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Identification of Structural Breaks in Major Food Commodity Prices of Sri Lanka

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ABSTRACT

Food is an essential need of human. The fluctuations in prices of food commodities effect to all stakeholders including consumers, producers *etc.* Identification of structural breaks of a food commodity is very useful to make decisions about the market behavior and setting price polices. Thus this study focus on examining the price volatility and identification of structural breaks of food commodities found in the food basket of a rational consumer in Sri Lanka. In this study, a change point analysis was carried out using package 'changepoint' in R software to investigate the structural breaks a present in respective commodities. It was found that not only changes in price trends but also shifts in price variability over different time periods is apparent in all food commodities under the investigation. It revealed that structural breaks in prices of food commodities are more common during the recent past for which the reason need to be further investigated.

KEYWORDS: Change point analysis, Food commodity prices, Stochastic volatility, Structural breaks

INTRODUCTION

Sri Lankan food market prices are stochastic in its nature which creates a risky situation in the market. Moreover, periods with different levels of prices and price fluctuations can be experienced over the time for various food commodities. Structural break in price takes place when mean and/or variance of price changes persistently at a point in a time series. Usually a change point analysis helps to determine the point where significant change happened either with respect to mean or variance. Structural breaks appear to affect models used for evaluation of key economic and financial time series such as output growth, inflation, exchange rates, interest rates and stock returns (Ferreira *et al.*, 2013). Rappoport and Reichlin (1989) independently suggested that structural breaks provide a useful description of a variety of economic time series. Furthermore structural breaks of stock market prices were used to evaluate strategic positioning of European economics, namely interest rate fluctuations, stock market crises and regional effect of oil price (Ferreira *et al.*, 2013).

Understanding both long run and short run food price behaviors and relationships are important for basic production, marketing and food policy decision (Brenda *et al.*, 2008). Knowledge about the structural breaks throughout the marketing channel of food by various stockholders is a prime factor to predict future economic inventions.

Vegetable and field crop show high price fluctuations due to seasonal impact, agro-ecological factors, crop variety, demand and supply, degree of perishability *etc.* Generally market decisions are taken by both producers and consumers who are directly affected by the price fluctuations of many food commodities in Sri Lanka. Thus price information coupled with structural breaks is vital to all stakeholders including producers, distributors and consumers in making their market decisions properly. However, in Sri Lankan context, the research studies regarding change points on food prices are not so common.

Structural breaks of a time series can be easily detected by using change point package available in R (3.2.3) software with respect to mean and variance. Within the available time series, one of the key challenge in change point analysis is the ability to detect the multiple change points. A choice of multiple change points search methods is given by the change point package (Killick and Eckley, 2014).

With this background, this study was carried out to examine the dynamic price behaviors and identify structural breaks in prices of food commodities in Sri Lanka with respect to mean and variance by using change point analysis. The outcome of this study will be helpful for the policy makers and other stake holders for making of better market decisions.

METHODOLOGY

Data Collection

Monthly retail price of thirteen food commodities *viz.* milk, potato, onion, dhal, rice, tea, wheat flour, fish, chicken, eggs, up country vegetable and low country vegetable were used for the analysis which are commonly found in common Sri Lankan food basket.

Prices were collected from secondary data bases available at the Hector Kobbakaduwa Agrarian Research and Training Institute (HARTI) for the period from January 1985 to

December 2014. The monthly retail price (1985-2014) of rice, potato, onion, dhal, and 17 major vegetables were collected for the period from 1985 to 2014. Monthly price of fish, milk and tea were available for the period from 1996 to 2014. Colombo Consumer Price Index (CCPI) and Gross Domestic Production (GDP) deflator for the period under investigation was collected from the sources available at the Central Bank of Sri Lanka.

Data Analysis

Other than the nominal prices, real prices were also subjected to the analysis done in this study. For that purpose, nominal prices were deflated using the Colombo Consumer Price Index (CCPI) and Gross Domestic Production (GDP) as the price deflator, using the procedure given by Perera and Herath (2014).

Price returns were used in analysis for the purpose of understanding the rate of change in the price which reflects the risk associated with prices. Real price is adjusted for inflation, enabling comparison of quantities as if prices had not changed due to inflation. Changes in real terms therefore exclude the effect of inflation. In contrast with real value, nominal value is not adjusted for inflation, and so increases in nominal value reflect the effect of inflation as well. Price return is the rate of return on an investment portfolio which is more important to stakeholders to make their investment decision. Price return (r_t) can be obtained by using equation 1.

$$r_t = \frac{x_t - x_{t-1}}{x_{t-1}} \qquad (1)$$

Where, x_t and x_{t-1} is prices at time t and $t-1$. Preliminary analysis of time series data was done by constructing time series plots for nominal, real price with CCPI and GDP deflators and price returns. Time series data was tested for stochastic volatility by using Autoregressive Conditional Heteroscedasticity Lagrange Multiplier test (ARCH-LM) (Engle, 1982), MacLeod Li test (MacLeod and Li, 1983) and BDS test (Bowbrick *et al.*, 1976).

Change Point Analysis

All change point computations were done using 'changepoint' package in R (3.2.3) which facilitate to do number of methods for change point analysis found in recent literature for both change point with respect to mean and variance (Killick and Eckley, 2014). Change points can be detected thorough the single change point and multiple change point analysis. Single change point detection is used to detect only one change point of the data set. Detection of more than one change point can be done by using multiple change point analysis which mostly minimize

$$\sum_{i=1}^{m+1}[C(y_{(\tau_{i-1}+1):\tau_i})] + \beta f(m) \qquad (2)$$

Where, C is a cost function for a segment and $\beta f(m)$ is a penalty to guard against over fitting. If, m is known, a brute force approach to solve this minimization considers 2^{n-1} solutions reducing to $\binom{n-1}{m}$ number of solution. In this study, 'SegNeigh' method (Killick and Eckley, 2014) was used to identify the change points of food commodities since it provides the exact structural breaks which is one plus the number of change points (Killick *et al.*, 2016).

RESULTS AND DISCUSSION

Time series plot of nominal prices for all food commodities showed an increasing trend over the time. While that of real prices showed a decreasing trend over the time except for few commodities. As an example, nominal and real prices of *Samba* (Type 1) are depicted in Figure 1.

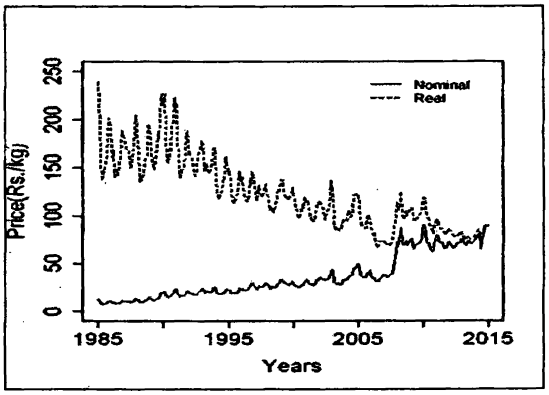


Figure 1. Time series plot of nominal and real price of *Samba* (Type 1)

Nominal price of *samba* (Type 1) shows an increasing trend over time, while its real price showed a decreasing trend. However, the magnitude of the trend was variable among different food commodities. In 2007, nominal price of *samba* (Type 1) showed a rapid increase which is lasting to date. Real price of *samba* (Type 1) showed sudden increasing and decreasing pattern from 1985 to 1992 without an apparent trend and continued to decrease thereafter. Unlike the other commodities, real price of wheat flour showed an increasing pattern though out the year. Real price of some fish verities (*Balaya, Thora, Mora etc.*) showed a decreasing pattern initially and then gradually an increasing trend.

Moreover, time series plots of prices provide some indication that there might be some volatility clustering present which may be

as a result of some structural breaks in the price series of respective food commodities of which the exact change point is not clearly found in the time series plot.

Results of the three tests for stochastic volatility/ volatility clustering applied on nominal price, real price and returns of all food commodities are given in Table 1. Results in Table 1 confirm that there is volatility clustering apparent in both nominal and real prices of all food commodities under investigation. This further alarm that there may be structural breaks in prices with respect to the price variance. This indicates that apart from the dynamic nature of the price trends, price volatility have also become dynamic which might have direct impact on decision at both consumer and producer sides. The three tests applied on price returns were not in agreement either to reject or accept the null hypothesis of not stochastic volatility for most of the food commodities under the investigation.

Table 1. Results of stochastic volatility tests for nominal price, real price and returns

Commodities	Nominal			Real			Returns		
	ARCH LM test	MacLoid Li test	BDS teat	ARCH LM test	MacLoid Li test	BDS test	ARCH LM test	MacLoid test	BDS test
Fish									
Salaya	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0271	0.0045	0.9872
Balaya	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0218	0.0039	-
Thora	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.9927	-
Mora	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.5758	0.6764	-
Sparats	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.4265	0.5885	-
Anguluwa	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.4581	0.3310	<0.001
Kelawalla	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0000	-
Kattawa	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0469	-
Chicken									
Curry	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0027	<0.001	-
Broiler	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0005	<0.001	-
Egg									
White	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0238	0.0503	-
Brown	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0467	0.0905	-
Rice									
Samba 1	<0.001	<0.001	<0.001	<0.001	<0.001	-	0.3118	0.2734	-
Samba 2	<0.001	<0.001	<0.001	<0.001	<0.001	-	0.2056	0.0238	-
Samba 3	<0.001	<0.001	<0.001	<0.001	<0.001	-	<0.001	<0.001	-
Nadu 1	<0.001	<0.001	<0.001	<0.001	<0.001	-	0.2031	0.3679	-
Nadu 2	<0.001	<0.001	<0.001	<0.001	<0.001	-	0.3389	0.4860	-
Row red	<0.001	<0.001	<0.001	<0.001	<0.001	-	<0.001	0.0652	-
Row white	<0.001	<0.001	<0.001	<0.001	<0.001	-	0.0273	0.0476	-
Potato									
Nuwara eliya	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0476	-
Walimada	<0.001	<0.001	<0.001	<0.001	0.111	-	0.0073	0.0011	-
Red onion	<0.001	<0.001	<0.001	<0.001	<0.001	-	<0.001	0.9492	-
Big onion	<0.001	<0.001	<0.001	<0.001	<0.001	-	<0.001	0.4132	-
Red dhal	<0.001	<0.001	<0.001	<0.001	<0.001	-	<0.001	<0.001	-
Wheat flour	<0.001	<0.001	<0.001	<0.001	<0.001	-	<0.001	0.6728	-
Milk	<0.001	<0.001	<0.001	<0.001	<0.001	-	<0.001	<0.001	-
Tea	<0.001	<0.001	<0.001	<0.001	<0.001	-	<0.001	<0.001	-
Vegetable									
Greenbeans	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.9529	0.9379	<0.001
Carrot	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.2842	0.1501	0.8278
Leeks	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.1029	0.0901	-
Beetroot	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0001	<0.001	-
Knolkhol	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0063	0.7890	-
Raddish	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0002	<0.001	-
Cabbage	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.5624	0.9999	0.9519
Tomato	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.9751	0.9734	0.5532
Ladies fingers	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-
Brinjal	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0002	<0.001	0.8268
Pumpkin	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.3424	0.1978	-
Cucumber	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.1412	0.0639	-
Bitter gourd	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0001	<0.001	-
Snake gourd	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0075	0.0603	-
Luffa	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.1395	0.1638	-
Long bean	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0068	0.0001	0.8849
Ash plantain	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0371	0.0080	-

Note: All values in the table are resulted p-values of each test

The Change Point Analysis revealed that there are structural breaks with respect to mean and variance of all food commodities under the investigation. For an example, results of change point analysis done on nominal price series of *samba* (Type 1) with respect to mean (A) and variance (B) are depicted in Figure 2.

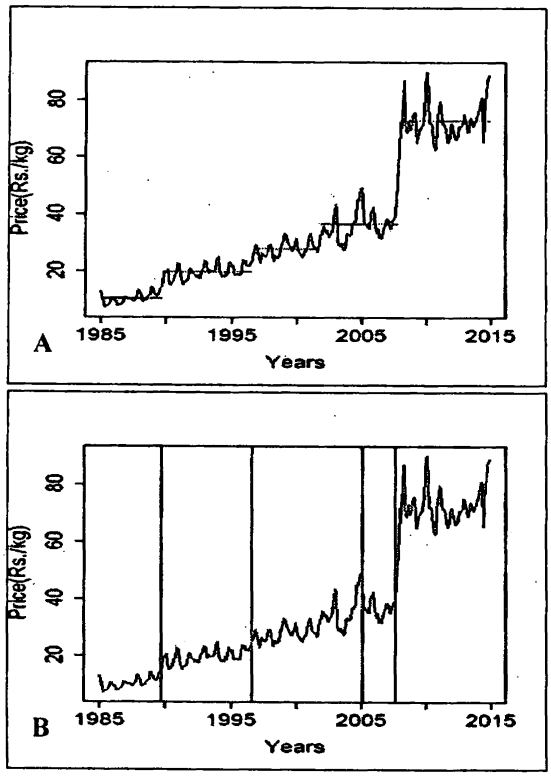
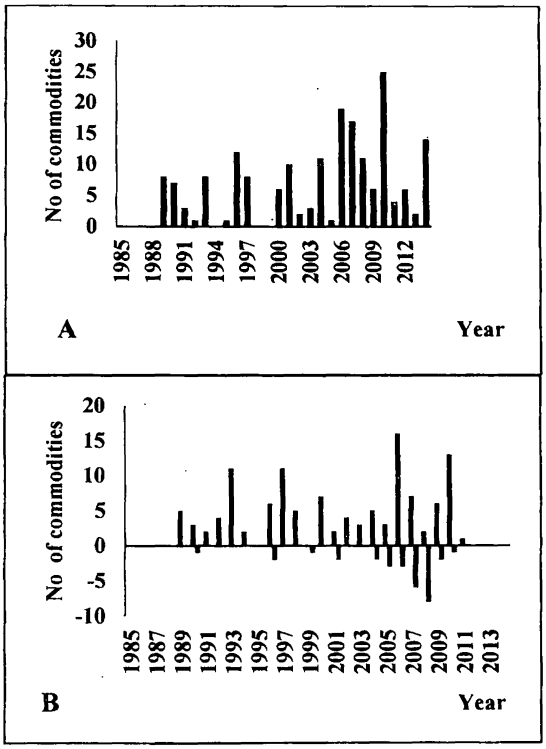


Figure 2. Change points in the nominal price series of *Samba* (Type 1) with respect to mean (A) and variance (B)

With respect to the mean (Figure 2A), it shows five significant positive structural changes in prices of *samba* (Type 1). However, with respect to the variance (Figure 2B), it shows four structural breaks with elevated variances (three from 1985 to 2005 and one from 2007-2014) and one structural break with declined variability (from 2005 to 2007) where different policies, political environments and climatic conditions had prevailed. Similarly change points that were reported for other food commodities can be used by various stakeholders for making decisions on the food market.

Number of commodities subjected to structural changes in nominal price and real price with respect to mean in a given year is depicted in Figure 3.

As indicated in Figure 3, it can be noticed that number of commodities that subject to structural changes in mean prices in both nominal and real terms has increased during pass two decade compare to 1980s and 1990s. Vibrant policies, political stability/instability and variable weather condition prevailed during



Figures 3. Numbers of food commodities with respect to mean changes in nominal price (A) and in real price (B) by year

these period may be the reason for observed high volatility of food prices during these periods. However, in terms of real prices, some commodities with down ward shifts in their real prices can be seen which coincide in the period from 2004-2010 for which the reason should be further investigated. However, there were no change points in mean price return of any food commodity observed during the reporting period which indicates that mean rate of change in food commodity prices remain unchanged over the time.

Numbers of food commodities with change points in the variance of nominal prices, real prices and nominal price returns by year are depicted in Figure 4. According to Figure 4A, in 1996, it shows the highest number of commodities with upward shift and in 2001 and 2008 show the highest number of commodities with downward shifts in nominal prices.

A quite unique distribution in number of commodities with upward changes can be seen throughout a long period (1985-2014). As depicted in Figure 4C, consequences of structural breaks in variance of price returns of the food commodities looks frequent in the recent past. This indicates that fluctuation of the rate of price changes of food commodities has gone up during recent past.

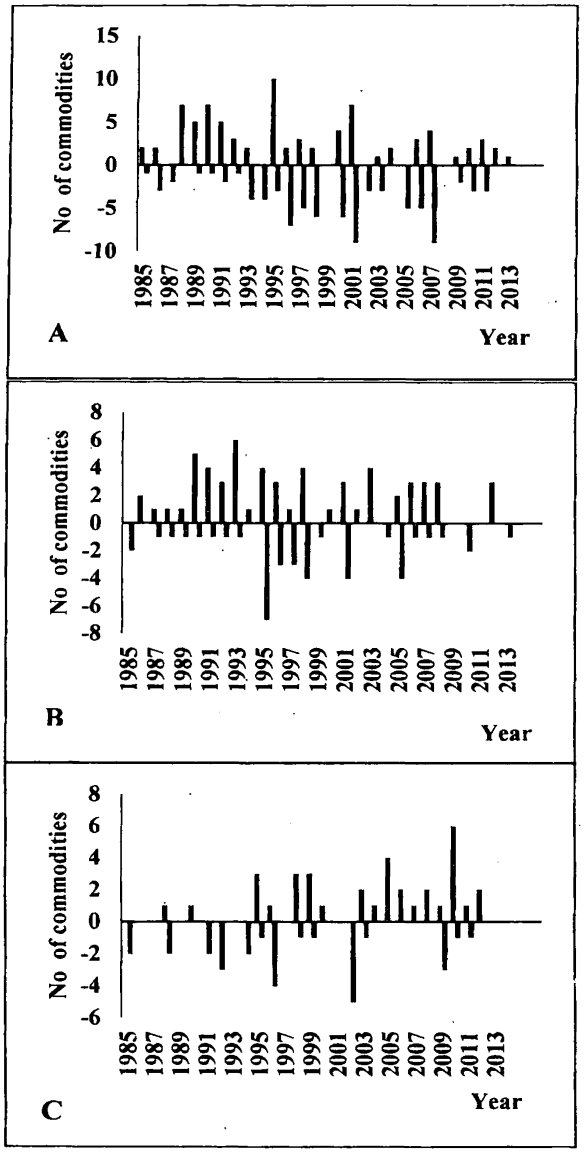


Figure 4. Numbers of commodities with respect to change in variance of nominal prices (A), real prices (B) and price returns (C)

CONCLUSIONS

In this study, it can be concluded that there is an increasing trend in nominal food prices while it turns either into a decreasing trend or rather remain unchanged in terms of real prices. This concludes that price hicks apparent in most of the food commodities are a consequence on increasing inflation. All food commodities have subjected to some structural change in terms of their average prices and/or their variability which can be used in support of better decision making by various stakeholders including the policy makers. It can be further verified that food commodities tends to change with respect to mean frequently during the recent past for which the reasons need to be further studied.

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