Tests on Seasonal Unit Roots in Taiwan's Vegetable Prices

Abstract

Taiwan's retail and farm prices were examined for unit roots at various seasonal frequencies. The results show that no unit roots exist at any seasonal frequency. Additionally, retail and farm prices are not co-integrated with vector (1,-1) at the long-run frequency, reflecting that the marketing system is not efficient.

I. Introduction

Most agricultural products are characterized by some seasonality in production pattern, which mainly arises from climatic factors. Taiwan's vegetable industry is a case in point. Traditionally, fried vegetables are very important daily dishes for Chinese. Recently, per capita consumption has substantially increased from 56.16kg in 1962 to 115.15kg in 1992 due to growing awareness by consumers of the nutritional and health benefits of fresh vegetables in the diet. Although various vegetable species can be planted and harvested at all seasons in Taiwan, farmers prefer to plant vegetables in winter for paddy field rotation. Hence, overproduction usually results from mild temperature in winter, while supply shortage results from natural catastrophes such as floods and typhoons in summer. In normal year, vegetable prices tend to have the seasonal peak during the period from August to October and to have the seasonal trough from December to the following February. However, extremely high prices could happen in winter due to abnormal cold weather. Consequently, vegetable prices are highly volatile and largely unpredictable, and then consumers have to suffer from unstable supply of fresh vegetables. To stabilize vegetable prices is becoming a major issue for agricultural officials due to increasing importance of vegetable industry in agricultural sector. Obviously, to identify price behavior, especially seasonal pattern of vegetable prices is essential for government to regulate the market.

There are three seasonal models commonly used in empirical study: deterministic seasonal processes, stationary seasonal processes, and seasonal unit roots processes. The first process uses seasonal dummies to account for seasonal pattern, while the second one uses the autoregression specification. The series characterized by the seasonal unit root

process needs to be differenced before it is used in modeling. However, the applications of the first two models can produce spurious results if individual economic series is not stationary due to the presence of seasonal unit roots. Hence, the investigation of seasonal unit roots should come before the examination of other kinds of seasonality. Hylleberg, Engle, Granger, and Yoo (1990) [HEGY] provide a procedure to detect the existence of seasonal unit roots in quarterly time series. Beaulieu and Miron (1993) extend HEGY testing procedure to aggregate U.S. macro data such as retails sales, unemployment, and so on. The data reject the presence of unit roots at most seasonal frequencies. Bose and Mcilgorm (1996) find that monthly price series of Japanese frozen tuna do not contain any seasonal unit roots at any seasonal frequency other than zero. The evidence obtained in previous studies has indicated that unit roots are often absent at some or all of seasonal frequencies. Therefore, it is more important to check for the presence of seasonal unit roots than to impose them a priori when modeling economic series.

Although economic researches on Taiwan's vegetable industry are plentiful, the investigation of seasonal unit roots in vegetable prices has not been conducted in previous works (Wann and Peng, 1995). As pointed out by Engle and Granger (1987), individual time series may not be stationary, linear combination of them can be stationary due to long-run equilibrium forces. When this happens, these economic variables are co-integrated. Retail prices and farm prices tend to move in the same direction because of marketing margin. If marketing system is efficient, there should be a long-term equilibrium relationship between price variables implied by the co-integration. Therefore, it is of interest to examine the co-movement of vegetable price series in vertical points by testing unit roots in the linear combination of them. The objective of this study is to

examine unit roots in fresh vegetable prices for various seasonal frequencies using the procedure proposed by Beaulieu and Miron (1993). The results from present paper are expected to improve the understanding of seasonality for future studies on vegetable price movements.

The next section presents method for testing unit roots at seasonal frequencies in monthly data. Then, the test results for individual retail and farm prices, and the differences between them are conveyed in sections III and IV, respectively. The final section discusses the implications of the results and concludes the paper.

II. Methodology of Seasonal Unit Roots Test

Seasonal frequencies in monthly data are π, $\pi/2$, $2\pi/3$, $\pi/3$, $5\pi/6$, and $\pi/6$ (or equivalently 2, 4, 3, 6, 2.4, and 12 cycles per year, Hylleberg, et al., 1990), respectively. To test hypotheses about various seasonal unit roots in the series of interest, x_t, the following equation is estimated by Ordinary Least Squares (OLS):

$$(1)\quad \varphi(B)\, y_{13t} = \alpha_0 + \alpha_1 T + \sum_{k=1}^{12} \pi_k\, y_{k,t-1} + \sum_{k=2}^{12} \alpha_k\, SD_{kt} + \varepsilon_t$$

where $\varphi(B)$ is a polynomial in the back shit operator, T is a time trend, SD_{kt}'s is seasonal dummies, and $y_{k,t-1}$'s is linear combination of lagged x_t (Beaulieu and Miron, 1993, p.308)[1]. Additional lagged y_{13t} can be included to whiten the errors of the equation.

To examine unit roots for frequencies 0 and π, the t-test for $\pi_k = 0$ against the alternative $\pi_k < 0$ is performed. For other frequency, it is to test $\pi_k = 0$, where k is even, with a two-side test. The coefficient is zero if the series contains a unit root at that frequency. If the hypothesis of $\pi_k = 0$ fails to reject for frequencies other than $\pi/2$, then the t-statistic for $\pi_{k-1} = 0$ versus the alternative that $\pi_{k-1} < 0$ is examined to reach final

conclusion. For frequency $\pi/2$, the rejection of hypothesis of $\pi_k = 0$ concludes no unit root exists. Alternatively, unit roots at any seasonal frequencies can be examined by testing $\pi_{k-1} = \pi_k = 0$ with an F-statistic. To conclude that no unit root exists at any seasonal frequency, the test results must show that π_2 and at least one member of each of the sets $\{\pi_3, \pi_4\}$, $\{\pi_5, \pi_6\}$, $\{\pi_7, \pi_8\}$, $\{\pi_9, \pi_{10}\}$, $\{\pi_{11}, \pi_{12}\}$ are significantly different from zero (Beaulieu and Miron, 1993, p.309). The existence of unit roots at seasonal frequencies implies that shocks on series will last forever and can permanently change the seasonal patterns by resulting in substantial deviation from equilibrium conditions (Hylleberg, et al., 1990).

III. Results of Unit Roots Test on Individual Series

Monthly retail prices and farm prices (in NT$ per kilogram) for five different vegetable species: radishes, cabbages, headed cabbages, cauliflower, and cucumbers are employed for analysis. The sample period is from January 1985 to December 1996. These five vegetables are chosen as their production accounts for over 70% of total vegetable production in Taiwan. Retail price variables are deflated by consumer price index (1991=100), and farm price variables are deflated by wholesale price index (1991=100). All price variables are in real and logarithmic form.

Tables 1 and 2 present OLS t- and F-statistics from results of the seasonal unit roots test for retail prices and farm prices, respectively. The t- and F-statistics were obtained via the programming procedure in *SHAZAM* version 7.0. Since the hypothesis of the presence of serial correlation on regression residuals is rejected according to the values of Box-Pierce-Ljung statistic (denoted as Q), no any lagged dependent variable is included in the model. Therefore, the regression equation includes an intercept, time trend and eleven

seasonal dummy variables.

Unit roots are found for all price series at the zero frequency as shown in Table 1. For retail prices of radishes, cabbages, headed cabbages, and cucumbers, the null hypotheses of unit roots are rejected at the 5% significance level at seasonal frequency π using the t-statistic. The data of cauliflower fail to reject unit roots at the 5% significance level, but reject unit roots at the 10% significance level. For frequency $\pi/2$, the values of π_4 are significantly different from zero at the 5% significance level using t-statistic, which concludes that the studied series contain no unit roots. For frequencies $2\pi/3$ and $5\pi/6$, prices of radishes and cabbage fail to reject the existence of unit roots as the calculated values (denoted as t-π_6 and t-π_{10}) are lower than the critical values. Therefore, the t-statistic for $\pi_{k-1} = 0$ versus the alternative that $\pi_{k-1} < 0$ is examined. The values of t-π_5 and t-π_9 are higher than the critical value implying that there are no any unit roots for radishes and cabbage. For frequencies $\pi/3$and $\pi/6$, all price series fail to reject unit roots. However, the values of t-π_7 and t-π_{11} for all price series are smaller than the critical value implying that there are no unit roots at the frequencies $\pi/3$ and $\pi/6$. The F-statistics for the test of $\pi_{k-1} = \pi_k = 0$ are also examined. The results strongly reject unit roots at all frequencies for all retail prices.

Turn to the case of farm prices, unit roots are found for radishes and cauliflower at the zero frequency as shown in Table 2. For frequency π, the null hypothesis of seasonal unit roots is rejected at the 5% level of significance for all vegetables. For frequencies $2\pi/3$, $\pi/3$, $5\pi/6$, and $\pi/6$, and when k is even, most of data fail to reject null hypothesis at the 5% significance level. However, the t-statistics in the case that k is odd reject unit

roots. For frequency $\pi/2$, the t-statistics reject the hypothesis of unit roots. Moreover, the results of F-statistic for joint test of $\pi_{k-1} = \pi_k = 0$ reject the null hypothesis as all the calculated F-values are higher than the critical values at all frequencies for all price variables.

The overall test results indicate that all retail price series, and farm price series of radishes and cauliflower do not contain any seasonal unit roots at any seasonal frequency other than zero. There is no any seasonal unit roots in farm price series of cabbage, headed cabbage, and cucumbers at any seasonal frequency including zero. The implication is that shocks on vegetable prices will not last forever and can not permanently change the seasonal patterns. The results may be explained by that farmers grow leaf vegetables such as Chinese cabbage and spinach to make up temporary supply shortage due to climatic factors. In the case of overproduction, farmers tend to fertilize their field using unsaleable products in order to reduce supply of vegetables. Accordingly, the studied retail prices and farm prices can be modeled using stationary seasonal pattern.

IV. Tests on Differences of Retail and Farm Prices

Goodwin and Schroeder (1991) argue that if price series for two separate locations are co-integration then a form of spatial efficiency for regional market linkages exists. Retail prices and farm prices tend to move in the same direction in a free market with normal demand and supply functions. Additionally, marketing margins can be defined as a difference between retail prices and farm price (Tomek and Robinson, 1982, p.120). Therefore, co-integration between retail price and farm price for the co-integration vector (1, -1) can be expected if the marketing system is efficient[2]. The existence of vertical

integrated markets implies that any price change in one market such as farm market should be fully reflected by an equilibrating force in retail market.

According to HEGY, equation (1) is applied to differences between retail and farm price to test unit roots in marketing margins at seasonal frequencies. Since the Box-Pierce-Ljung statistic fails to detect the presence of serial correlation on regression residuals, no any lagged dependent variable is included in the model. Table 3 presents OLS t- and F-statistics from results of the seasonal unit roots test in differences between retail prices and farm prices. Unit roots are found for all price series at the zero frequency since the t-statistics are larger than the critical value. The null hypotheses of unit roots are rejected at the 5% significance level at the frequency π using the t-statistic for all vegetables. For frequencies $2\pi/3$, $\pi/3$, $5\pi/6$, and $\pi/6$, and when k is even, some of data fail to reject null hypothesis at the 5% significance level. However, the t-statistics in the case that k is odd reject unit roots. For frequency $\pi/2$, the t-statistics of vegetable species other than cucumber reject the hypothesis of unit roots. Moreover, the results of F-statistic for joint test of $\pi_{k-1} = \pi_k = 0$ reject the null hypothesis as all the calculated F-values are higher than the critical values at all frequencies for all price variables.

A unit root exists at the zero frequency in marketing margin implying that there is no co-integration between retail and farm prices at the long-run frequency for the co-integration vector (1, -1). The results show that marketing margins are not stationary at long-run frequency, reflecting that marketing system for the studied vegetables is not efficient. Wann and Yang (1996) find that oligopoly power in retail markets accounts for 15% and 45% of marketing margins of radish and headed cabbage, respectively. Hence, the finding of inefficiency may result from the oligopoly power in retail market, which

deserves further investigation.

V. Conclusions

Taiwan's vegetable industry is characterized by strong seasonality, which mainly results from weather conditions and planting customs. To understand seasonal pattern of vegetable prices, this study examines unit roots at seasonal frequencies for retail prices and farm prices of fresh vegetables using the approach developed by Beaulieu and Miron.

The test results indicate that the all studied retail prices and the farm prices of radishes and cauliflower have random-walk character at long-run frequency, but they are not seasonally integrated series. This finding suggests that shocks on vegetable prices will not last forever and can not permanently change the seasonal patterns. However, the studied series tends to move away from the long-run trend following a shock, which is implied by the existence of unit roots at zero frequency. Cares should be taken when modeling vegetable prices.

In addition, retail and farm prices are not co-integrated with co-integrating vector (1, -1) at the long-run frequency, implying that marketing system for the studied cases is not efficient. Since the individual price variable is not stationary at long-run frequency, co-integration vectors other than (1, -1) between variables are expected due to long-run equilibrium forces. Consequently, more efforts to examine dynamic linkage between price variables will be beneficial to future study on market failure questions.

Footnotes

1. As shown in Beaulieu and Miron,

$$y_{1t} = (1 + B + B^2 + B^3 + B^4 + B^5 + B^6 + B^7 + B^8 + B^9 + B^{10} + B^{11})\, x_t\,,$$

$y_{2t} = -(1 - B + B^2 - B^3 + B^4 - B^5 + B^6 - B^7 + B^8 - B^9 + B^{10} - B^{11})\, x_t$,

$y_{3t} = -(B - B^3 + B^5 - B^7 + B^9 - B^{11})\, x_t$,

$y_{4t} = -(1 - B^2 + B^4 - B^6 + B^8 - B^{10})\, x_t$,

$y_{5t} = -1/2\,(1 + B - 2B^2 + B^3 + B^4 - 2B^5 + B^6 + B^7 - 2B^8 + B^9 + B^{10} - 2B^{11})\, x_t$,

$y_{6t} = \sqrt{3}/2(1 - B + B^3 - B^4 + B^6 - B^7 + B^9 - B^{10})\, x_t$,

$y_{7t} = 1/2\,(1 - B - 2B^2 - B^3 + B^4 + 2B^5 + B^6 - B^7 - 2B^8 - B^9 + B^{10} + 2B^{11})\, x_t$,

$y_{8t} = -\sqrt{3}/2\,(1 + B - B^3 - B^4 + B^6 + B^7 - B^9 - B^{10})\, x_t$,

$y_{9t} = -1/2\,(\sqrt{3} - B + B^3 - \sqrt{3}B^4 + 2B^5 - \sqrt{3}B^6 + B^7 - B^9 + \sqrt{3}B^{10} - 2B^{11})\, x_t$,

$y_{10t} = 1/2(1 - \sqrt{3}B + 2B^2 - \sqrt{3}B^3 + B^4 - B^6 + \sqrt{3}B^7 - 2B^8 + \sqrt{3}B^9 - B^{10})\, x_t$,

$y_{11t} = 1/2(\sqrt{3} + B - B^3 - \sqrt{3}B^4 - 2B^5 - \sqrt{3}B^6 - B^7 + B^9 + \sqrt{3}B^{10} + 2B^{11})\, x_t$,

$y_{12t} = -1/2(1 + \sqrt{3}B + 2B^2 + \sqrt{3}B^3 + B^4 - B^6 - \sqrt{3}B^7 - 2B^8 - \sqrt{3}B^9 - B^{10})\, x_t$,

$y_{13t} = (1 - B^{12})\, x_t$.

2. Consider the price series, RP_t (retail price) and FP_t (farm price), the marketing margin, MM_t is defined as the difference between these two price series, $MM_t = RP_t - FP_t$. The series of RP_t and FP_t are co-integrated with co-integrating vector (1, -1) if the series of MM_t is stationary.

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