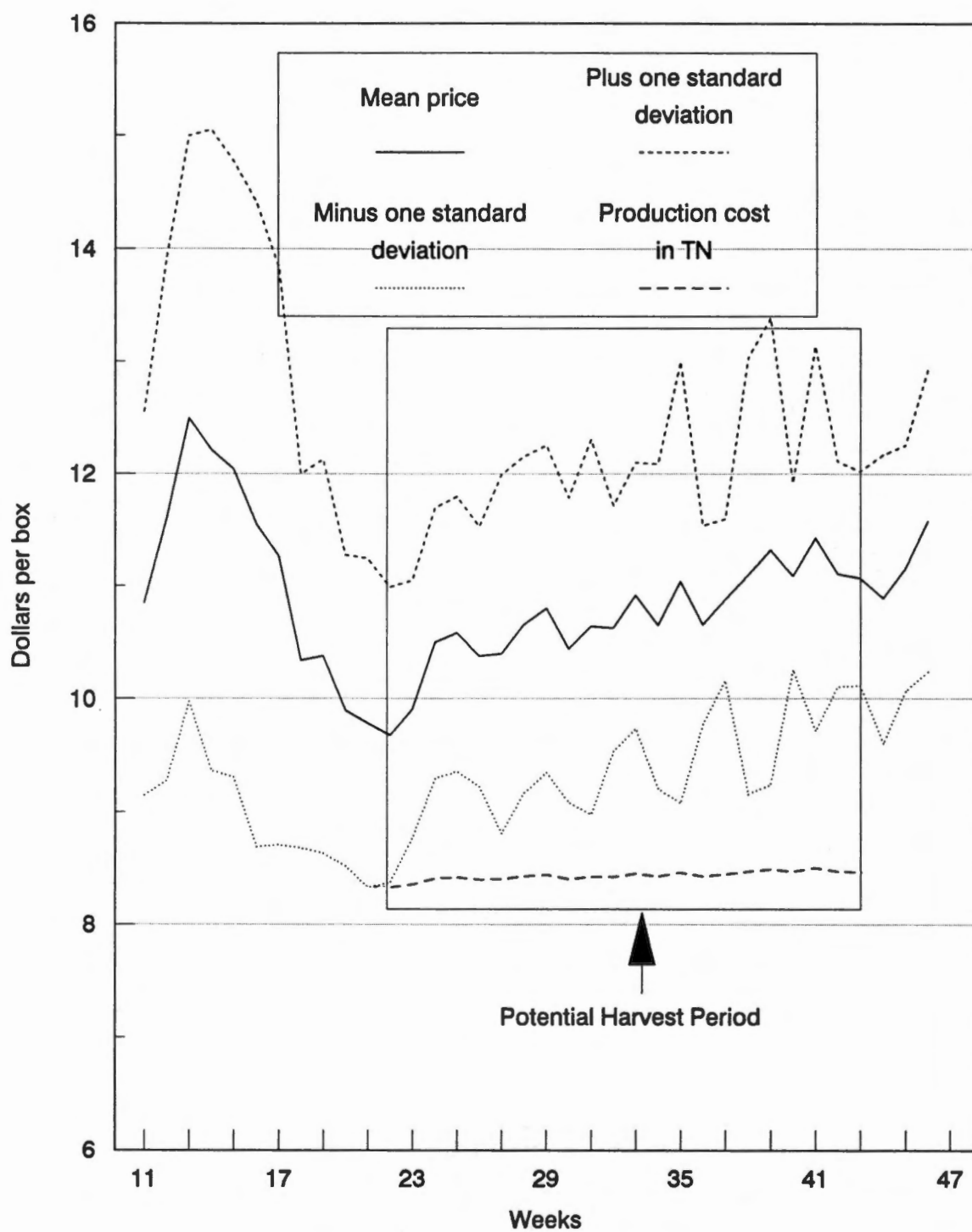


Figure 8. - Broccoli: Cincinnati, OH, Average
Wholesale Market Price, 1979-1989.

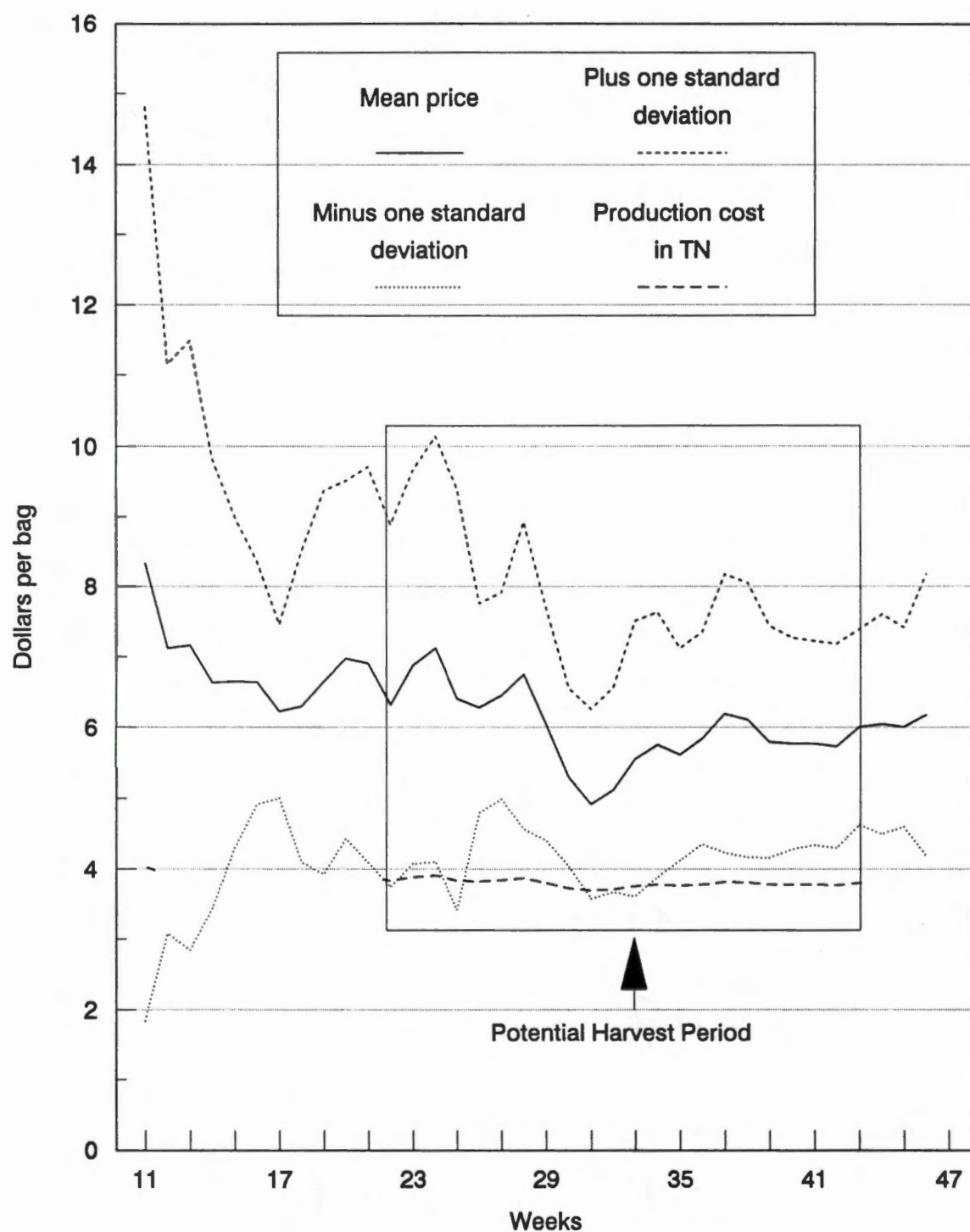


Figure 9. - Cabbage: Atlanta, GA, Average
Wholesale Market Price, 1979-1989.

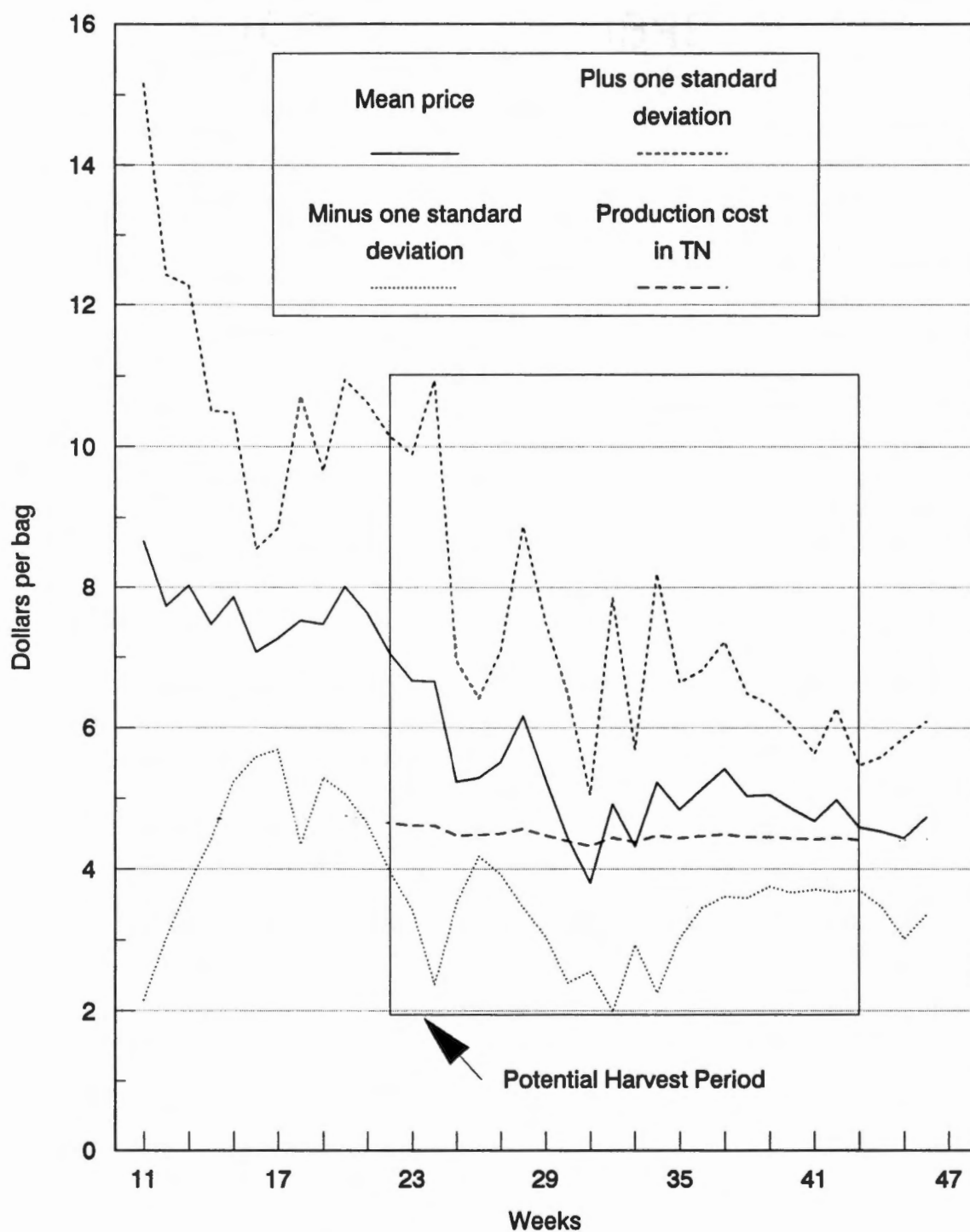


Figure 10. - Cabbage: Baltimore, MD, Average
Wholesale Market Price, 1979-1989.

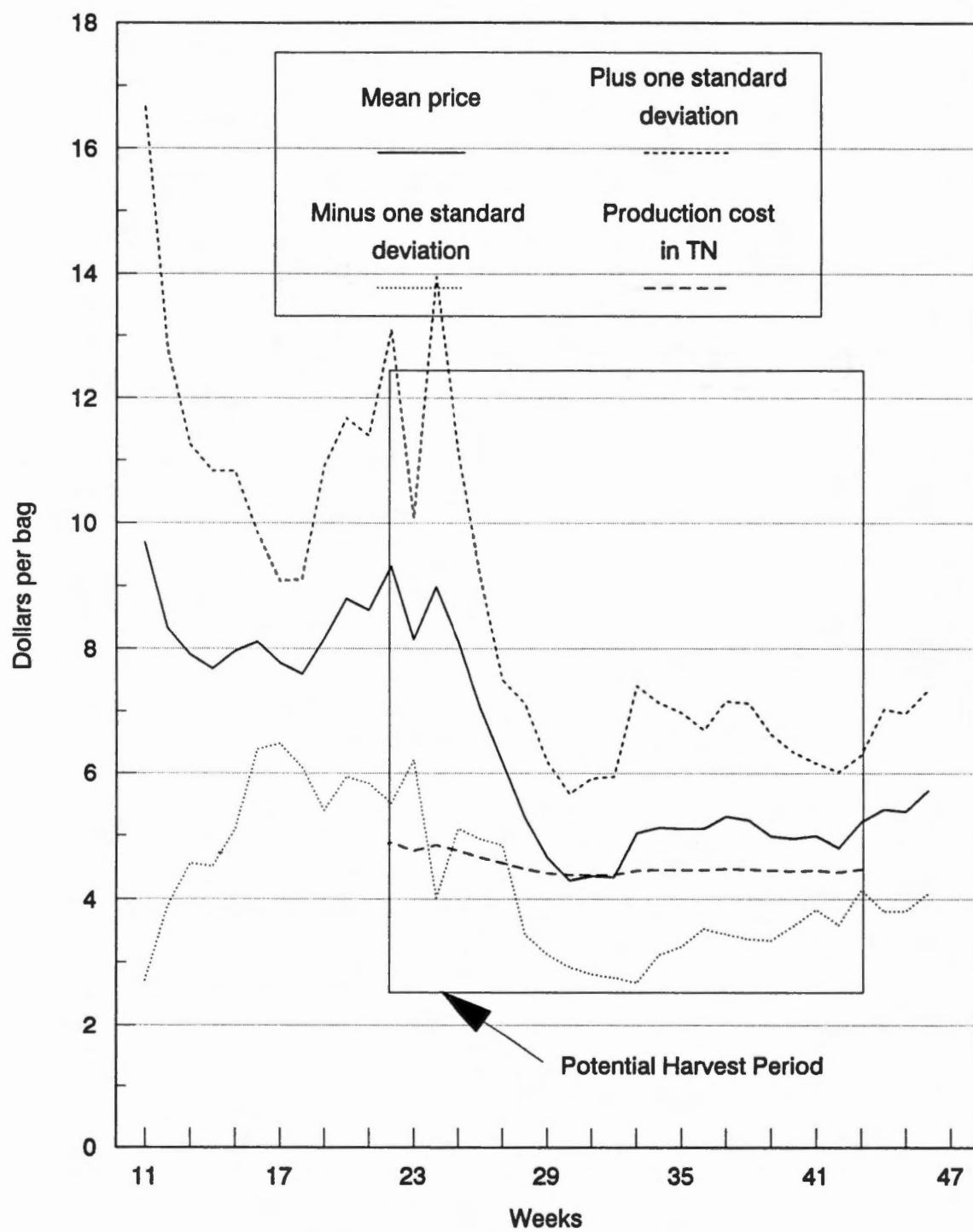


Figure 11. - Cabbage: Chicago, IL, Average
Wholesale Market Price, 1979-1989.

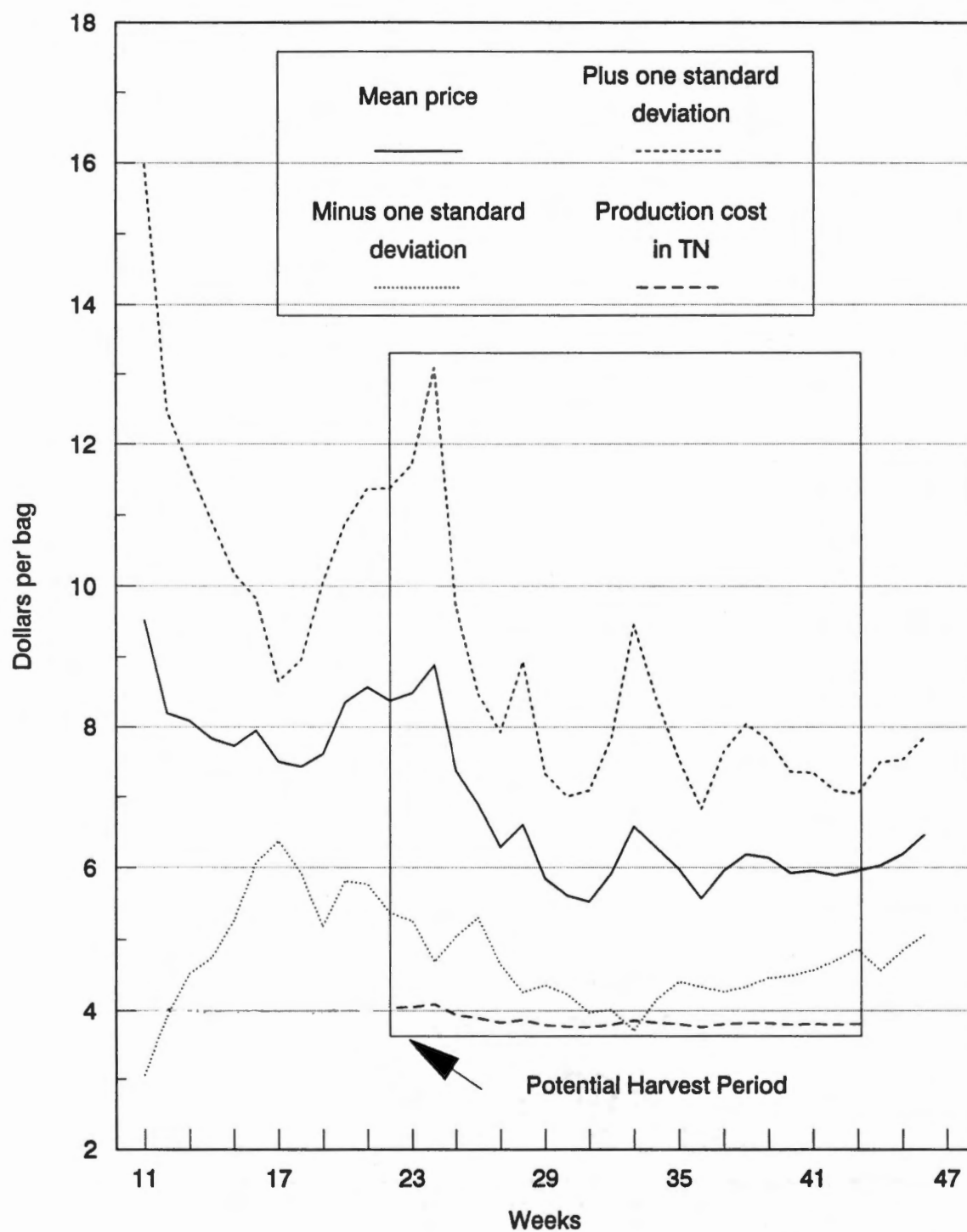


Figure 12. - Cabbage: Cincinnati, OH, Average
Wholesale Market Price, 1979-1989.

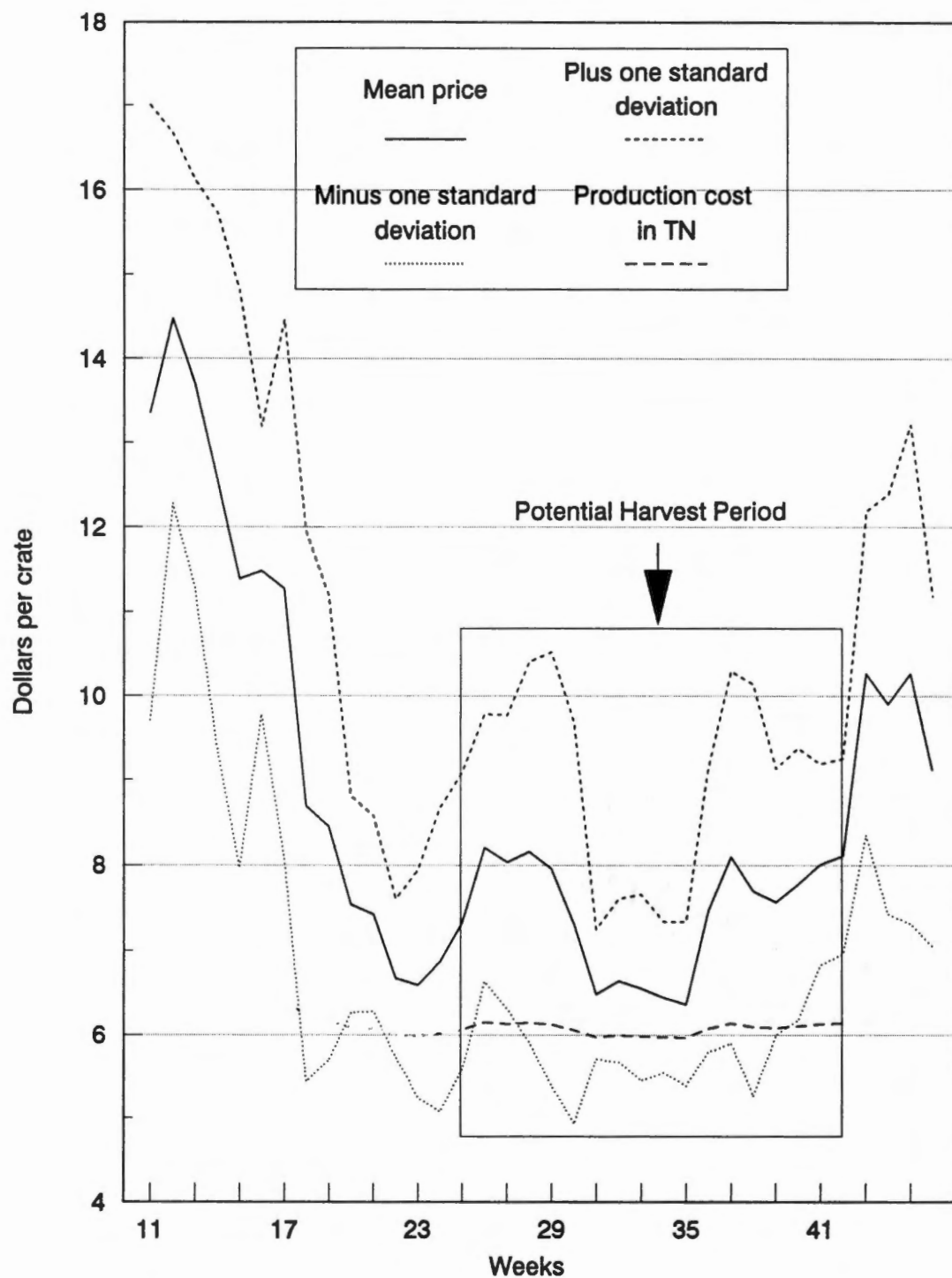


Figure 13. - Sweet Corn: Atlanta, GA, Average
Wholesale Market Price, 1979-1989.

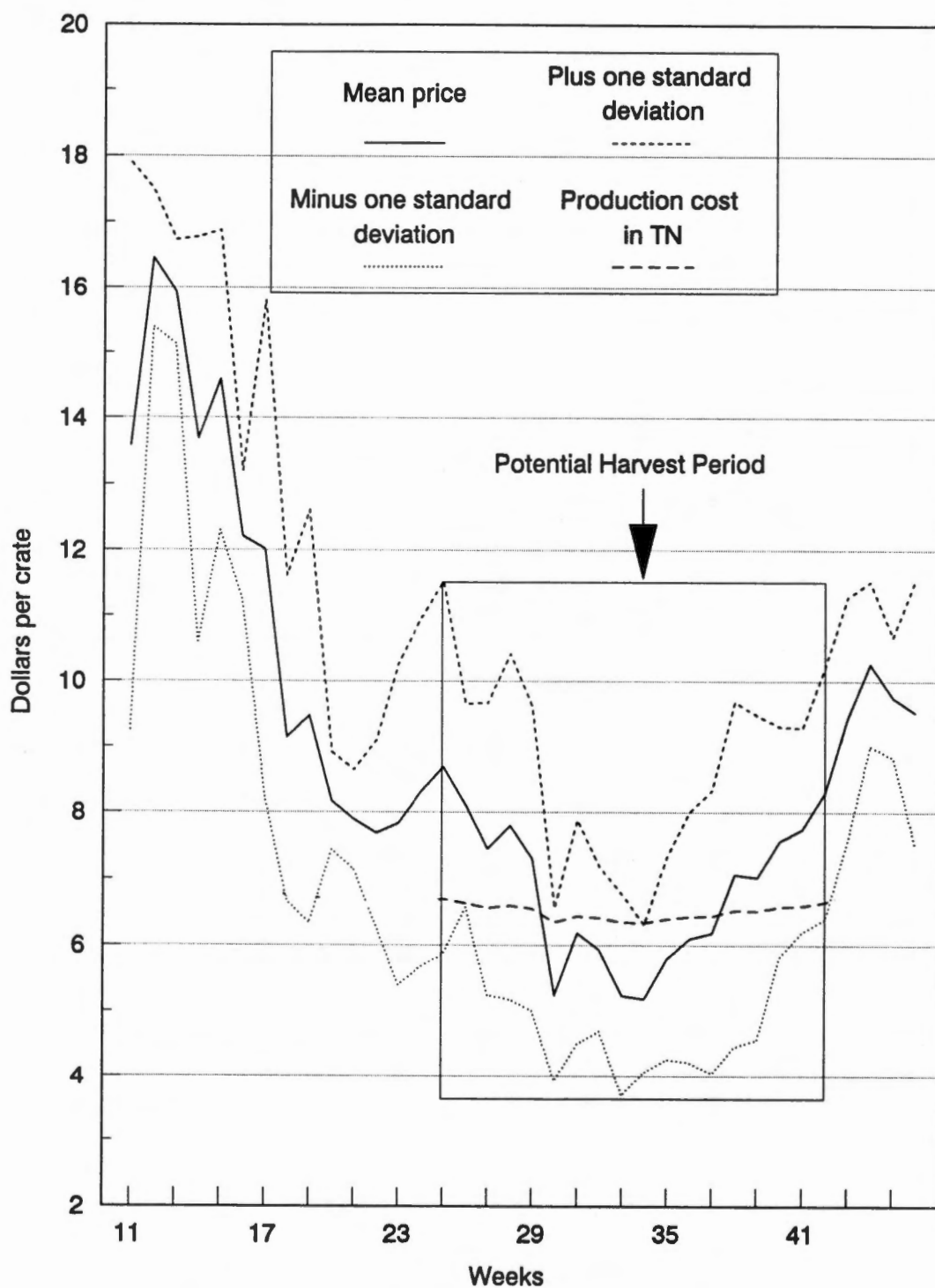


Figure 14. - Sweet Corn: Baltimore, MD, Average
Wholesale Market Price, 1979-1989.

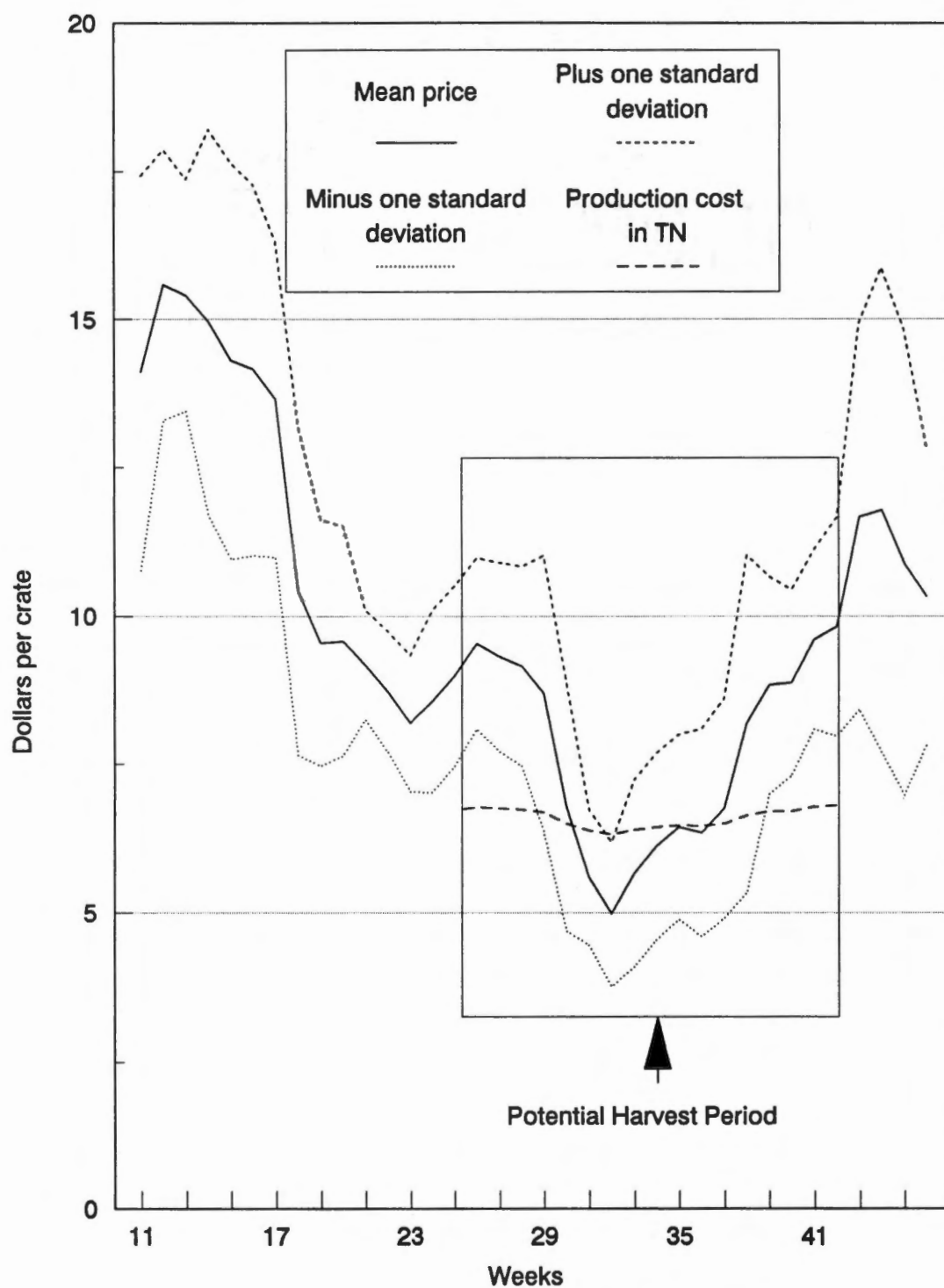


Figure 15. - Sweet Corn: Chicago, IL, Average
Wholesale Market Price, 1979-1989.

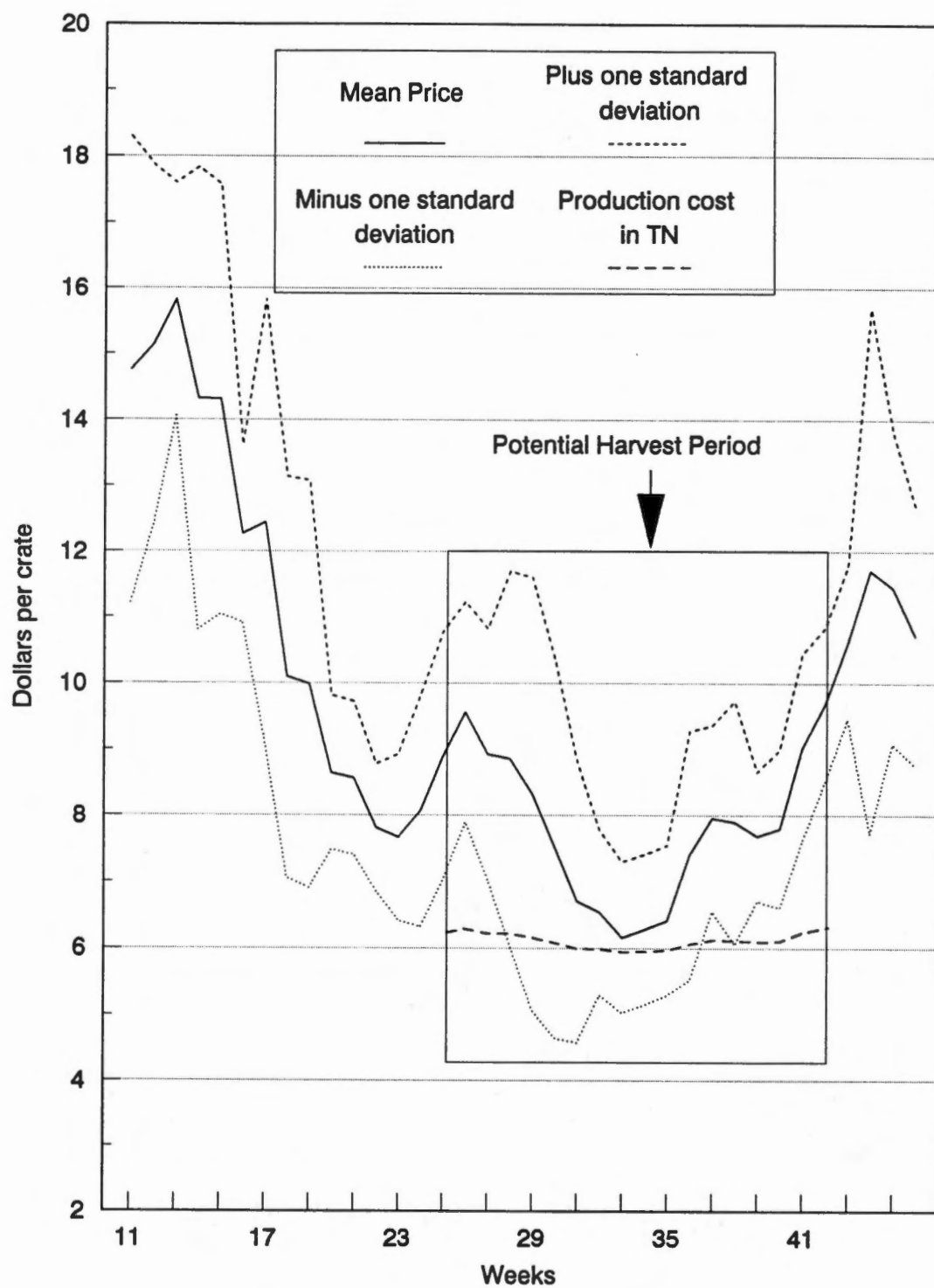


Figure 16. - Sweet Corn: Cincinnati, OH, Average
Wholesale Market Price, 1979-1989.

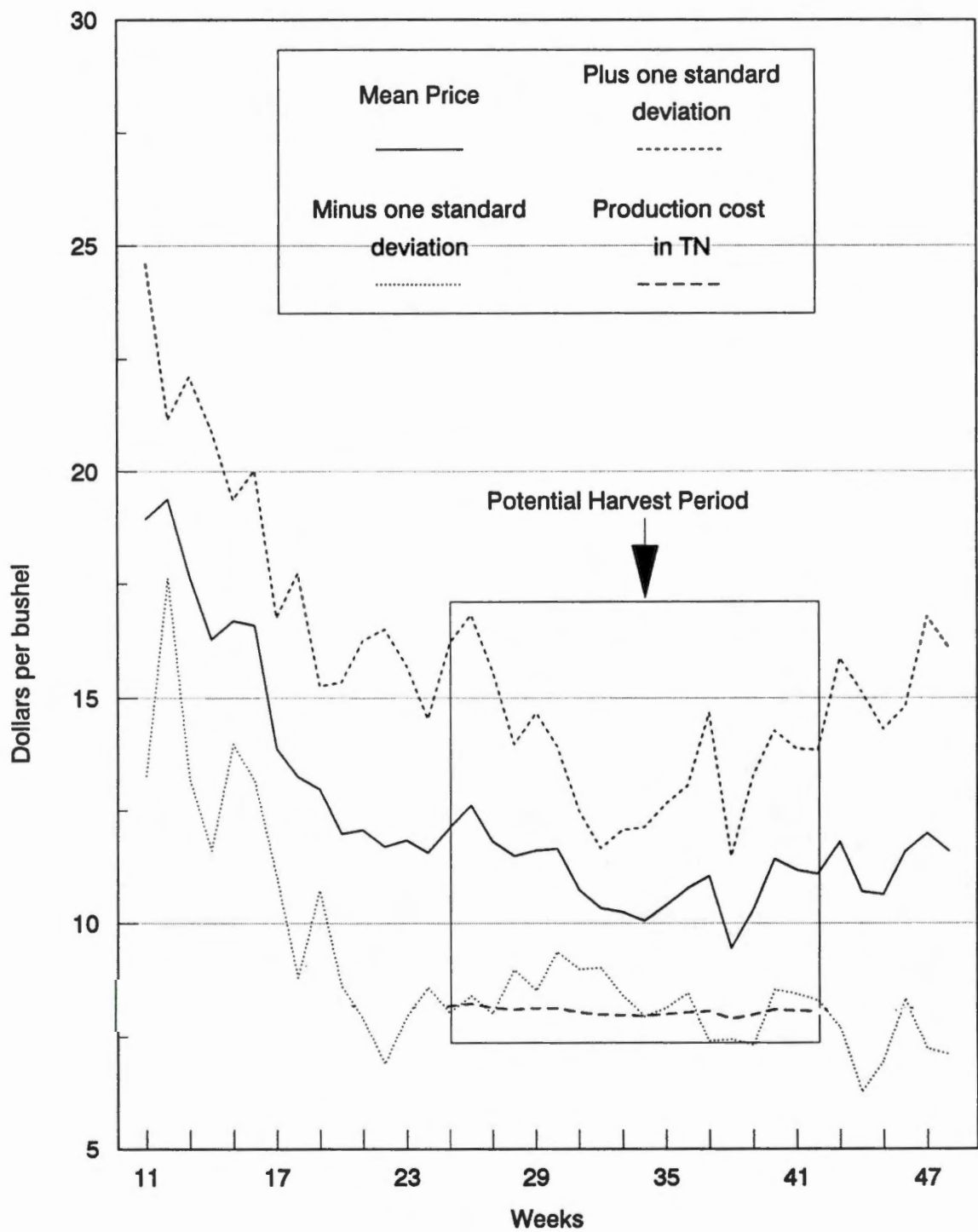


Figure 17. - Cucumbers: Atlanta, GA, Average
Wholesale Market Price, 1979-1989.

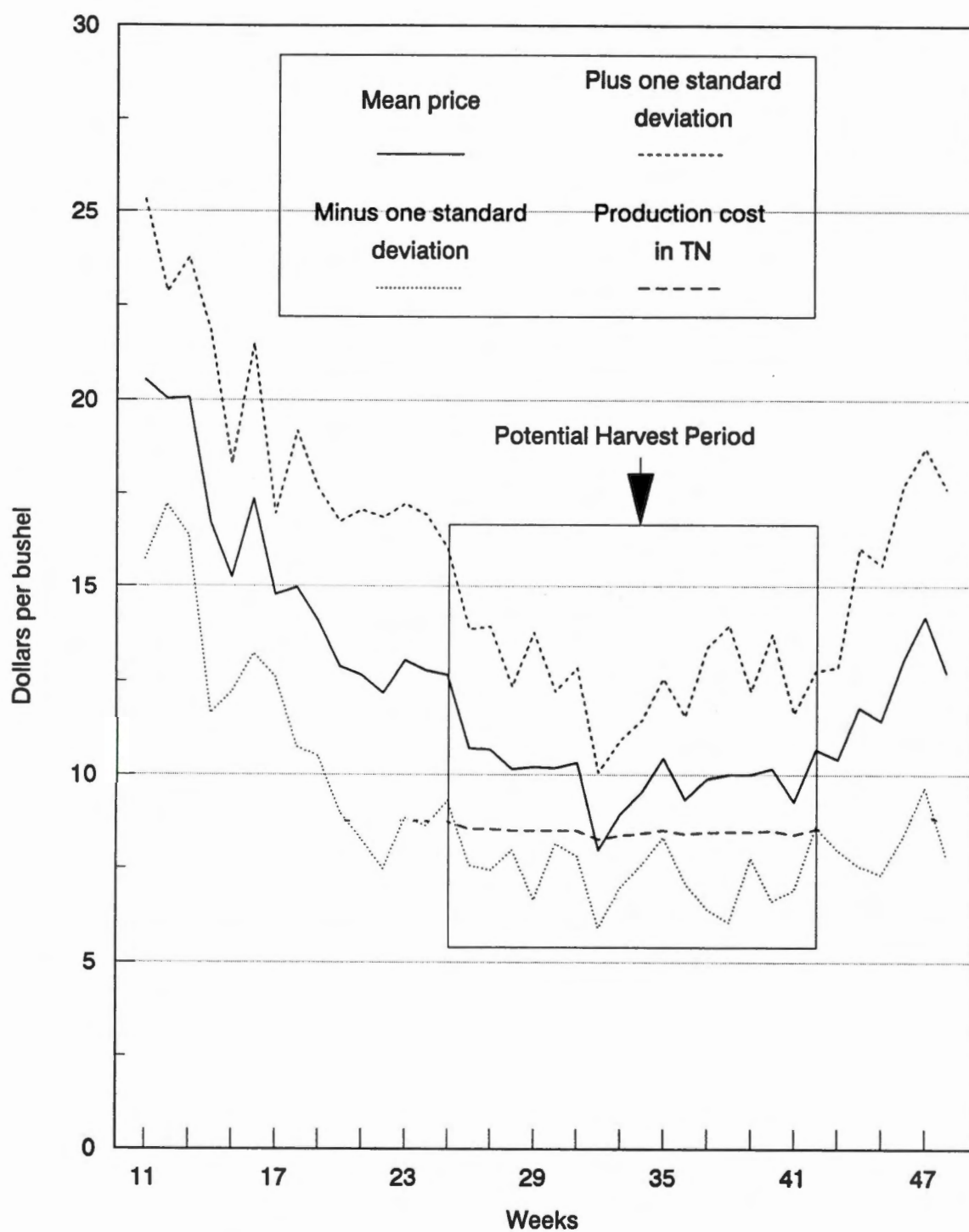


Figure 18. - Cucumbers: Baltimore, MD, Average
Wholesale Market Price, 1979-1989.

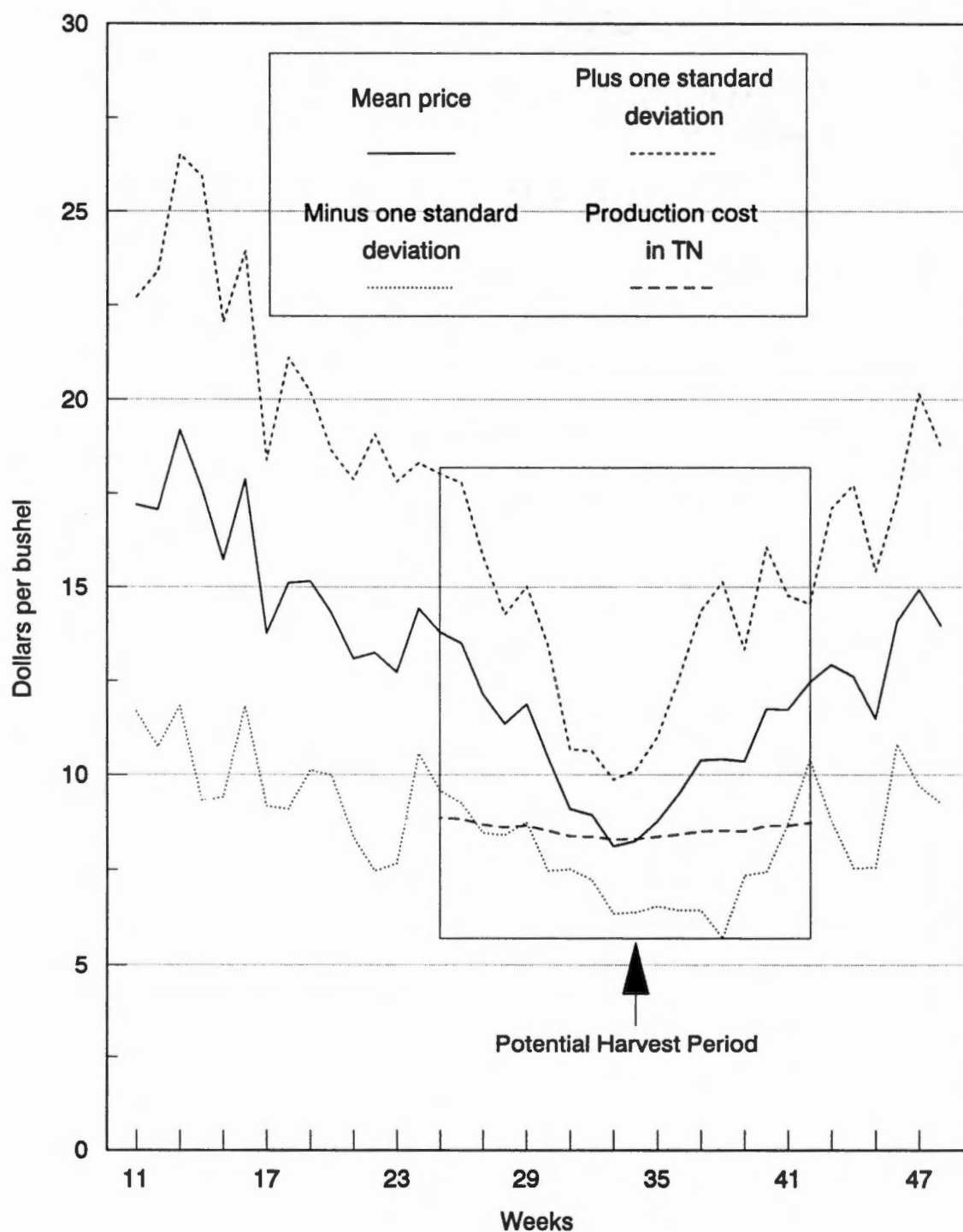


Figure 19. - Cucumbers: Chicago, IL, Average
Wholesale Market Price, 1979-1989.

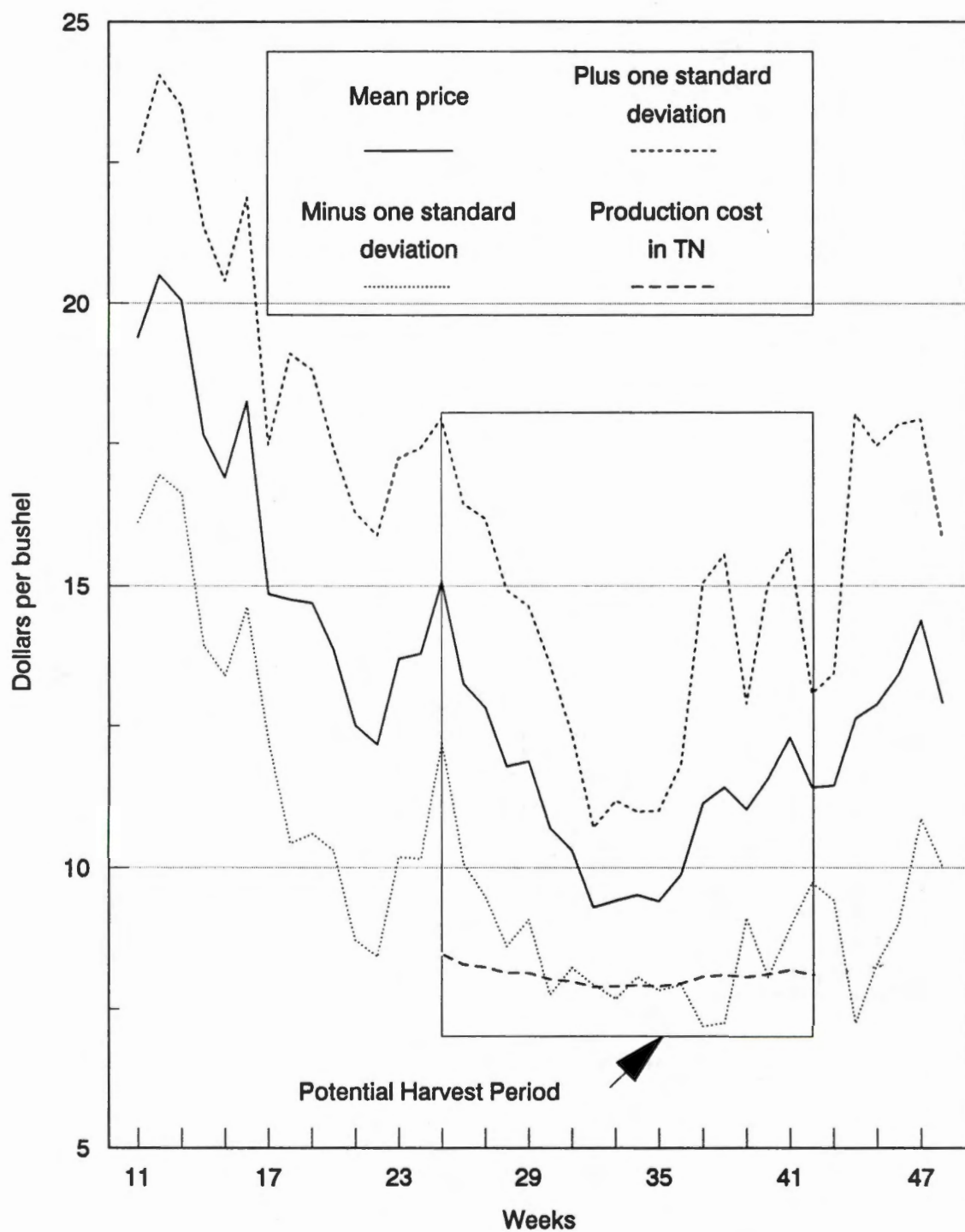


Figure 20. - Cucumbers: Cincinnati, OH, Average
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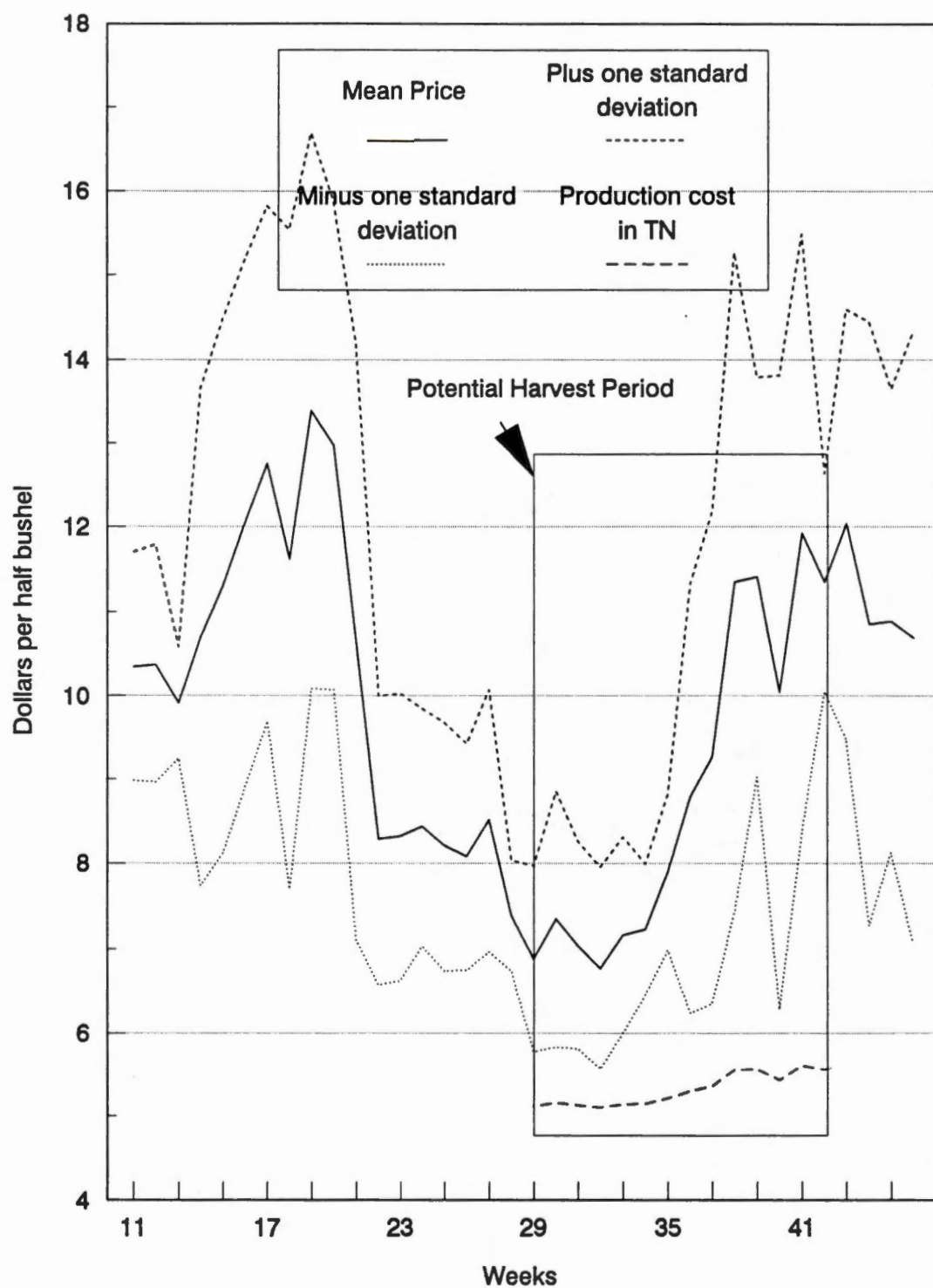


Figure 21. - Okra: Atlanta, GA, Average

Wholesale Market Price, 1979-1989.

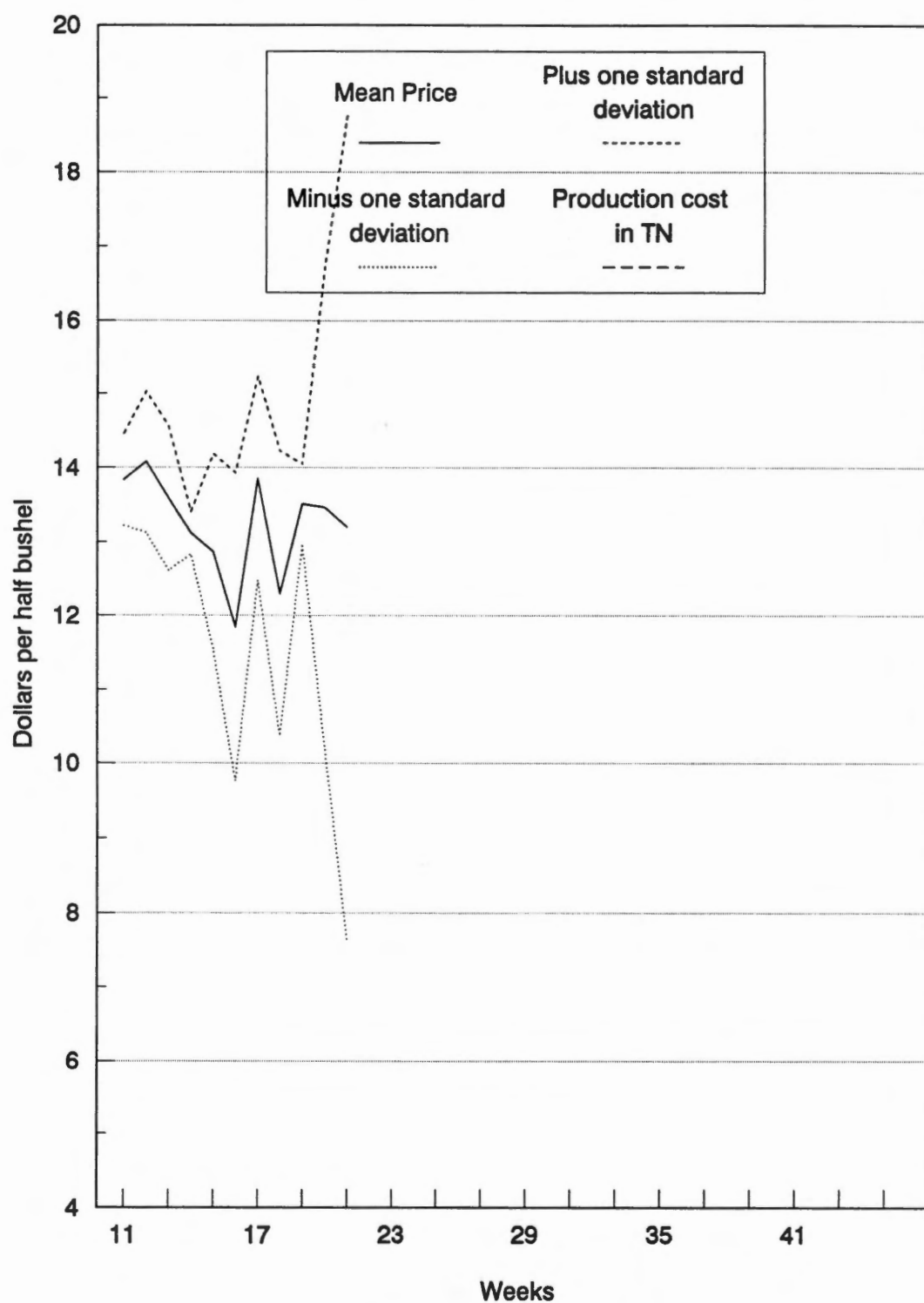


Figure 22. - Okra: Baltimore, MD, Average
Wholesale Market Price, 1979-1989.

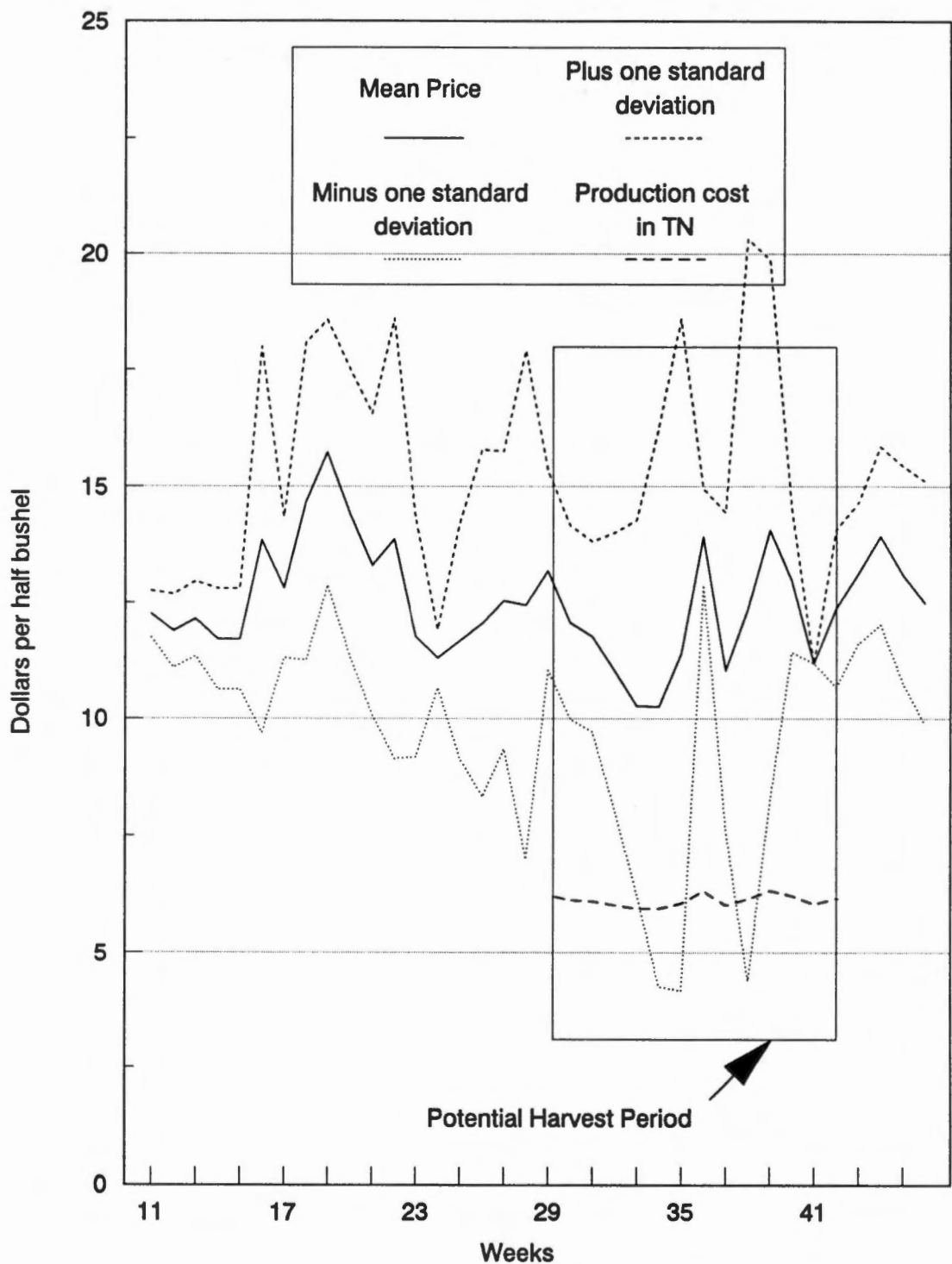


Figure 23. - Okra: Chicago, IL, Average
Wholesale Market Price, 1979-1989.

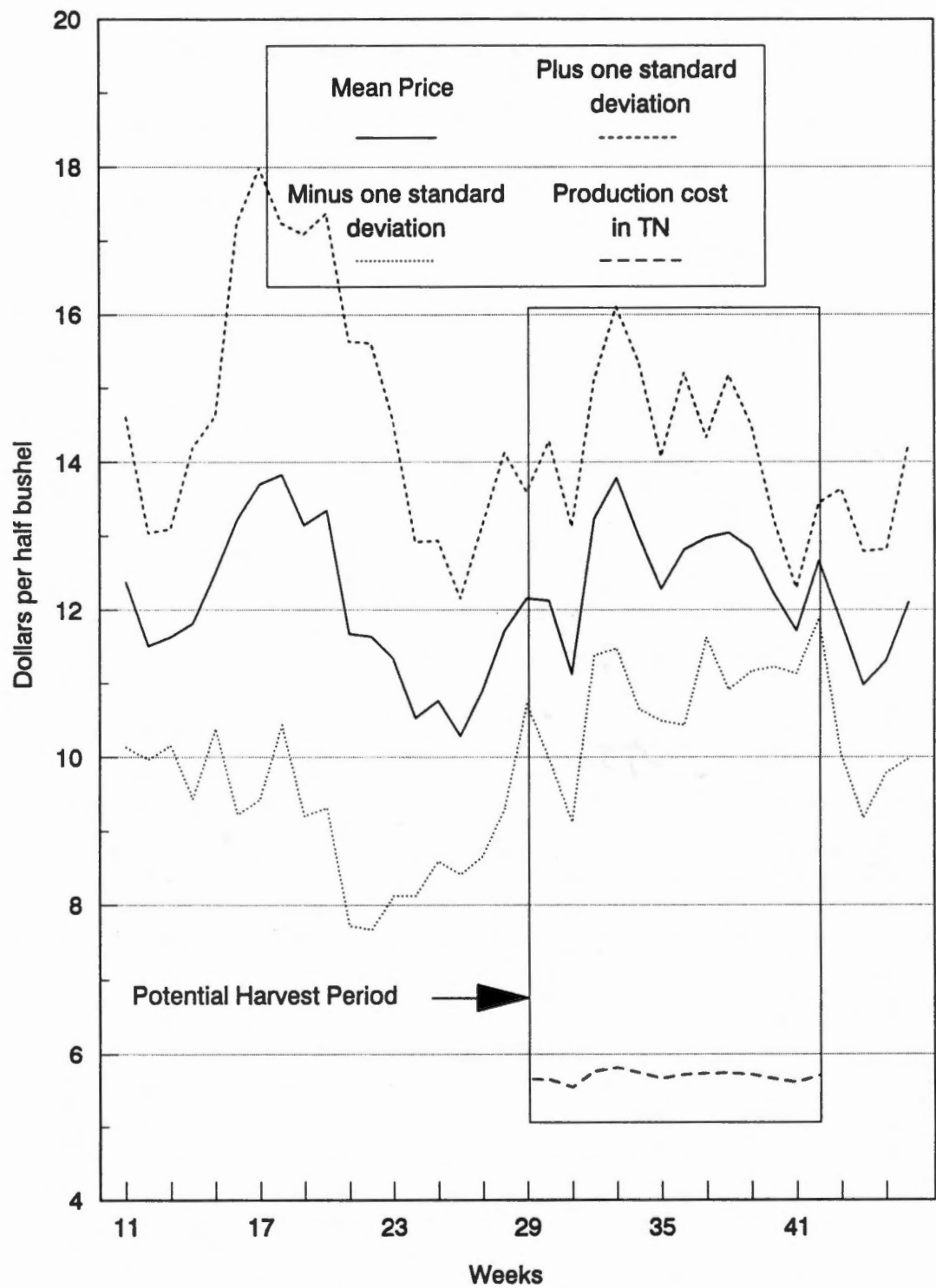


Figure 24. - Okra: Cincinnati, OH, Average
Wholesale Market Price, 1979-1989.

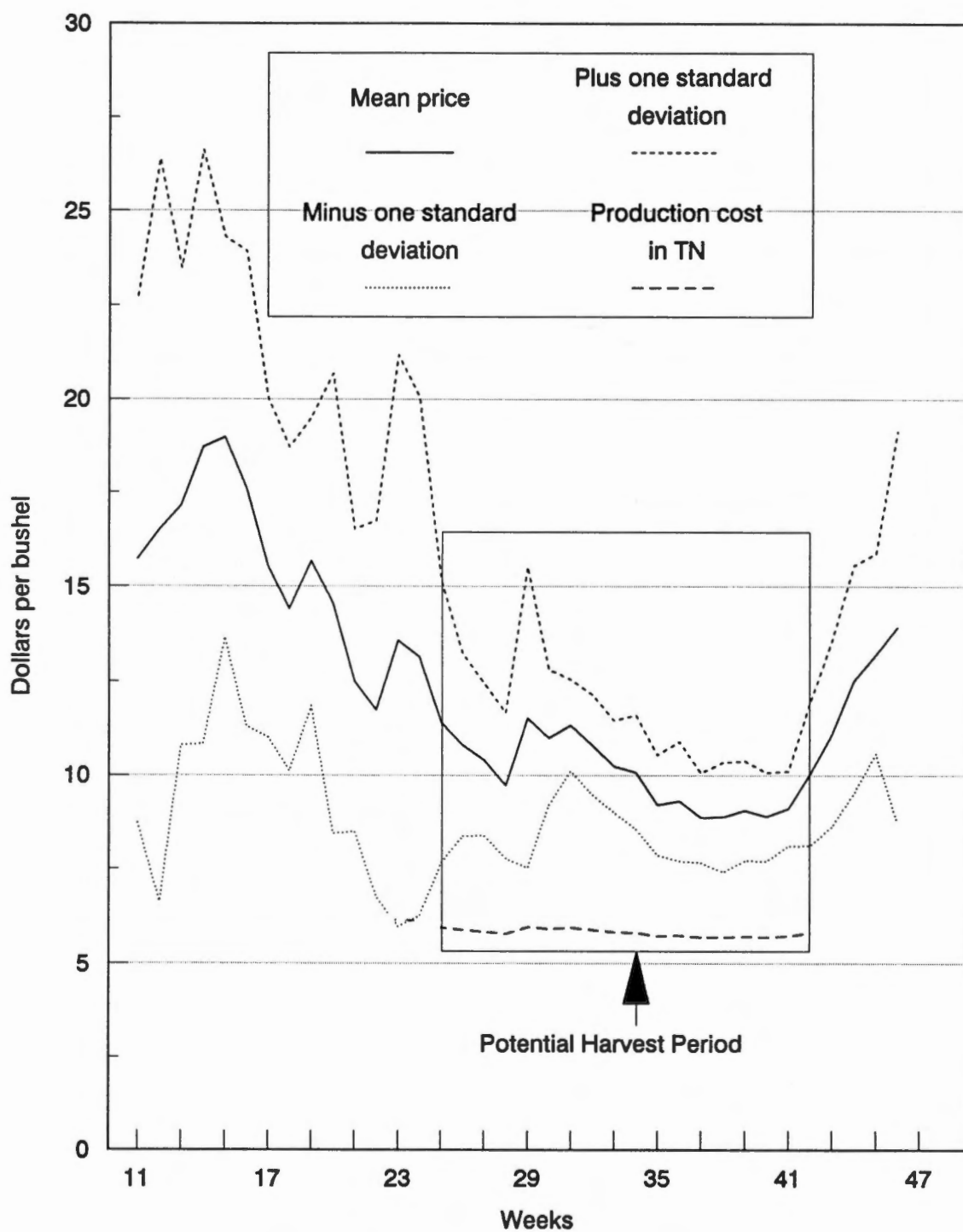


Figure 25. - Green Peppers: Atlanta, GA,
Average Wholesale Market Price, 1979-1989.

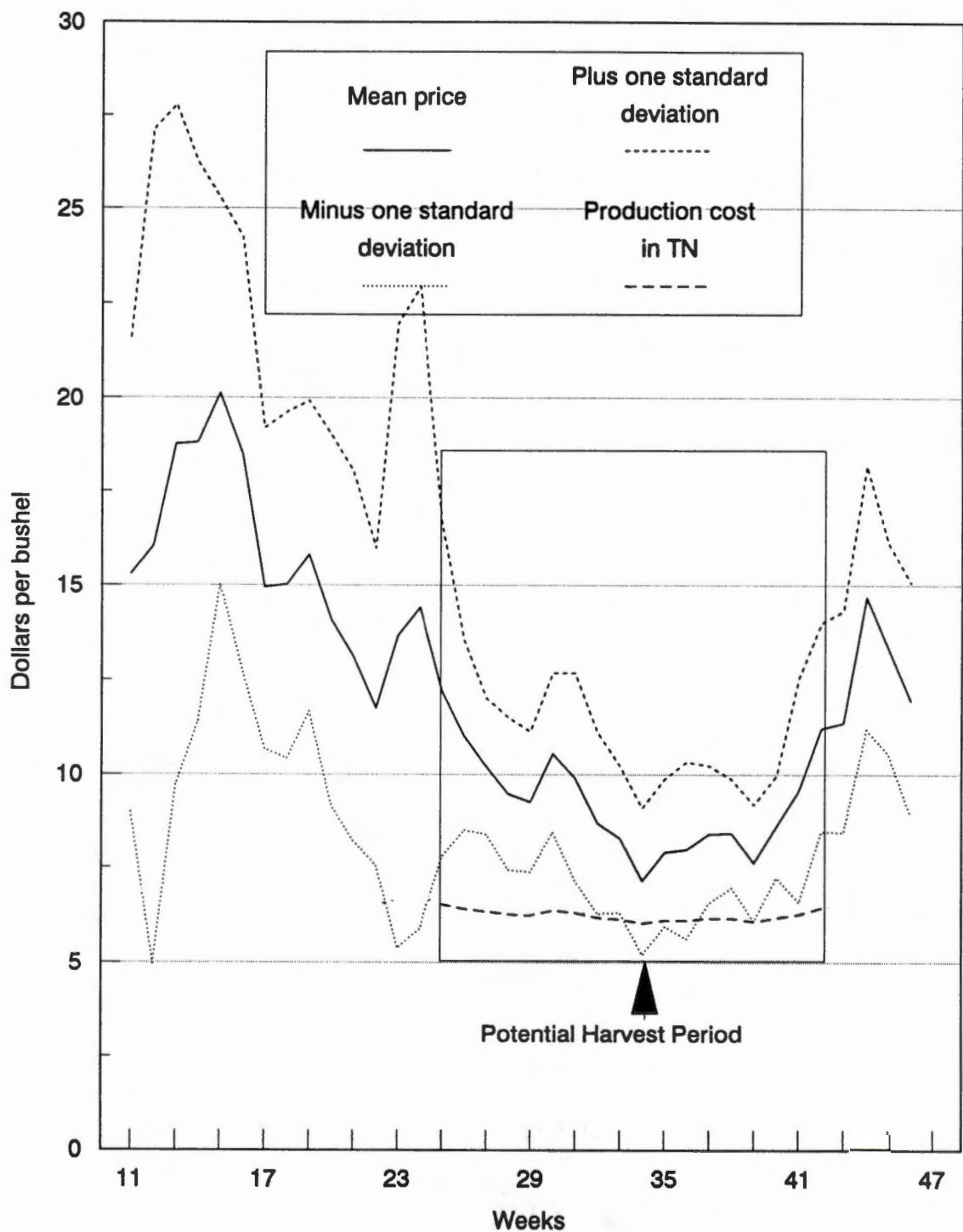


Figure 26. - Green Peppers: Baltimore, MD
Average Wholesale Market Price, 1979-1989.

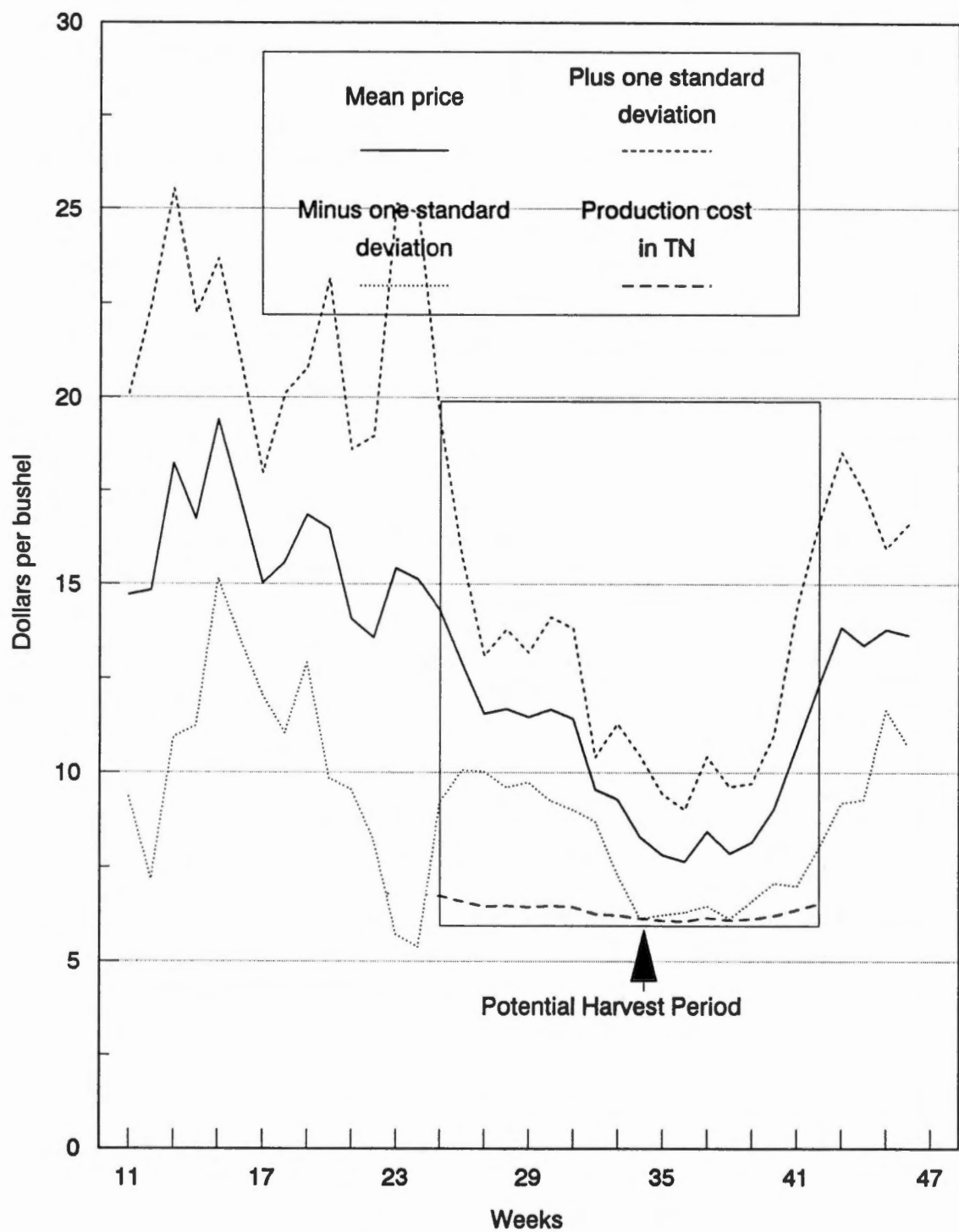


Figure 27. - Green Peppers: Chicago, IL,
Average Wholesale Market Price, 1979-1989.

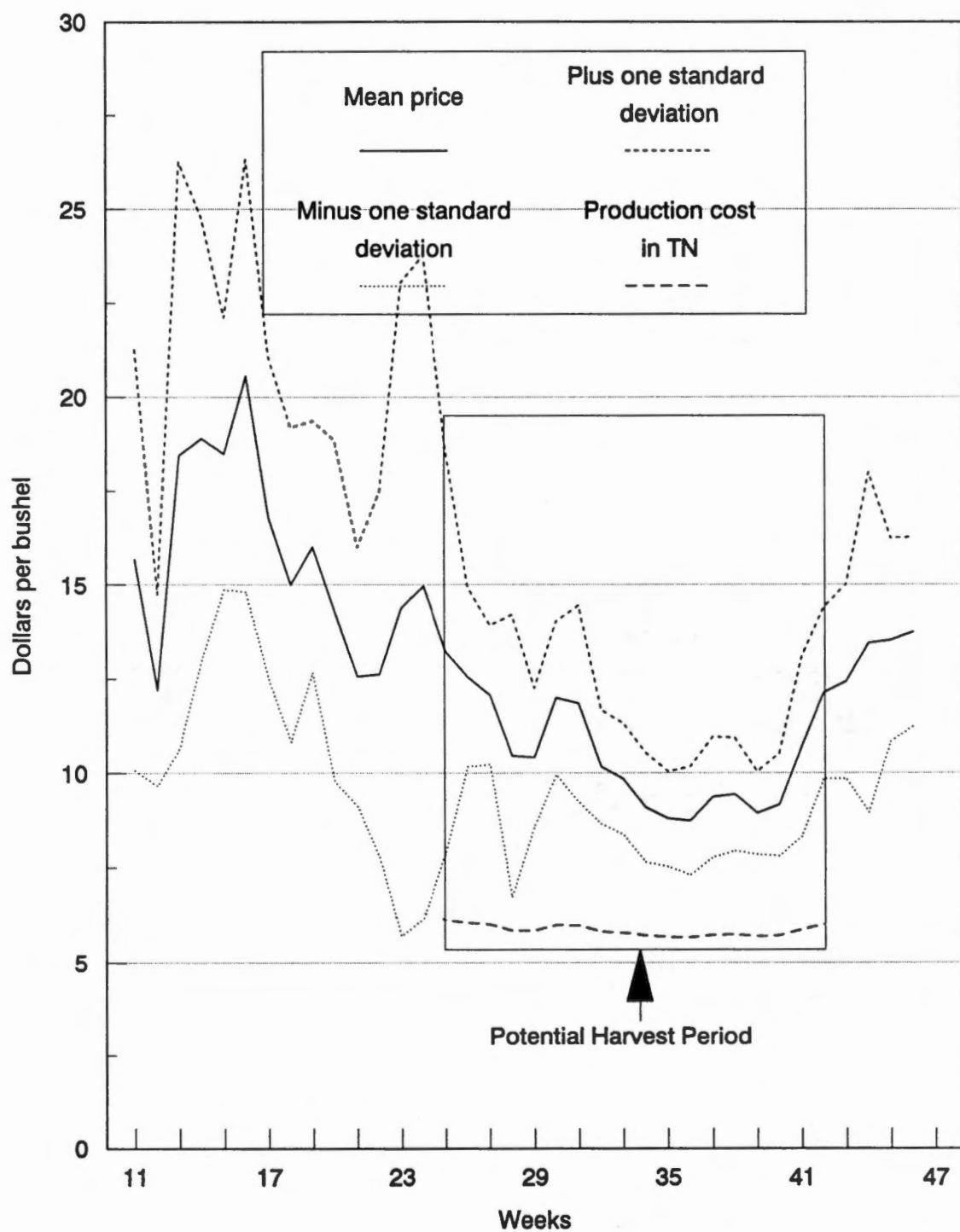


Figure 28. - Green Peppers: Cincinnati, OH,
Wholesale Market Price, 1979-1989.

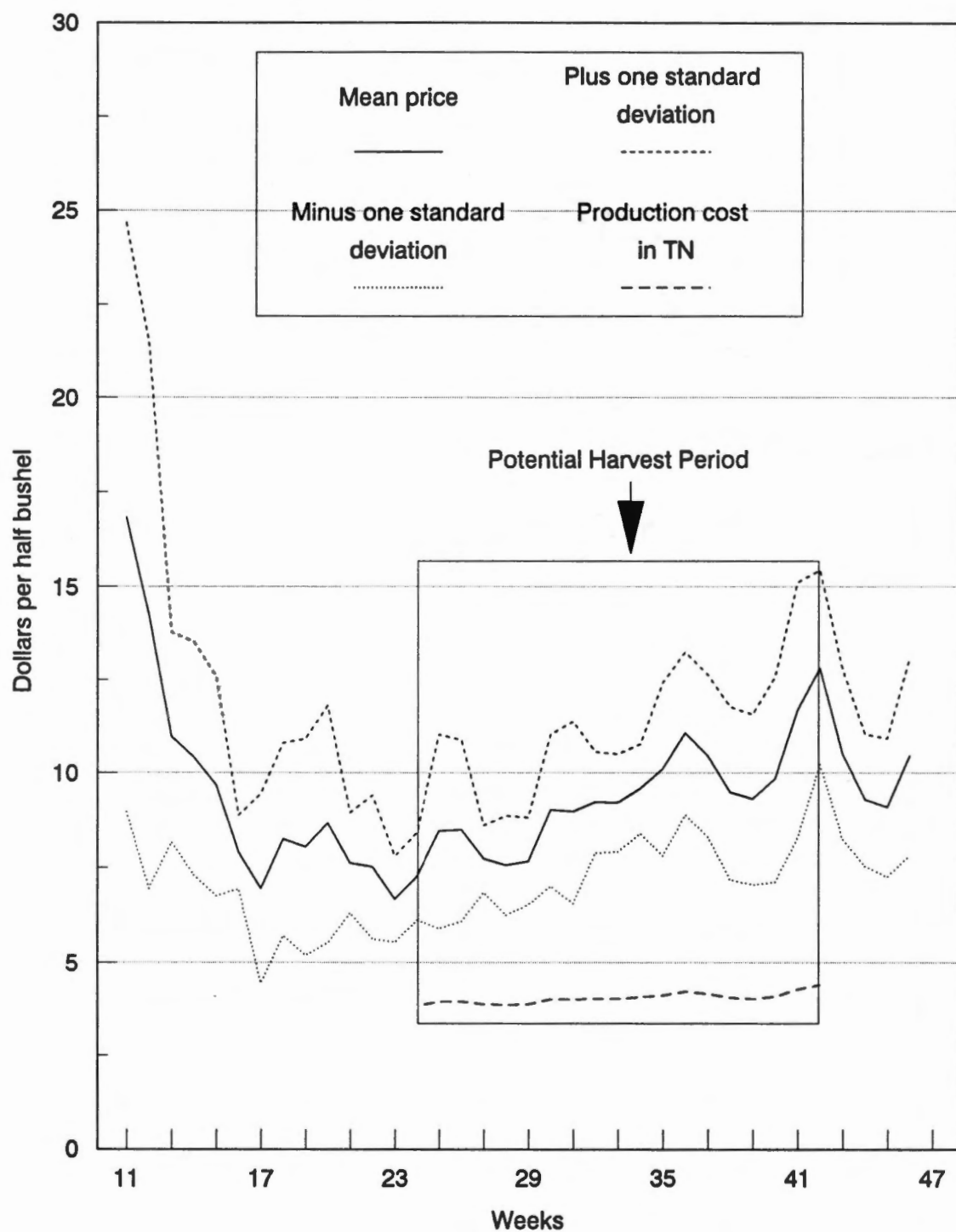


Figure 29. - Yellow Squash: Atlanta, GA, Average
Wholesale Market Price, 1979-1989.

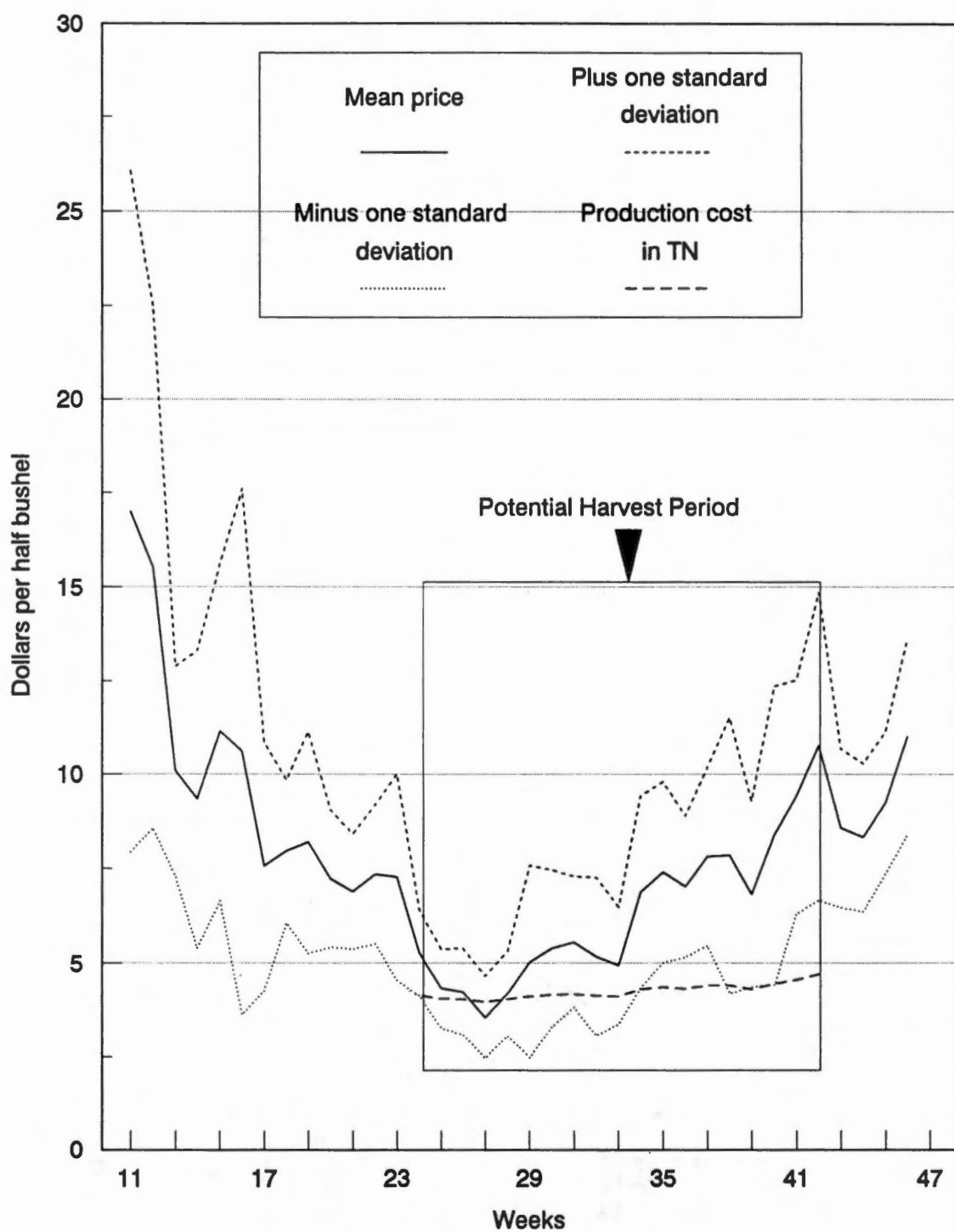


Figure 30. - Yellow Squash: Baltimore, MD,
Average Wholesale Market Price, 1979-1989.

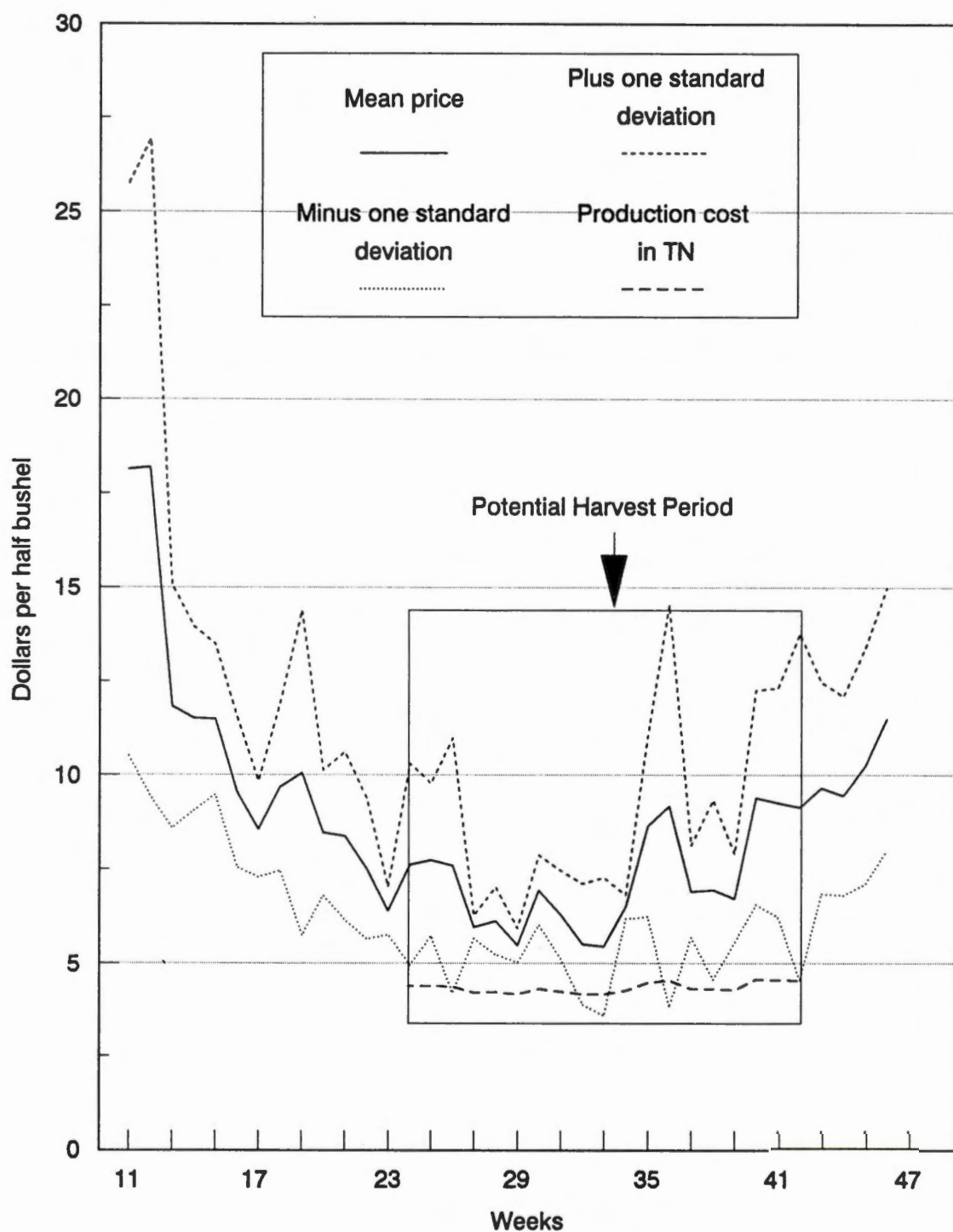


Figure 31. - Yellow Squash: Chicago, IL,
Average Wholesale Market Price, 1979-1989.

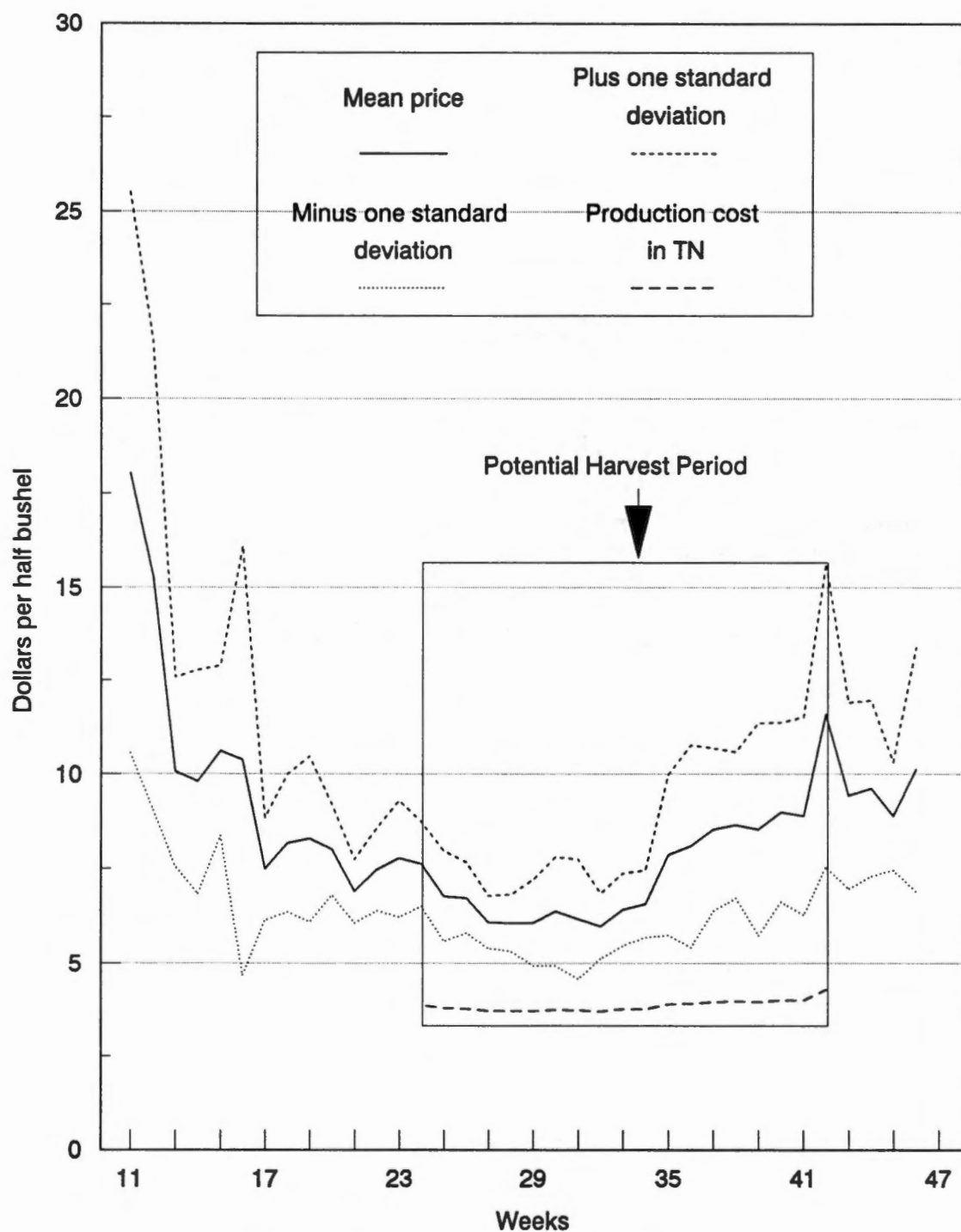


Figure 32. - Yellow Squash: Cincinnati, OH
Average Wholesale Market Price, 1979-1989.

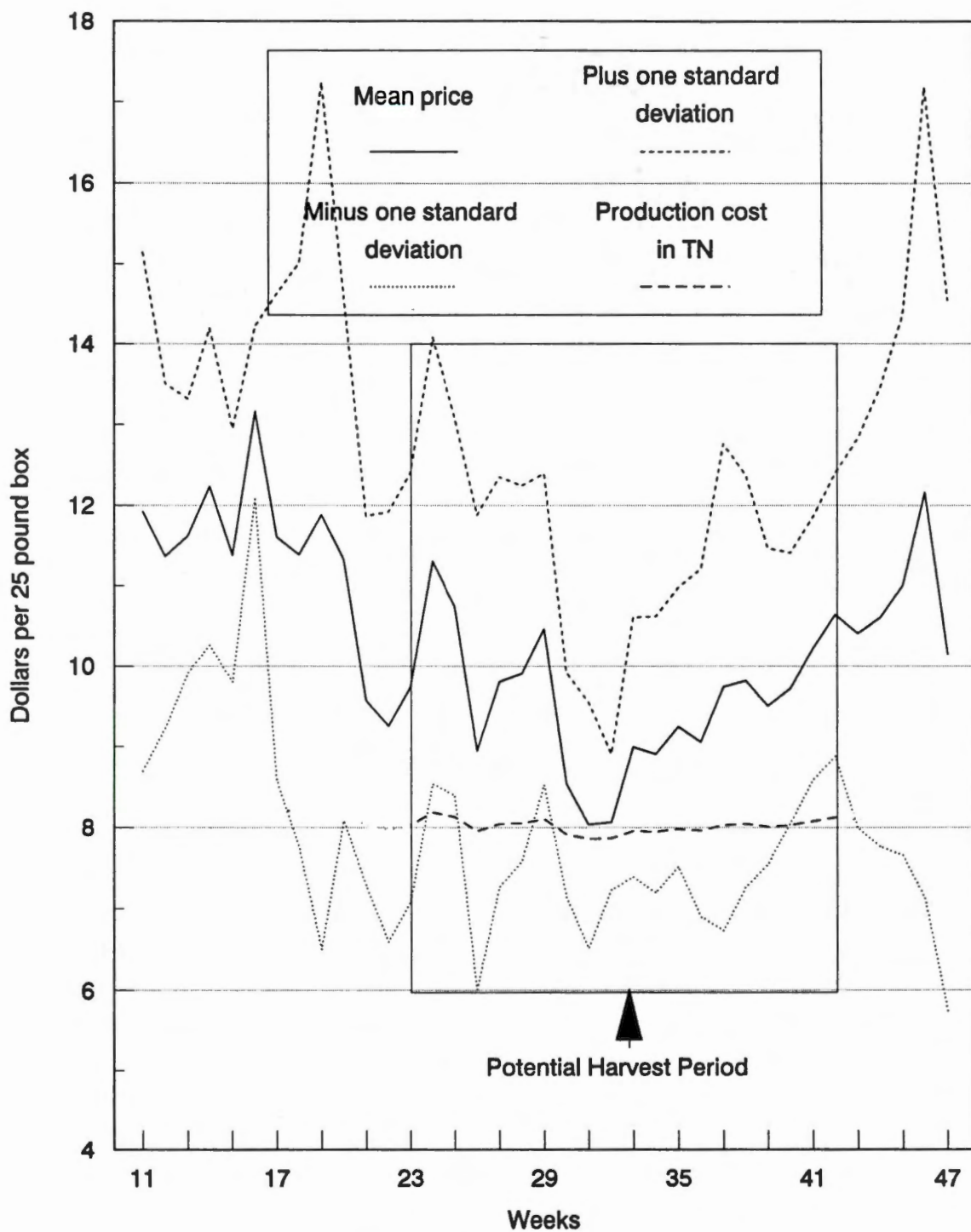


Figure 33. - Tomatoes: Atlanta, GA, Average
Wholesale Market Price, 1979-1989.

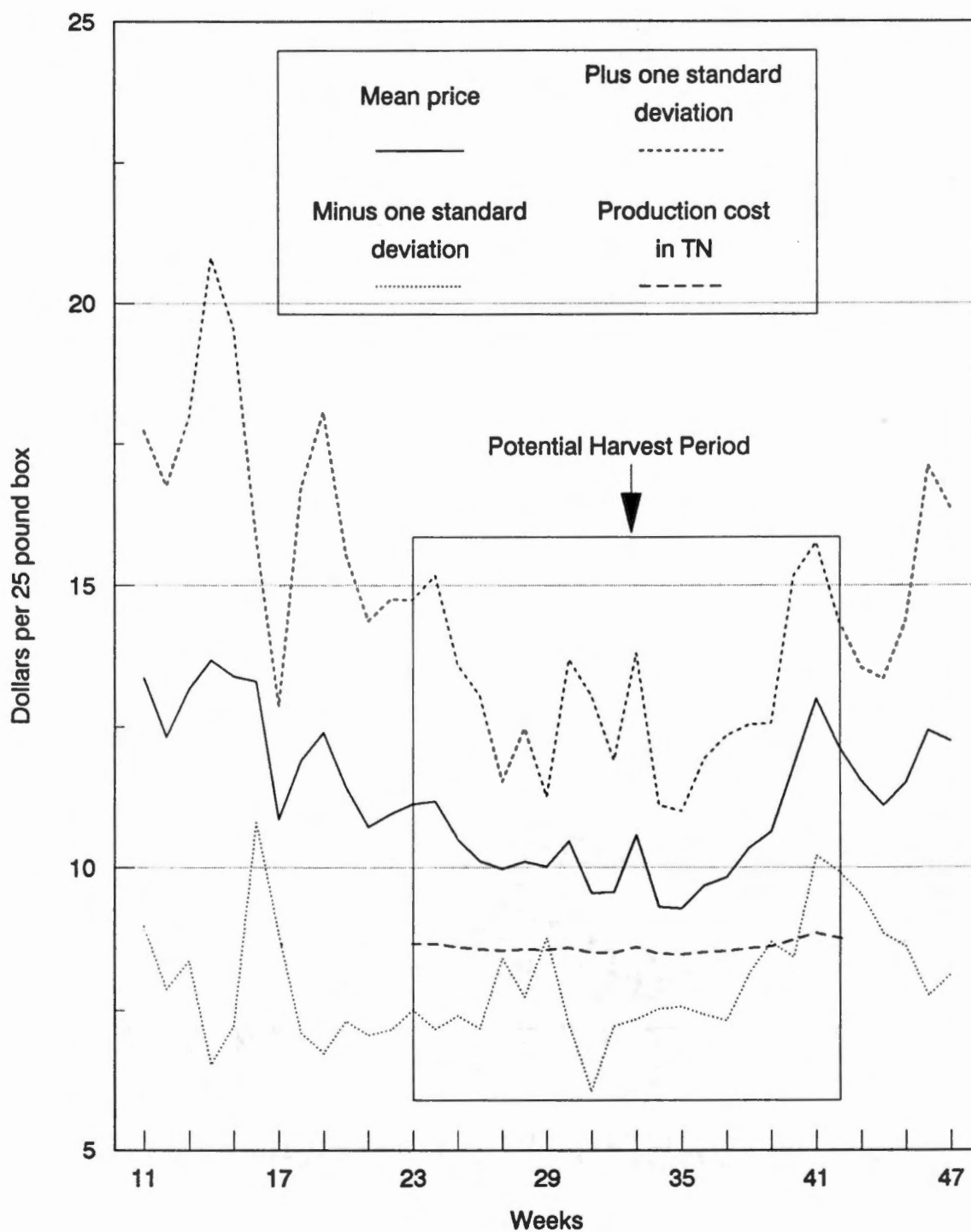


Figure 34. - Tomatoes: Baltimore, MD, Average
Wholesale Market Price, 1979-1989.

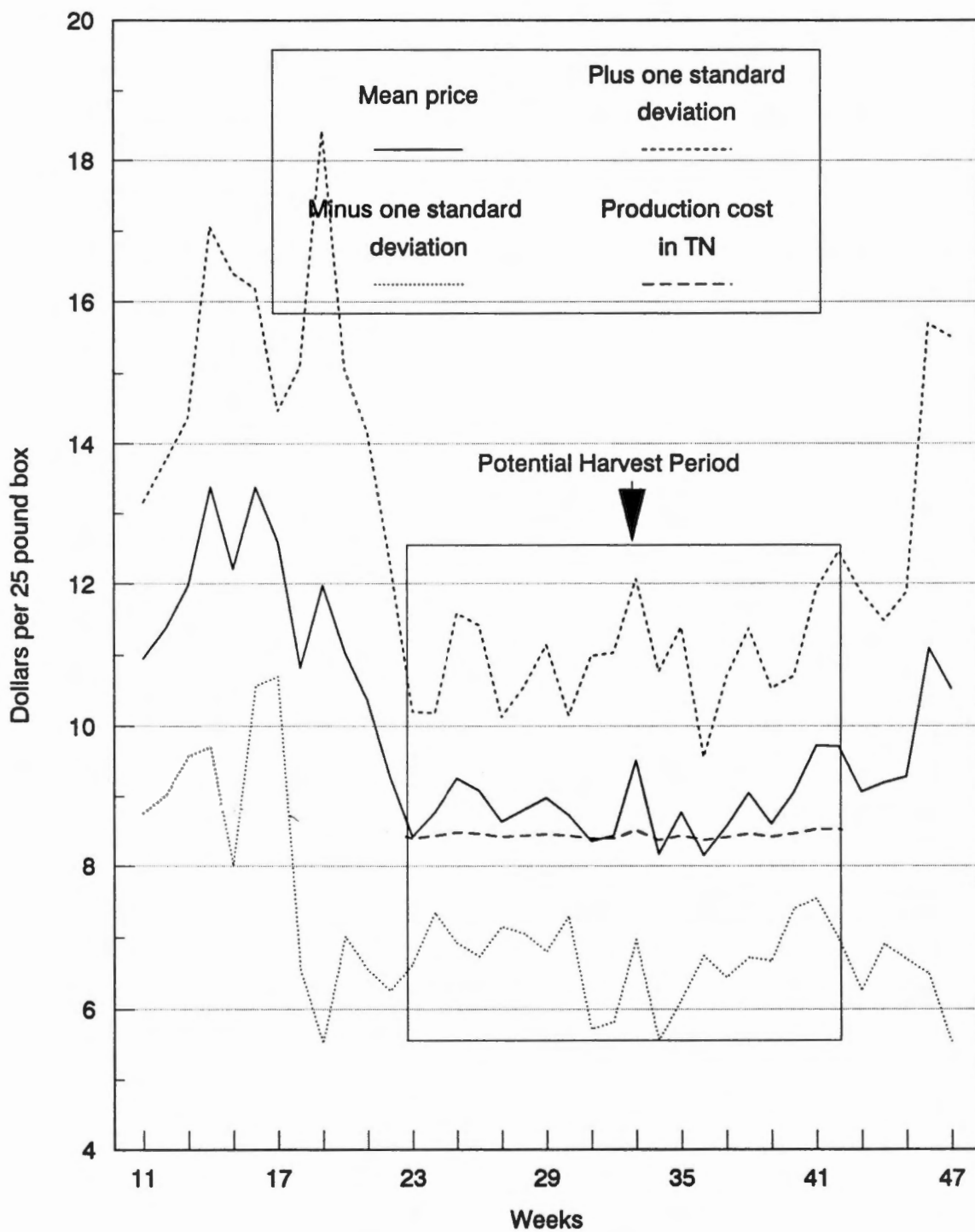


Figure 35. - Tomatoes: Chicago, IL, Average
Wholesale Market Price, 1979-1989.

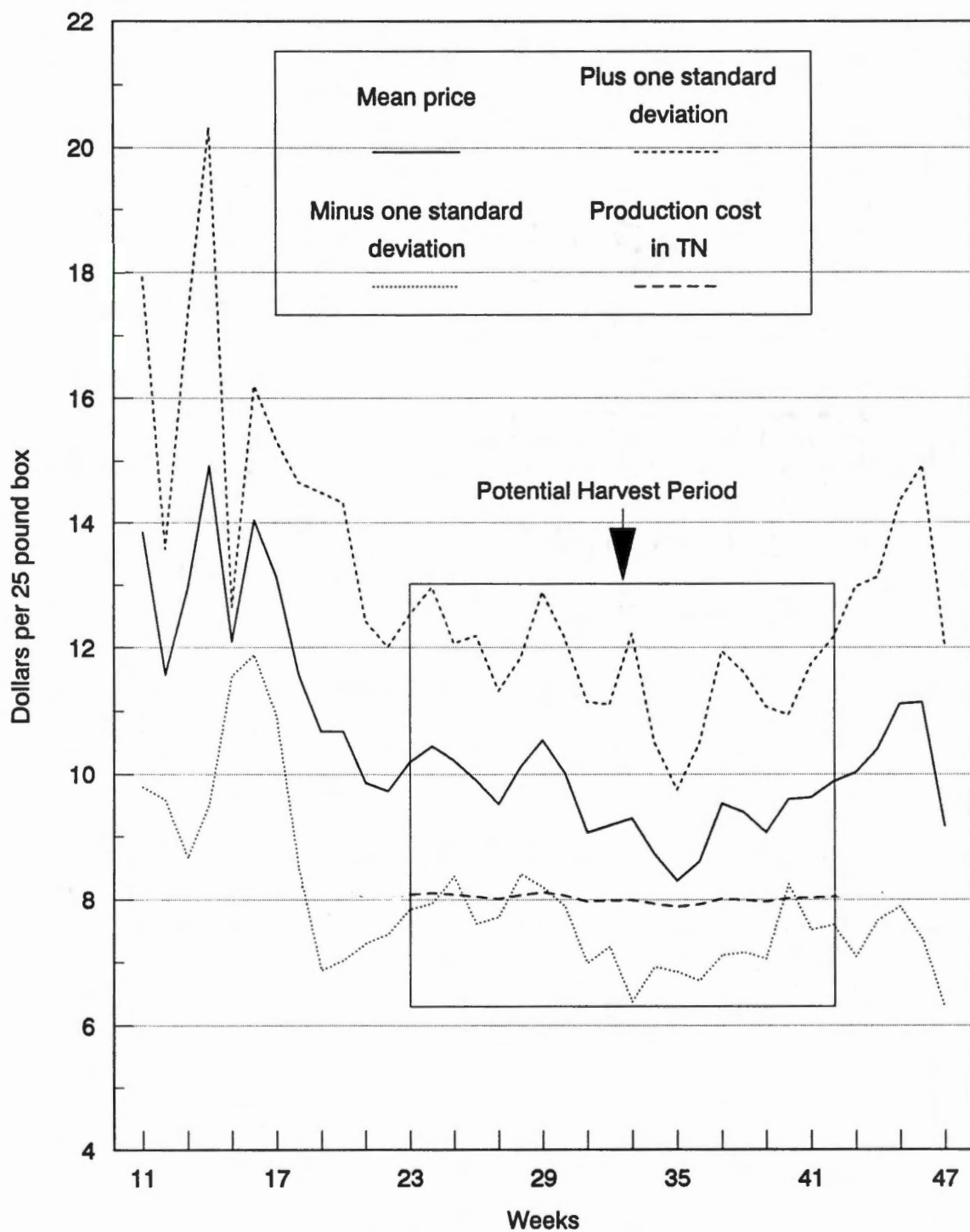


Figure 36. - Tomatoes: Cincinnati, OH, Average
Wholesale Market Price, 1979-1989.

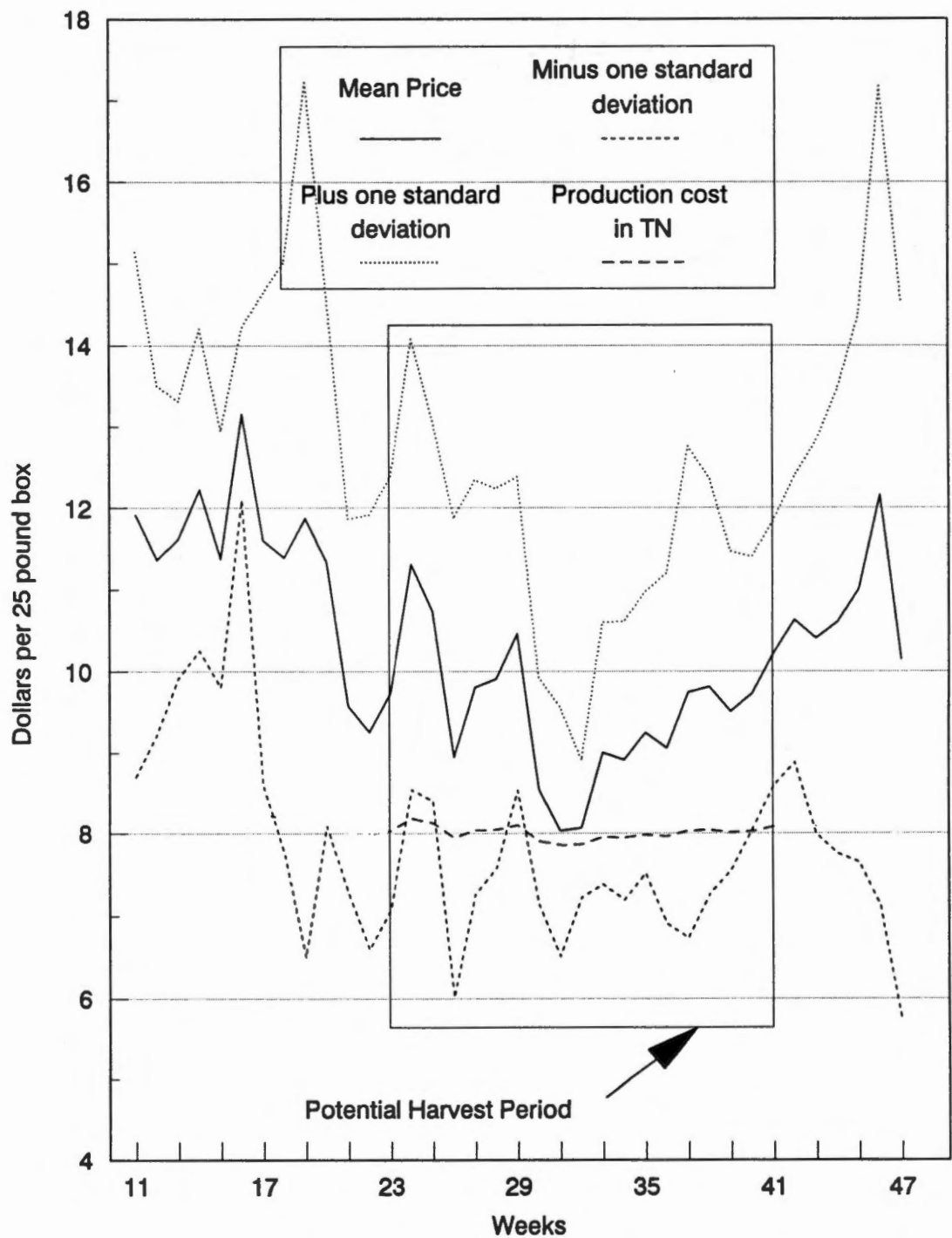


Figure 36 a. - Tomatoes: Atlanta, GA, Average
Wholesale Market Prices, 1979-1989.
Harvest Period For Columbia, TN.

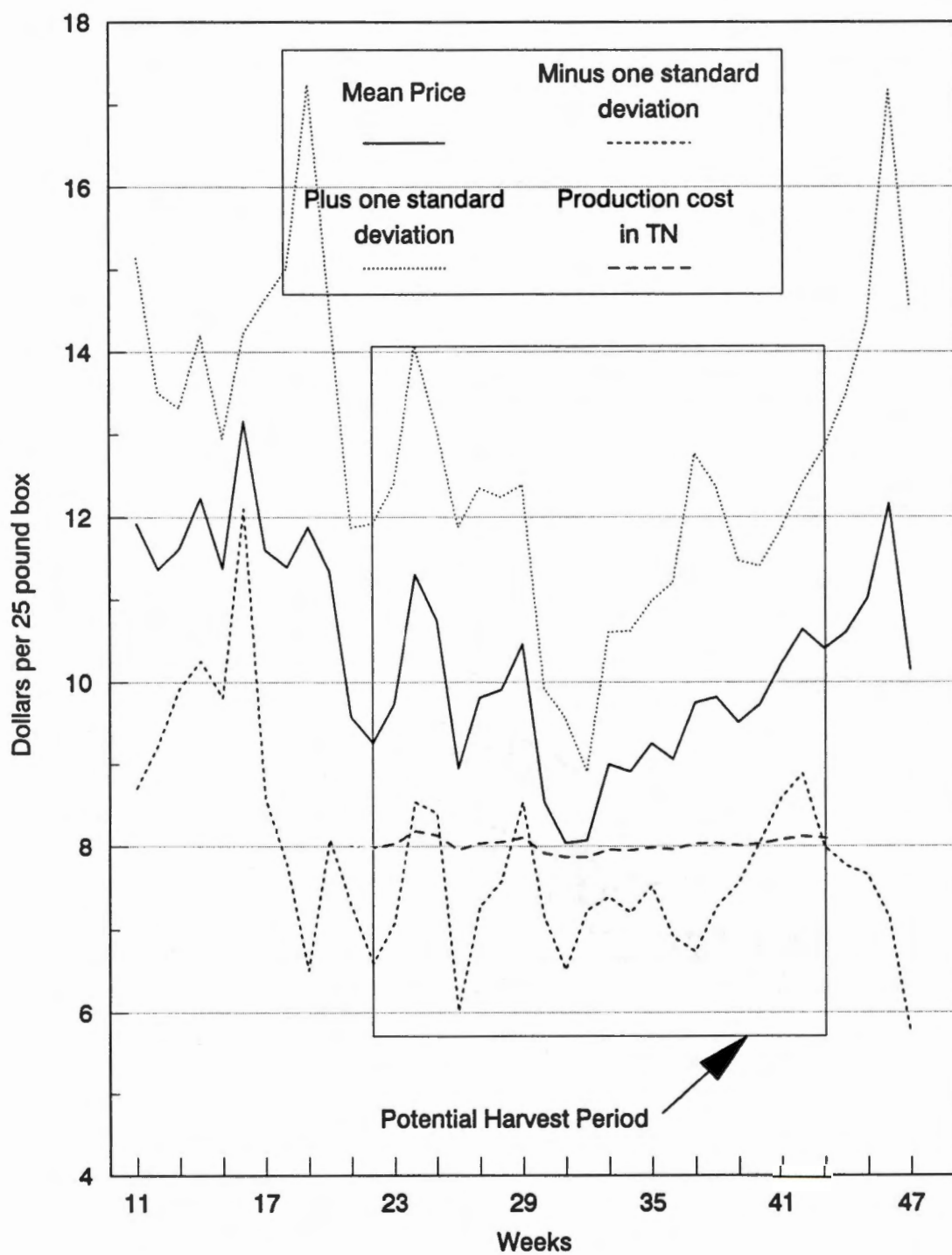


Figure 36b. - Tomatoes: Atlanta, GA, Average Wholesale Market Prices, 1979-1989.
Harvest Period For Covington, TN.

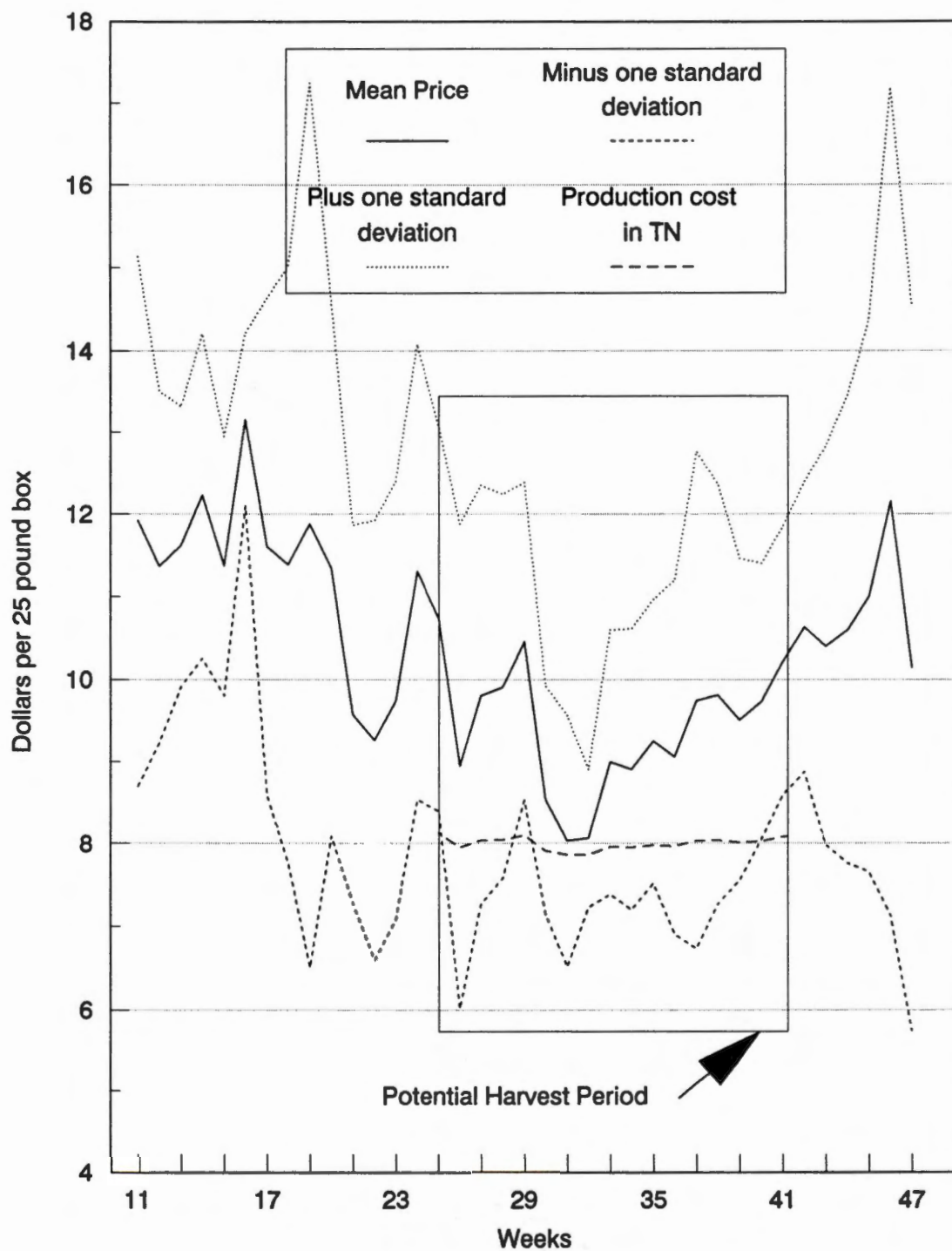


Figure 36c. - Tomatoes: Atlanta, GA, Average
Wholesale Market Prices, 1979-1989.
Harvest Period For Greenville, TN.

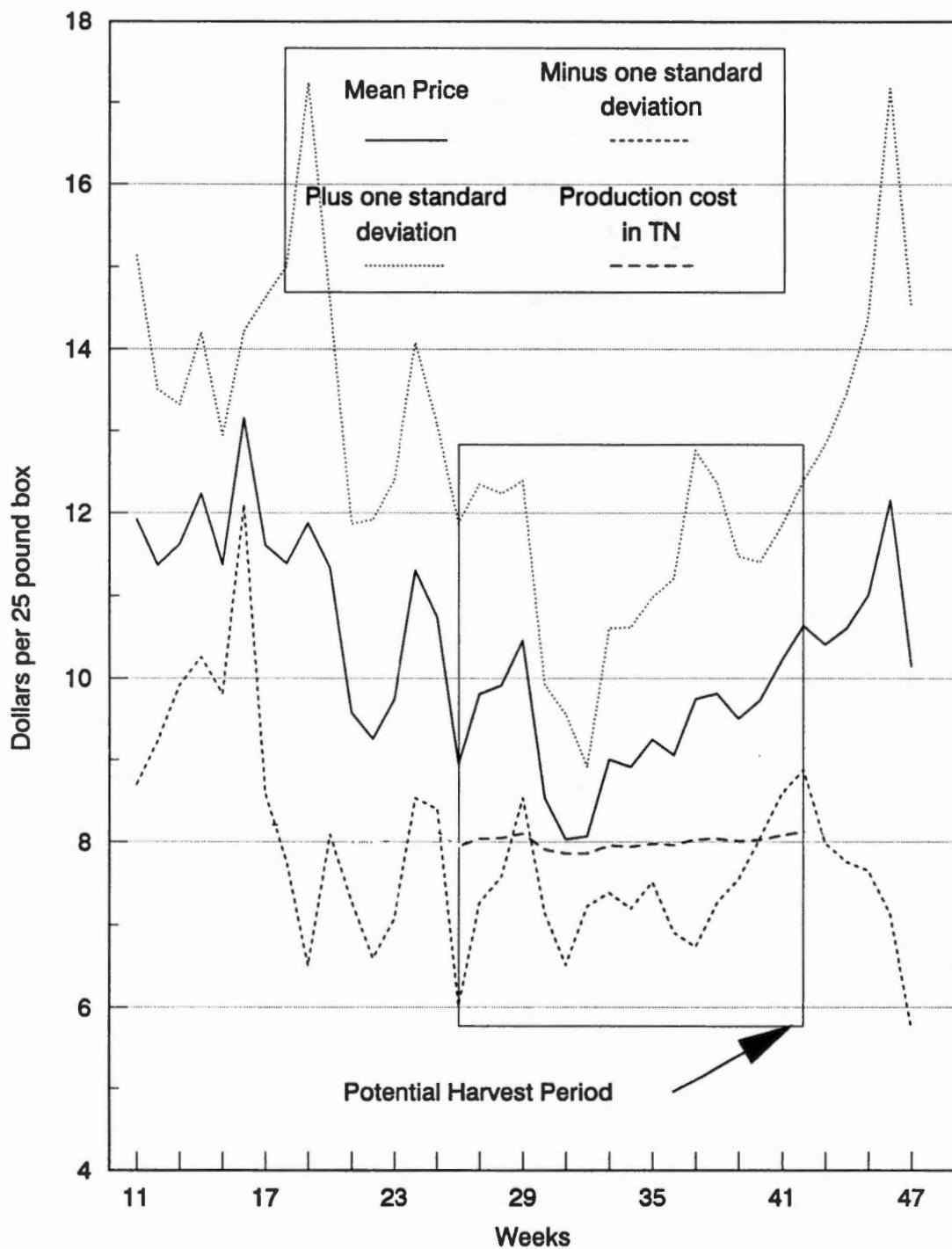


Figure 36d. - Tomatoes: Atlanta, GA, Average
Wholesale Market Prices, 1979-1989.
Harvest Period For Monteagle, TN.

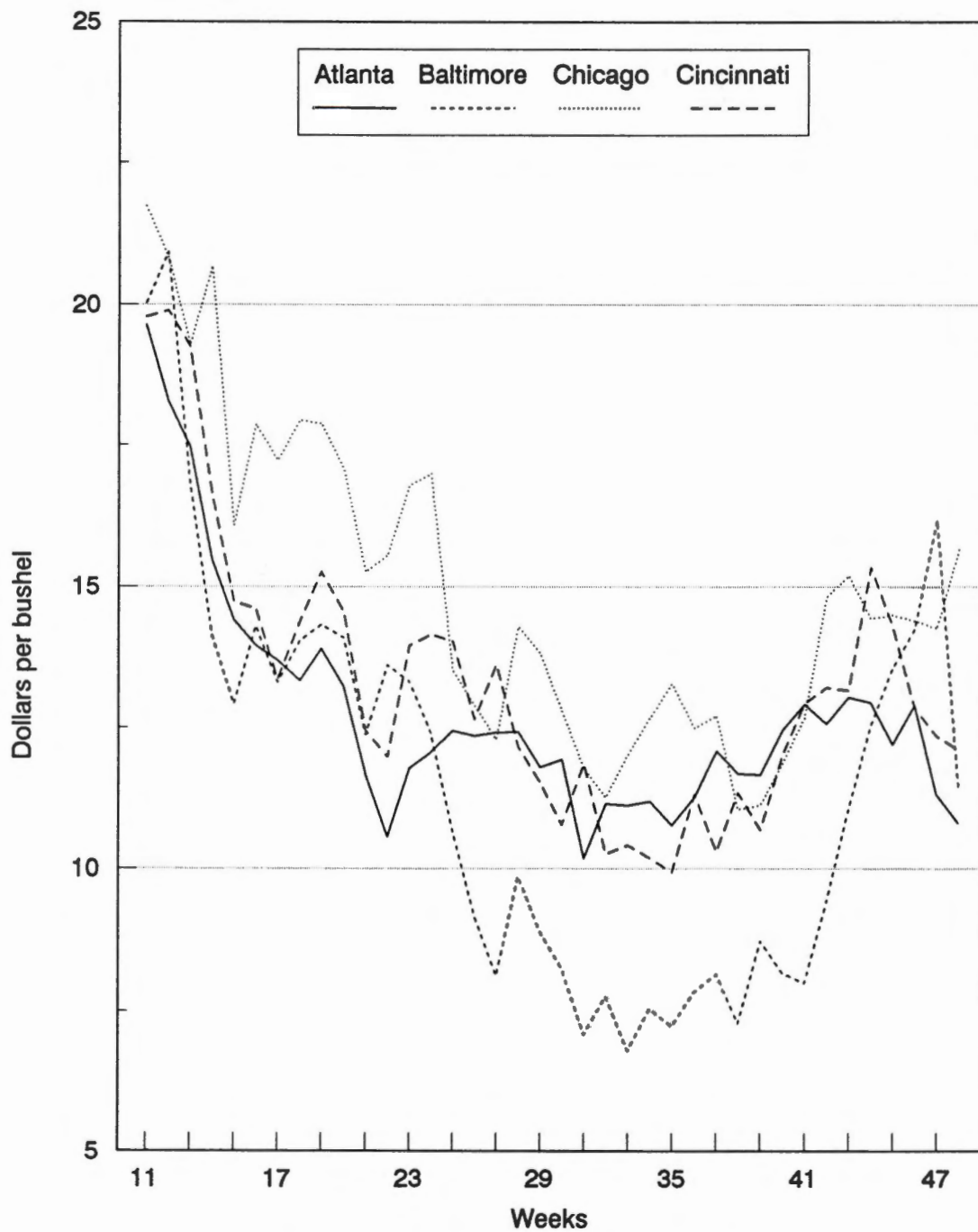


Figure 37. - Beans: Atlanta, Baltimore, Chicago,
Cincinnati, Average Wholesale Market Prices,
1979-1989.

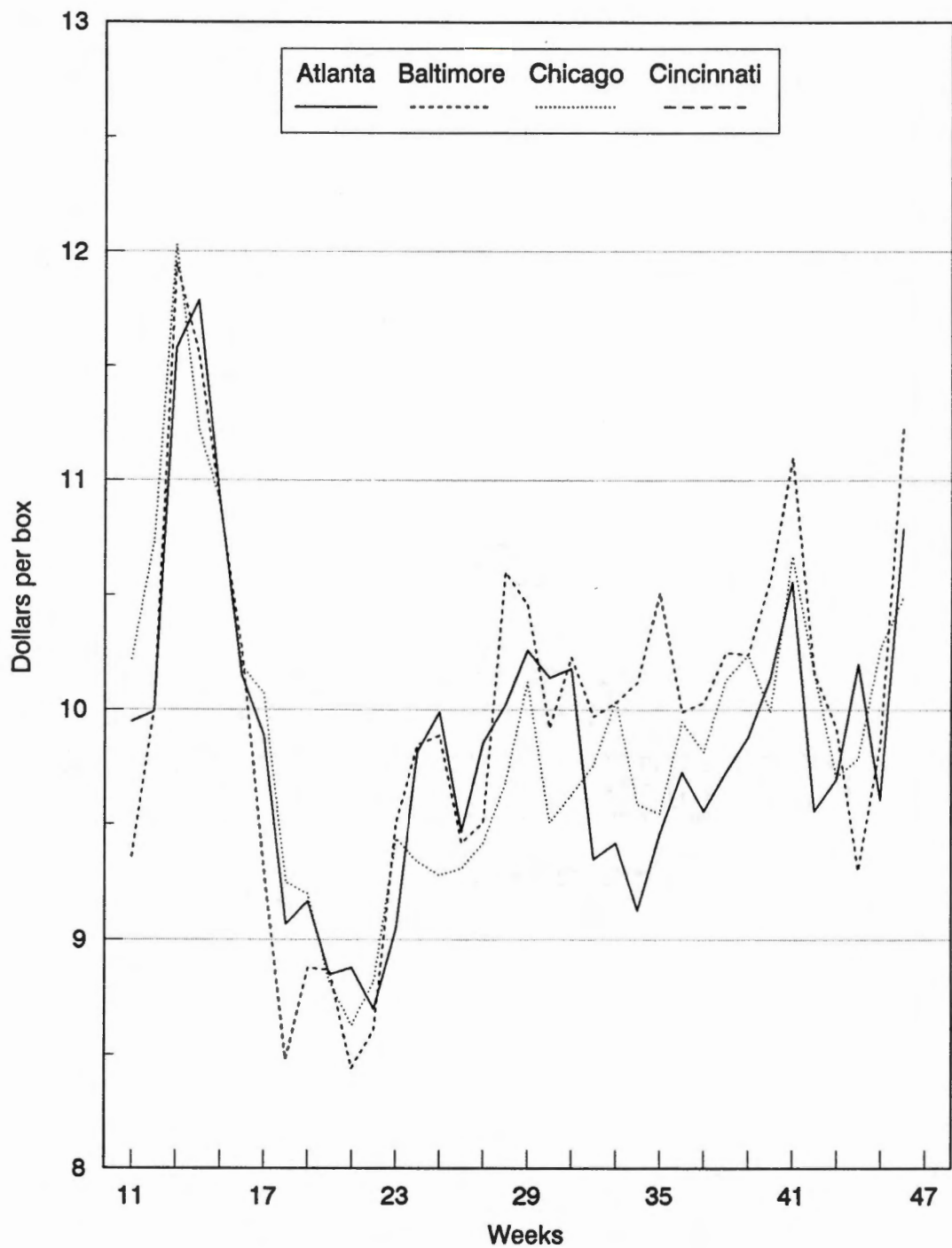


Figure 38. - Broccoli: Atlanta, Baltimore, Chicago, Cincinnati, Average Wholesale Market Prices, 1979-1989.

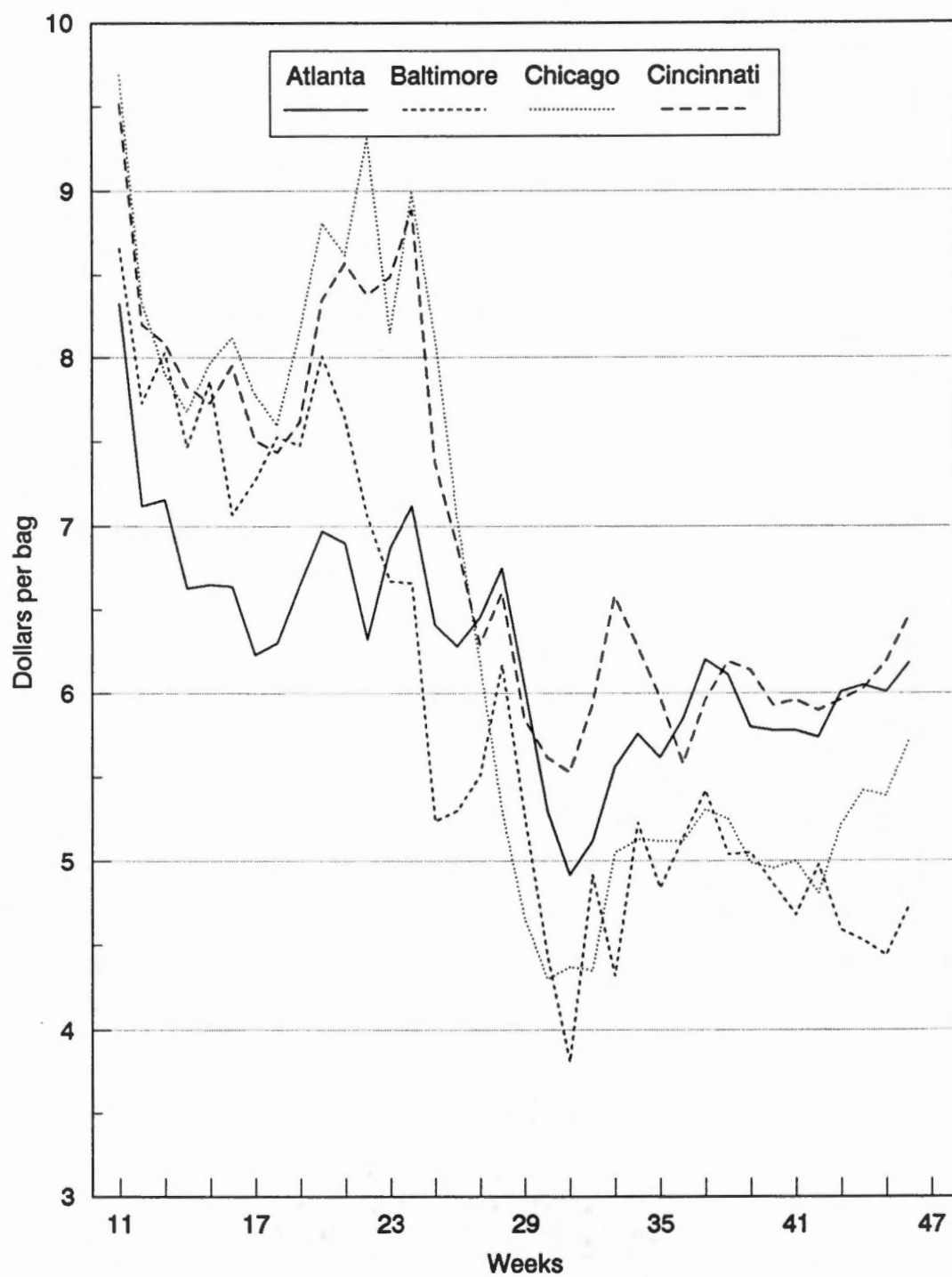


Figure 39. - Cabbage: Atlanta, Baltimore, Chicago, Cincinnati, Average Wholesale Market Prices, 1979-1989.

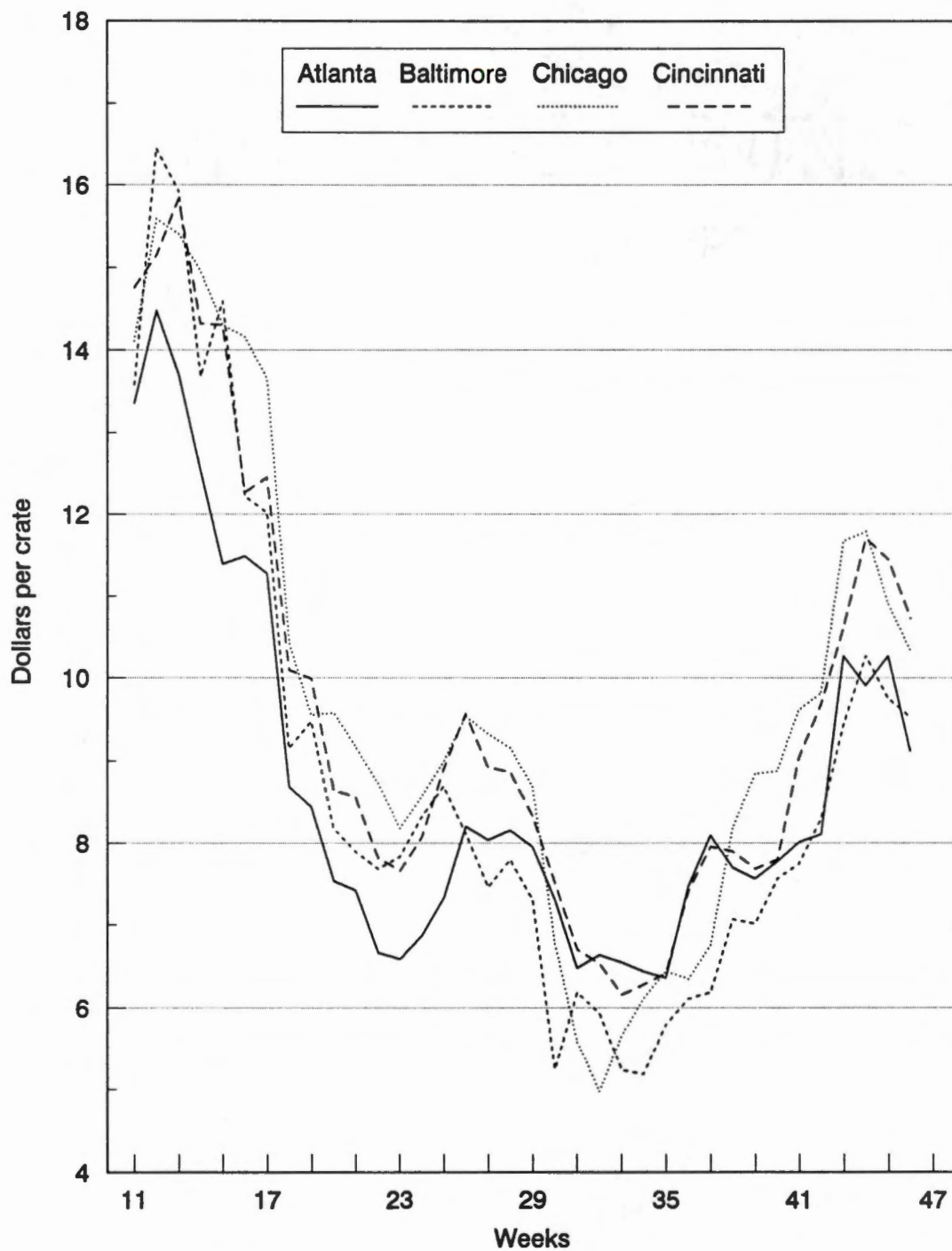


Figure 40. - Sweet Corn: Atlanta, Baltimore, Chicago,
Cincinnati, Average Wholesale Market Prices,
1979-1989.

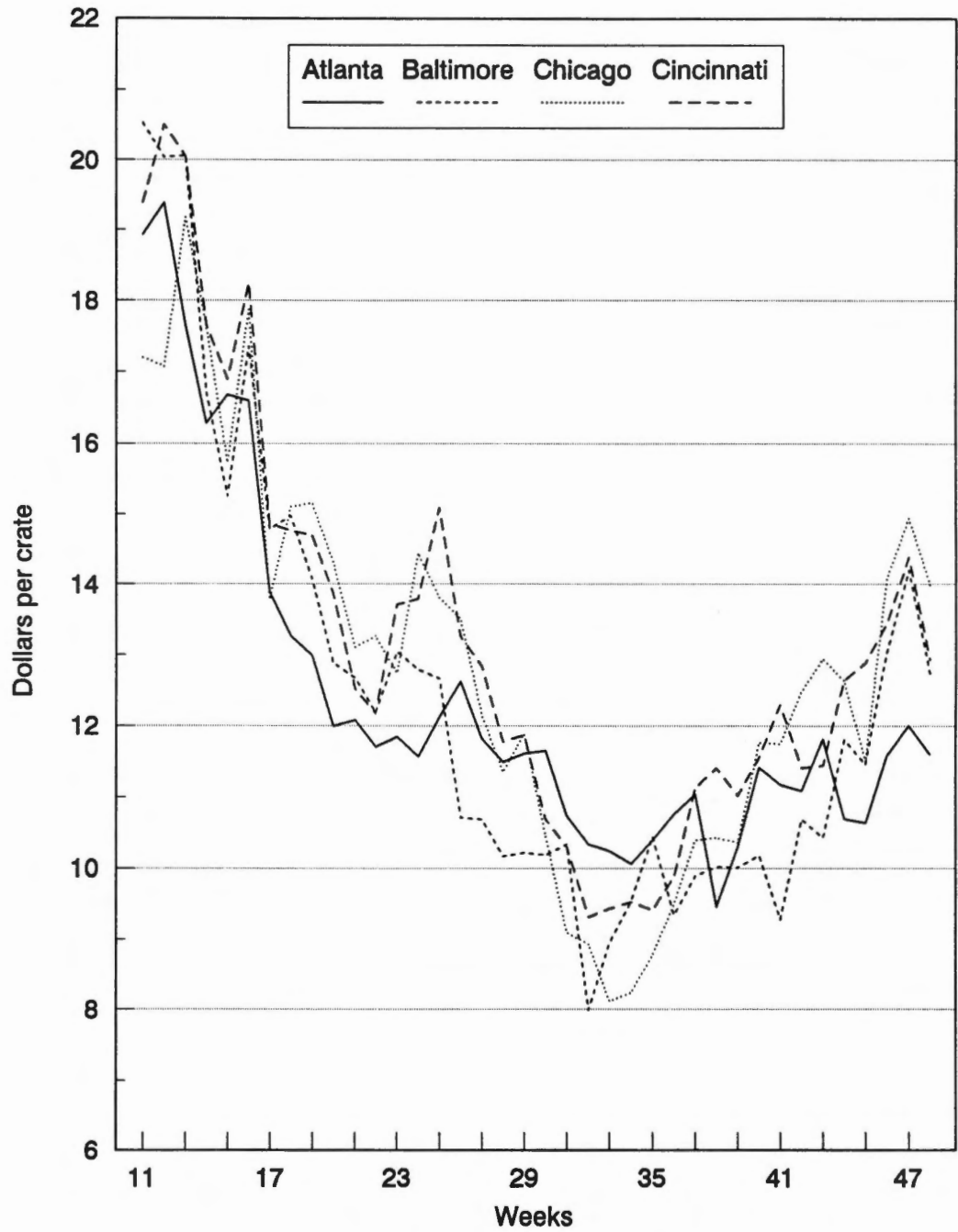


Figure 41. - Cucumbers: Atlanta, Baltimore, Chicago,
Cincinnati, Average Wholesale Market Prices,
1979-1989.

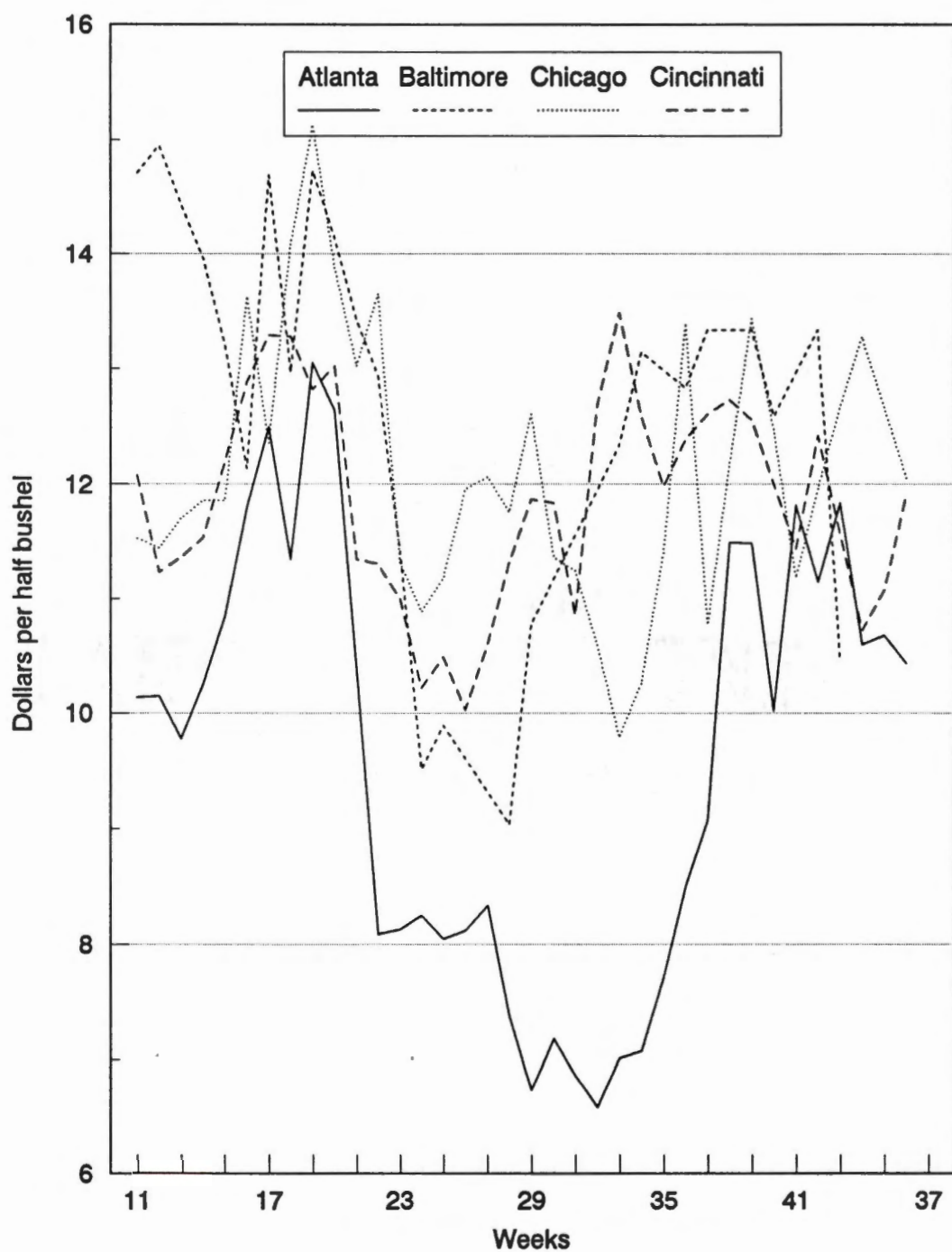


Figure 42. - Okra: Atlanta, Baltimore, Chicago, Cincinnati, Average Wholesale Market Prices, 1979-1989.

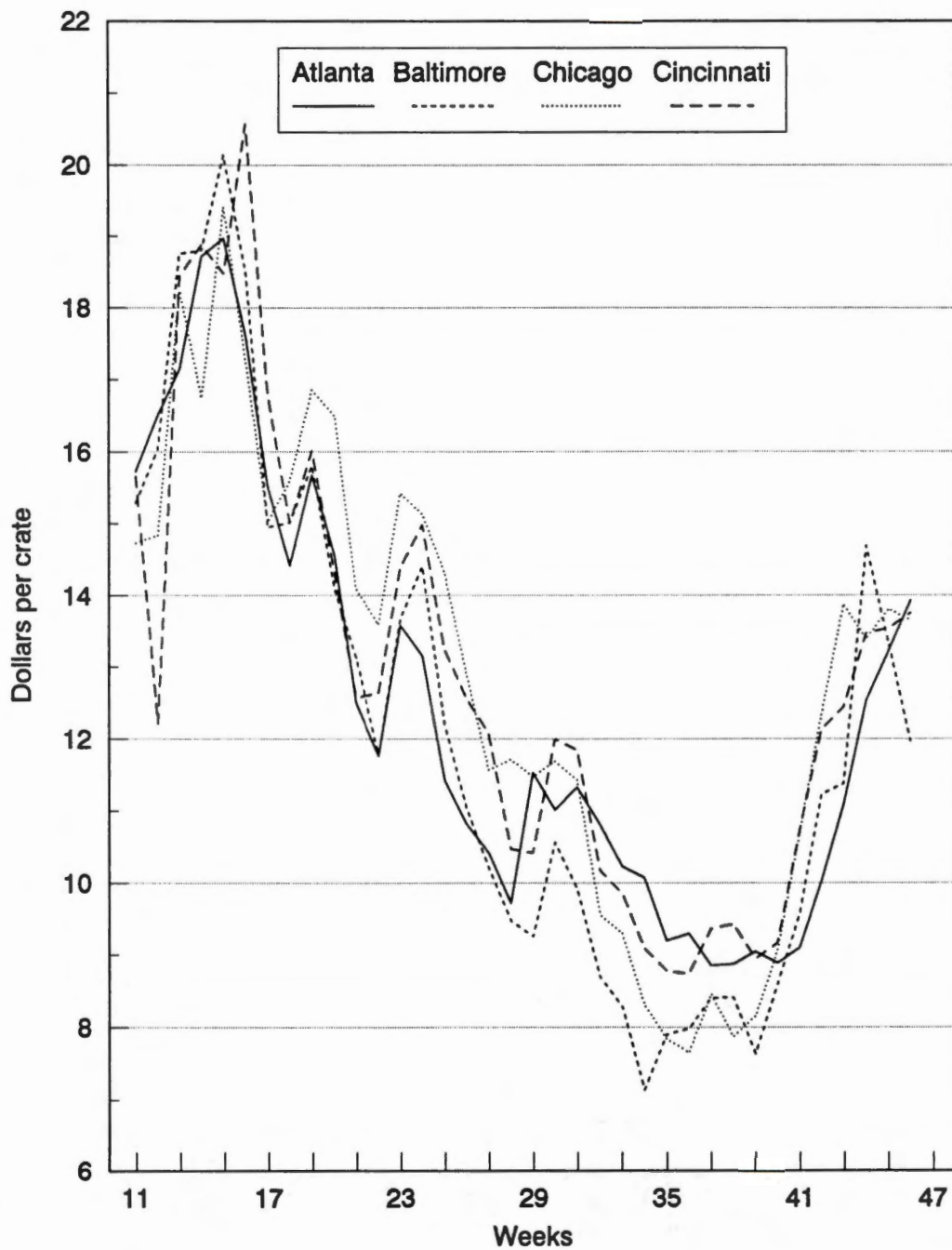


Figure 43.- Green Peppers: Atlanta, Baltimore, Chicago, Cincinnati, Average Wholesale Market Prices, 1979-1989.

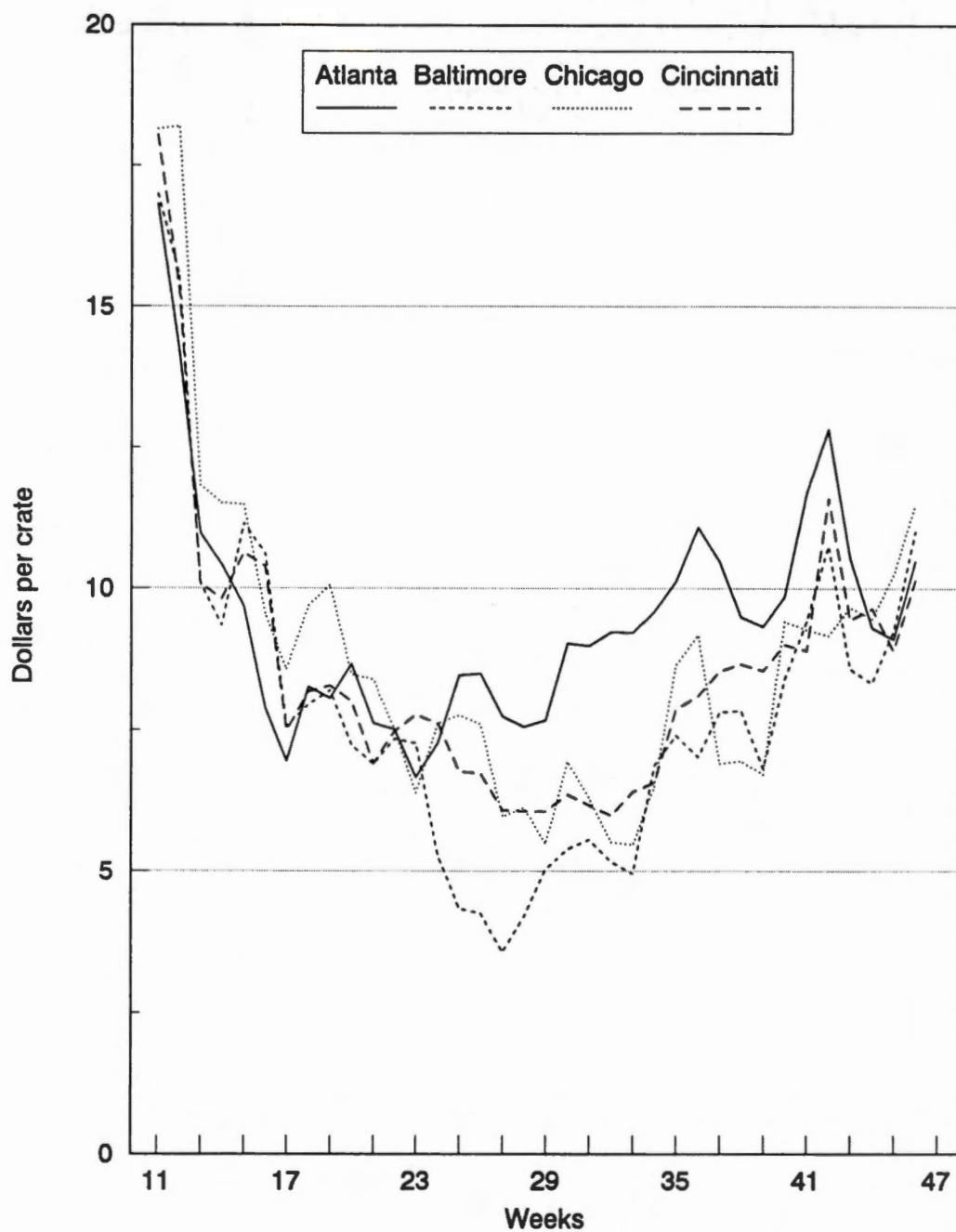


Figure 44.- Yellow Squash: Atlanta, Baltimore, Chicago,
Cincinnati, Average Wholesale Market Prices,
1979-1989.

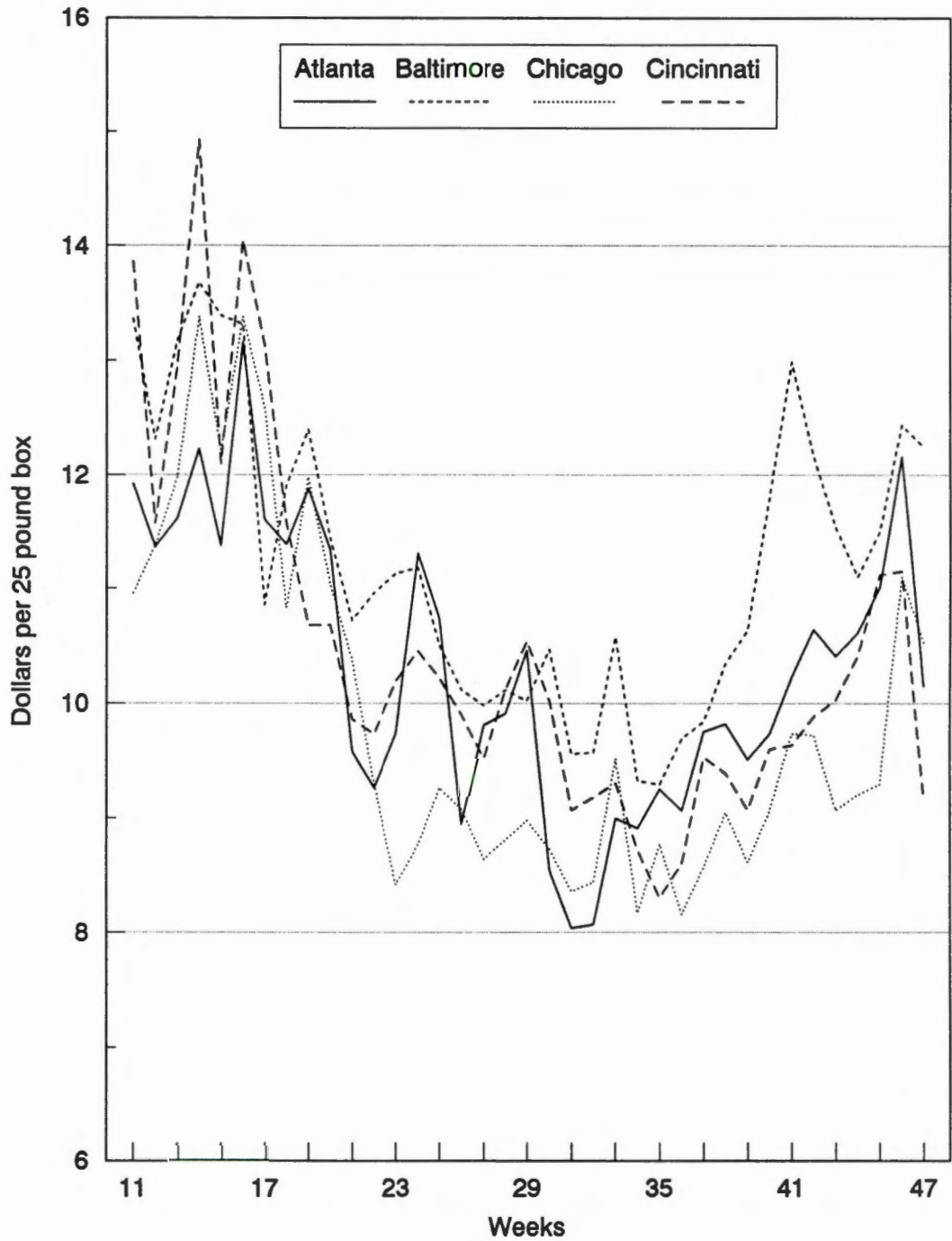


Figure 45.- Tomatoes: Atlanta, Baltimore, Chicago, Cincinnati, Average Wholesale Market Prices, 1979-1989.

VITA

Michael John Best was born in Berea, Kentucky on December 9, 1966. He attended Berea Community Elementary and High School and graduated in 1984. He received a Bachelor of Science degree in Agriculture from Berea College in May 1988. After graduation he accepted a graduate research assistantship in the Agricultural Economics department for an M.S. at the University of Tennessee. Mr. Best completed the requirements for the Master of Science degree at the University of Tennessee, Knoxville in December 1990.