

Estimation of Cointegrating Relationship Between Agricultural Wage and Rice Price in Bangladesh

Masud Ibn Rahman*

Abstract: In this study, attempts have been made to present an empirical investigation on the agricultural wage and rice price in Bangladesh from 1973 to 2005 on various aspects of stationary and cointegrating regressions. Analysis followed by Dickey Fuller tests indicated that both the variables are integrated of order (0) and cointegrated. So the ordinary least square will give best results and there exists a long run relationship between these variables.

1. Introduction

In recent years, an increasing number of alternative models and estimation methods have been proposed for the analysis of multivariate cointegrated economic time series data. The original idea was to approach the problem using single statistic regression models, (e.g., Engle and Granger, 1987), but some researchers have investigated cointegration in a multivariate set up. For example, a system of statistical regressions was proposed by Park (1990), while dynamic short run models are favored in the studies of Johansen (1991), Johansen and Juselius (1990) and also Boswijk (1992). In all these multivariate analyses, one of the crucial problems is the identification of the various long-run relationships when they exist. This approach is very popular, i.e., the vector autoregressive based analysis of Johansen (1991), Johansen and Juselius (1992). The analysis of non-stationary time series, unit roots and cointegration developed dramatically over the last 25 years. The random walks model is one of the most well known time series model now a days. The Regression analysis based on time series data implicitly assumes that the underlying time series are stationary. The classical t test, F tests etc. are based on this assumption. But in practice, most time series are found non-stationary. If the mean, variance, and autocovariances of a stochastic process are constant over time (i.e. they are time invariant), it is called weakly stationary. At the formal level, stationary can be checked by finding out if the time series contains a unit root. For this purpose, the Dickey fuller (DF) and Augmented dickey Fuller (ADF) tests can be used. Those tests can be applied to determine whether a time series is Trend Stationary or Difference Stationary (DS). Regression on one time series variable on one or more time series variables often give non-sensual or spurious results. This phenomenon is known as spurious regression. One way to guard against it is to find out if the time series are cointegrated. Cointegration means that despite being individually non-stationary, a linear

* Assistant Professor, Faculty of Business and Economics, Daffodil International University, Dhaka.

combination of two or more time series can be stationary. Cointegration of two (or more) time series suggests that there exists long-run, or equilibrium relationship between them.

A belief in a systematic and stable relationship between wage and price behavior underlies much of standard macroeconomic theory. While most models share this belief, they differ dramatically when it comes to their presumed direction of casual influence. For example, the original Phillips curve relationship hypothesized that change in price imparts pressure on wages. Such an assumption is indicative of prices having a unidirectional impact on wage process. Within post-Keunesian economic thought, the notion that prices are set at a given percentage mark up over wage costs is popular. Interestingly, such models maintain that the wage process performs an independent casual role in the inflationary process. Furthermore, the expectations-augmented Phillips curve combines these theories and would, therefore, predict joint causality between price inflation and wage inflation. Finally, in order to complete the possibilities, many monetarist models fail to recognize any systematic relationship, let alone any causal relationship, between the two economic variables.

The dynamics of agricultural wage formation and its implications for poverty and income distribution have been a subject matter of much debate in Bangladesh. There are three major questions at the center of this debate: i) has an increase in agricultural productivity through green revolution technology translated into a reduction in rural poverty through increased wage income¹? ii) what has been the trend in the long-term movement of real agricultural wages and what welfare implications does it have for various groups of rural households? and iii) how do agricultural wages respond to changes in prices and other wages in the economy? In the face of low per capita income and increasing dependence of the poor on labor markets for their livelihood, these questions are of significant importance to the policy makers and development practitioners in the country². However, the answers to these questions, largely based on time series analyses, continue to remain elusive. While there is overwhelming micro-level evidence to suggest that the new technology has had positive impacts in alleviating poverty through direct productivity gains and through indirect linkage effects, macro-econometric analyses present a different set of results³. Using time series data from 1949/50 to 1980/81, available studies argue that real agricultural wage was on a downward trend during the period in which the

¹ In the context of green revolution in India, the debate over this question went on for long time. A collection of papers in the book edited by Mellor and Desai (1985) discuss different dimensions of this basic issue.

² In fact, this study was initiated in response to a request from the Ministry of Food, Government of Bangladesh, to re-examine the issue.

³ For micro-level evidence in Bangladesh, see Hossain (1988); for farm non-farm growth linkage, see Haggblade and Hazell (1989).

country experienced positive growth in overall agricultural productivity (Khan 1984, Ravallion 1990, Boyce and Ravallion 1991, Ravallion 1994). Furthermore, on the basis of their finding of low short-run elasticity of wages to rice price, Boyce and Ravallion (1991) express concerns that an increase in nominal rice price can have detrimental effects on the poor, for whom wage is the main source of income and rice occupies a major share of their expenditure⁴.

This study analyzes the wage-price dynamics using the most recent data. The first task is motivated by the new developments in time series econometrics, namely multivariate cointegration techniques, which have revolutionized the analyses of historical data. Since all of the past studies are based on classical regression method, the author of the present study consider it to be a worthwhile effort to re-examine the data under the new analytical framework.

Also within the framework of Johansen's multivariate cointegration technique, analyses suggest that agricultural wages and rice prices maintained a strong co-integrating relationship throughout the period from 1949/50 to 1979/89 (Rashid 2002). Using data from 1976/77 to 1998/99, Rashid (2002) demonstrated that rice price, which was strongly cointegrated until the late 1970s, was no longer a significant determinant of agricultural wages in Bangladesh. This implies that the widespread concern about declining purchasing power due to a sluggish adjustment of wages to rice prices was no longer valid in Bangladesh.

2. Literature Review

There are at least a dozen studies that have analyzed various aspects of agricultural wage formation in Bangladesh. Three major issues addressed by these studies are: (i) whether or not agricultural wages adjust to food prices and other wages in the economy (Ravallion 1987, Boyce and Ravallion, 1991; and Palmer-Jones 1993); (ii) whether productivity gains through green revolution technology trickled down to laborers through increased wage rates (Bose 1974; Khan 1984; and Boyce 1989); and (iii) whether market theory of labor demand and labor supply provides a better explanation of wage determination than *subsistence* or *efficiency wage* theories (Ahmed 1981, and Hossain 1990). The first two issues are the focus of this study.

An obvious starting point to re-examine these issues is the study of Boyce and Ravallion (1991), which is by far the most rigorous econometric study on the dynamics of agricultural wages in Bangladesh. Using annual data from 1949/50-1980/81, the study

⁴ Available studies suggest that expenditure elasticity of rice for the bottom quartile of the rural population in Bangladesh ranges from 0.68 to 1.01. See Ahmed and Shams (1996), Goletti (1994), and Hossain (1988).

pointed out several shortcomings of past empirical research on the subject and presented a new dynamic model for agricultural wage determination. In particular, Boyce and Ravallion (1991) demonstrated that Khan's (1984) findings of significant positive relationships between real wage, agricultural productivity, and improved agricultural terms of trade were spurious due to the failure to account for autocorrelation. Thus, following Sargan (1964) and Hendry, Pagan, and Sargan (1984), Boyce and Ravallion (1991) reformulated the wage equation in an *error-correction* framework, which included prices of rice, jute, and cloth (p^r p^j p^c), the manufacturing wage (w^m), agricultural output per net cropped area Q^b , and a time trend as explanatory variables. Assuming log-linear functional form, the wage equation was represented in 1-year vector autoregression in level as follows:

$$W^a_t = \alpha_0 + \alpha_1 w^a_{t-1} + \beta_0 p^r_t + \beta_1 p^r_{t-1} + \gamma_0 p^j_t + \gamma_1 p^j_{t-1} + \delta_0 p^c_t + \delta_1 p^c_{t-1} + \varepsilon_0 w^m_t + \varepsilon_1 w^m_{t-1} + \phi_0 Q^b_t + \phi_1 Q^b_{t-1} + \pi_0 t + \pi_1 t^2 + v_t \quad (t=1, 2, \dots, T)$$

----- (1)

To give error-correction representation, the above equation was re-written in the following equivalent form:

$$\Delta W^a_t = \alpha_0 + (\alpha_1 - 1)(w^a_{t-1} - p^r_{t-1}) + (\gamma_0 - \gamma_1)(p^j_{t-1} - p^r_{t-1}) + (\delta_0 - \delta_1)(p^c_{t-1} - p^r_{t-1}) + (\varepsilon_0 - \varepsilon_1)(w^m_{t-1} - p^r_{t-1}) + \beta_0 \Delta p^r_t + \gamma_0 \Delta p^j_t + \delta_0 \Delta p^c_t + \varepsilon_0 \Delta w^m_t + (1 - \alpha_1 - \beta_0 - \beta_1 - \gamma_0 - \gamma_1 - \varepsilon_0 - \varepsilon_1) p^r_{t-1} + \phi_0 Q^b_t + \phi_1 Q^b_{t-1} + \pi_0 t + \pi_1 t^2 + v_t$$

----- (2)

By imposing homogeneity restriction, i.e.,

setting $(1 - \alpha_1 - \beta_0 - \beta_1 - \gamma_0 - \gamma_1 - \varepsilon_0 - \varepsilon_1) = 0$, and following a *general to specific* modeling technique to drop the insignificant variables, the authors estimated the following parsimonious model:

$$\Delta w^a_t = 0.045 + 0.22(p^r_t - p^c_t) + 0.47(w^m_t - w^a_{t-1}) - 0.32(w^m_{t-1} - w^a_{t-1}) - 0.00037t^2 + \hat{v}_t$$

----- (3)

The major conclusions of Boyce and Ravallion (1991) and Ravallion (1990) are based on these results. Pointing to low short-run elasticity of the agricultural wage rate with respect to a change in the rice price, which is estimated to be 0.22, the study expresses concerns that a sluggish adjustment of wages and rice prices can have detrimental effects on the poor, whose major source of income was presumed to be agricultural wages.

A second major conclusion was that increases in agricultural productivity (measured by the value of agricultural output per net cropped area) did not have a significant impact on agricultural wages. This conclusion was based on the insignificant coefficient of the

agricultural productivity variable in the initial regressions that led to this variable being dropped in the “parsimonious” model. Palmer and Jones (1993) criticized the analysis Boyce and Ravallion on the grounds that the “parsimonious” model failed the prediction and stability tests when estimated over the period up to 1989. The modeling framework of Palmer and Jones is essentially the same as that of Boyce and Ravallion, except the fact that he included a dummy variable for 1972-1974, and a discontinuous time trend (with a value of 1 in 1949 up to 16 in 1964 and 0 afterward) into his analyses. These new time trends and dummy variables are important for Palmer-Jones’s specification to support his conclusions that the longer period estimates do not support the earlier findings of Boyce and Ravallion’s finding that the implicit long run real wage rate was on an alarming downward trend. In his rebuttal, Ravallion (1994) acknowledged the prediction failure but forcefully criticized the use of dummies and the time trend, which in his view was an *odd half-time* trend because it suddenly dropped down to zero from 1964 onward. Using a new set of variables and a new parsimonious model, he showed that the longer time series can produce an equation that fits the 1980s data. Moreover, unlike the Palmer-Jones model, his model is homogenous, i.e. the real wage depends only on real, not nominal, variables. There are significant changes relative to the earlier model, however. There is no significant time trend and growth rate in output now have a significant effect on real agricultural wages. In conclusion of the rebuttal, Ravallion stood by the conclusions of Boyce and Ravallion (1991) that the real wages were declining much of the 1960s and 1970s. There are at least two reasons to be cautious about these studies. First, all of these studies are based on Ordinary Least Square (OLS) estimation with non-stationary explanatory variables, which gives rise to spurious relationships among the variables and inconsistency of parameter estimates (Dickey et. al 1994). This study addresses these issues in analyzing the dynamics of wages and prices. Some research areas received scant treatment, including other estimation methods for cointegration vectors, as well as studies of their properties, (see Bewley, Giden and Fisher (1991), Boswijk (1991), Box and Tio (1977), Engle and Yoo (1991), Phillips (1991) and Sikkonen (1991)).

3. Objective of the Study

The dynamic relationship between wage and price has long held a central place within the economic literature. Most macroeconomic model makes assumptions as to the casual relationship between the two variables. Unfortunately, empirical investigation has produced widely divergent results. So, the necessity of a long-run relationship between wage and price series is being felt. Once the wage-price relationship is embedded within a multiple vector system, identification of a wage-price cointegrating relationship is significant and that yields evidence in favor of the dual feedback between wage and price. The objective of present paper is to examine the results. If time-series studies to

test whether there is any cointegration between the agricultural wage and rice price in Bangladesh for the last 3 decades. So the main objective of this study is to examine the dynamics of agricultural wage formation in Bangladesh as well as relationship with rice prices.

4. Data and Methodology

The monthly data series for agricultural wage and rice price for 1973 to 2005 were taken from various sources of Bangladesh Bureau of Statistics (BBS). Daily wages (without food) for agricultural labors in Bangladesh are considered. The figures are in Taka, and are simple average of the districts wage rates; where the district wages are themselves average of several centers within the districts. Here wage without food means the “cash wage” if no food were provided to the laborer by the landlord. However the author of the present study did not consider the case when food is provided to the laborer by the landlord. Wage series are collected from the supplement to the Bangladesh Gazette, Government of Bangladesh, Various issues; Monthly Bulletin of Statistics, Ministry of Planning, Govt. of Bangladesh, and Statistical Yearbook of Bangladesh, various issues, Bangladesh Bureau of Statistics.

Average wholesale price of coarse quality rice (i.e. de-husked paddy) per mound (less than 40 kg) in Bangladesh is taken. This price is most near to the price paid by labourers as buyers. Rice price is actually a proxy for CLI (cost of living index) which is not available for such long time, especially for the early dates. Price series are taken from the Directorate of Agricultural Marketing, Government of Bangladesh; Monthly Bulletin of Statistics, Various Issues, Bangladesh Bureau of Statistics, Ministry of Planning, Government of Bangladesh; Statistical Yearbook of Bangladesh, various issues.

Note that agricultural wage rates in Bangladesh vary depending on whether or not employers provide meals to their workers. We use district-wise wage rates of agricultural workers without meals. This is different from the manufacturing wage rates used in the previous studies, which was an average wage rate of the unskilled workers in the manufacturing sector such as jute and textile industries.

In this research the empirical analyses are based on cointegration techniques. The concept of cointegration states that if a long run relationship exists among a set of nonstationary variables, then the deviation from the long run equilibrium path should be bounded. In other words, the existence of a long-run relationship implies that cointegrated variables cannot wander too far away from each other. Formally, two non-stationary series x_t and y_t are said to be cointegrated if the following two conditions are satisfied: (i) both series are integrated of the same order, and (ii) a linear combination of x_t and y_t exists which is $O(1)$ i.e., stationary. Therefore, the first step in cointegration analyses is to examine the

order of integration (stationarity) of relevant variables (Banarjee et. al., 1993; Muscatelli and Hurn, 1992).

Once the order of integration is determined, the next step is to determine whether the non-stationary variables form a co-integrating or long run relationship among them. Engle and Granger (1987) demonstrate that for any set of $I(1)$ variables, error correction and cointegration are an equivalent representation. In other words, if an error correction model provides sufficient depiction of the variables, then the variables must be cointegrated, and vice versa. This provides the basis for using an error correction model in the cointegration framework for analyzing the dynamics of agricultural wage formation. We have used Dickey and Fuller test for this purpose. Although Engle and Granger (1987) proposed a simple estimation technique, their methodology was subsequently criticized to have serious econometric shortcomings. The methodology presented in Johansen (1988) and Johansen and Juselius (1990) overcome those shortcomings and provide ways to test parameter restrictions and other structural hypotheses in a cointegrated system. One of the striking features of this method is that since estimation is carried out in a multivariate VAR framework, it does not make any *a priori* assumption on endogenous or exogenous divisions of variables. It also enables the determination of whether more than one co-integrating relationships exist. Estimation of the model of the present study in this framework is described in section 4.2. Data are analyzed by econometric software SHAZAME 7.0 and a simple cointegration model has been estimated.

5. Analysis of Individual Series

Both the price and wage series were analyzed using (Shazame 7.0, SPSS 12.0) to check for the order of integration. Both the series were found to be integrated of order 1. The findings of the analysis along with the considered models are presented in Table1, Table 2 Table 3 and Table 4.

Table1: Ordinary Least Square estimation of monthly agricultural wage and rice price from 1988- 2005

| Vriable | B | SE of B | Beta | T | Sig T |
|---------|-------|---------|-------|-------|-------|
| Wage | .1186 | .0193 | .2842 | 6.127 | .0000 |

Equation: $W_t = \alpha + \beta P_t + V_t'$ R square =.08082 Adjusted R Square =.0786 F =37.54
Sig F = .0000

Regression Results on monthly agricultural wage and rice price from 1973 to 2005 in Bangladesh are presented in the following Table 2 under the considered model:

$W_t = \alpha + \beta P_t + V_t'$. The P-value which is presented in the last column (Sig T=.000)

indicates the null hypotheses of stationarity is rejected. So some seasonal adjustments are necessary for the wage series. To do such, eleven seasonal dummies are considered to estimated the adjusted agricultural wage series. The adjusted cointegrating relations are shown in Table-4. The R square (.08) show the unexplained variation explained by the dependent variable. So the 8% of the variations are explained by the independent variable rice price in the process.

Table 2: Ordinary Least Square estimation of monthly agricultural wage and rice price from 1973- 2005

| Vriable | B | SE of B | Beta | T | Sig T |
|---------|--------|---------|-------|-------|-------|
| Price | .00932 | .00709 | .0634 | 1.314 | .1896 |

Equation: $W_t = \alpha + \beta P_t + V_t'$ R square =.00403 Adjusted R Square =.00169 F =1.726
Sig F = .1896

The ordinary least square estimate of the monthly agricultural wage and Rice Price of Bangladesh have shows that the relationship between these two variables is positive although it is not very strong. IT is also found from the P-value (Table-2 column 6) that the hypothesis of stationarity was accepted. So there exist a poor explanation of variation $R^2 = .001$ that are explained by the independent variable rice price in the process.

Therefore we can go for the integration order or integrating relationship of the series considered. Next section states on the basis of a test of conintegration whether these two series are cointegrated or not.

Test for Cointegration

Before discussing cointegration tests, it could simply be applied the unit-root tests to linear combinations of the data if we know the form of the cointegrating vectors present in the system of time series. For cointegratig tests it is only necessary that no univariate series have multiple unit roots which are found to be true for our data. Cointegration may still be used if some series are stationary if we wish to study long run relationship between variables.

Based on the idea that we could apply unit root test to nominal wage differentials and if we reject a unit root, we would conclude that we have indeed discovered a cointegrating vector which produces a stationary combination of our data. Consistent with this ideas, unit root tests were in fact, applied to wage differentials and the results indicated the need for using format test estimation procedures to determine the stationary linear combinations (if any) that is preset in our data.

Table-3: Cointegrating regression results between monthly agricultural Wage and Rice price of Bangladesh from 1952-1988.

| Vriable | B | SE of B | Beta | T | Sig T |
|-------------------|--------|---------|---------|--------|-------|
| $\Delta \hat{V}'$ | -.4086 | .4066 | -3.9052 | -8.766 | .0000 |

Eq: $\Delta \hat{V}'_t = \rho * \hat{V}'_{t-1} + \varepsilon_t$ R square= .15251 Adjusted R Square=.15053 F =76.84066 Sig F= .0000

We have estimated the cointegration regression $W_t = \alpha + \beta P_t + \varepsilon_t$ using both unadjusted and adjusted data and the estimated regression are

$$W_t = .4502 + .11861 P_t + \varepsilon_t$$

$$t: \quad (3.040) \quad (.1836E-01)$$

To perform the modified DF test we estimated the equations $\hat{\Delta \varepsilon}_t = \rho * \varepsilon_{t-1} + u_t$

And obtained the following equations $\hat{\Delta \varepsilon}_t = -0.408609 \varepsilon_{t-1}$ t: -8.766

Our null hypothesis for the equation is

$$H_0: \rho = 0$$

$$H_1: \rho \neq 0$$

Following is the result of seasonally adjusted series of agricultural wages and rice price in Bangladesh. The P-value presented in the last column (t=.0000) shows that there exist a cointegrating relationship between these tow variables, agricultural wage and rice price.

Table 4: Cointegrating regression results between monthly adjusted agricultural wage and rice price in Bangladesh from 1952-1988

| Vriable | B | SE B | Beta | T | Sig T |
|-------------------|----------|-------|---------|---------|-------|
| $\Delta \hat{V}'$ | -.911456 | .0481 | -.67511 | -18.910 | .0000 |

Eq: $\Delta \hat{V}'_t = \rho * \hat{V}'_{t-1} + \varepsilon_t$ R square = .45577 Adjusted R Square=.45450 F =357.600 Sig F= .0000

Here estimated t is found to be -8.766 and tabulated t is found to be -4.00 for the first equation and estimated t for second equation is -18.910 and tabulated t is found to be -4.00.

Thus for both the cases of agricultural wage and rice price, we find that calculated value is larger than tabulated value. So we reject the null hypothesis that the coefficient is equal to zero.

5. Findings

From the above analysis we reject the null hypothesis that the least square residuals are not stationary and therefore do not reject the null hypothesis that the agricultural wage and rice price, are cointegrated except that .1092 is a valid estimate of the long-run relationship between agricultural wage and rice price.

Unfortunately, the t statistics in equation $\hat{\Delta}\varepsilon_t = -0.408609 \varepsilon_{t-1} \quad t = -8.766$ do not indicate the precision of the least square estimator in the cointegrating equation, since \mathbf{W}_t and \mathbf{P}_t are both $I(1)$, the usual least square sampling results do not hold. Specially Stock (1987) has shown that the least squares estimator of the cointegration is super consistent, converging the true parameter at a rate faster than the least squares estimator converges in the usual case where variables like wage and price are not integrated. However the sample distributions are not normal, so usual inference procedures does not hold.

6. Conclusion

Like many other Asian countries, the causal relationship between agricultural wage and the rice price has been a widely debated subject in Bangladesh. A number of studies argued that the real agricultural wage rate was declining during the period when the country had experienced overall agricultural growth. This study analyzes dynamics of agricultural wage and rice price using the most recent data. Multivariate cointegration techniques are used to examine the long run and short run relationships among agricultural wage rate and rice price. The results show that agricultural wage and rice price maintained strong co-integrating relationships during the periods 1973-2005.

Some previously drawn conclusions by the researchers showed alarming downward trends in agricultural wages relative to rice prices. Results from Table-1 to Table-4 suggest that agricultural wage and rice price maintained a strong co-integrating relationship during the period 1973-2005. The long run elasticity of agricultural wage rate with respect to rice price is estimated to be 0.72 and 0.69 for Boyce-Ravallion (1991) and Palmer-Jones (1993) data sets, which are substantially higher than their estimates of 0.46 and 0.47 respectively. This study also supports the concept that there exists a cointegrating relationship between these two variables and thus, have a long run relationship between them.

7. Reference

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Appendix

Regression Results on monthly agricultural wage from 1973-2005 using 11 seasonal dummies for Bangladesh data.

Equation considered is $W_t = \mu + \sum \delta_i S_i + u_t$

| Variable | B | SE B | Beta | T | Sig T |
|-----------------|----------|----------|---------|--------|-------|
| S ₁ | -54.0387 | 9.911164 | -.32088 | -5.452 | .0000 |
| S ₂ | -54.0227 | 9.911164 | -.32078 | -5.451 | .0000 |
| S ₃ | -53.7287 | 9.911164 | -.31904 | -5.421 | .0000 |
| S ₄ | -53.5516 | 9.911164 | -.31798 | -5.403 | .0000 |
| S ₅ | -53.5179 | 9.911164 | -.31778 | -5.400 | .0000 |
| S ₆ | -53.3641 | 9.911164 | -.31687 | -5.384 | .0000 |
| S ₇ | -53.2964 | 9.911164 | -.31647 | -5.377 | .0000 |
| S ₈ | -53.4333 | 9.911164 | -.31728 | -5.391 | .0000 |
| S ₉ | -53.4084 | 9.911164 | -.31713 | -5.389 | .0000 |
| S ₁₀ | -53.2481 | 9.911164 | -.31618 | -5.373 | .0000 |
| S ₁₁ | -53.1139 | 9.911164 | -.31539 | -5.359 | .0000 |

Equation $W_t = \mu + \sum \delta_i S_i + u_t$ R Square=.1241 Adjusted R Square=.10100 F=5.371 Sig F = .0000