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Farm Wage and Rice Price Dynamics in Bangladesh

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Abstract

Concepts explaining the wage-price nexus in Bangladesh are diverse and conflicting. A proper understanding of the relationship between food prices and rural wages is essential for planning policies in support of the rural poor. In exploring the link between food prices and rising agricultural wages, this study analyzes the dynamic relations between those two by using monthly data from 1994 to 2014. A standard vector error correction model (VECM) is implemented to determine the short-run and long-run relationships between wages and food prices in eight divisions in Bangladesh. In addition, we use autoregressive distributed lag (ARDL) models to estimate the pass-through coefficients and to compare the short-run effects of rice price and urban wage shocks on agricultural wages. We find statistical evidence for a structural break between January 2007 and January 2009 in the relationships of the variables in all divisions. After the structural break, in six out of eight divisions, any shock in rice prices does not transmit to the farm wages in the short-run. Moreover, our findings show that in the long-run food prices have become less influential in explaining the changes in rural wages while the influence of urban wages has become stronger in some divisions.

Keywords: Agricultural Wages, Lewis Transformation, Rural labor markets, Bangladesh

JEL codes: Q11, J21, J31

1 Introduction

It is one of the primary objectives of low-income countries to achieve economic development. To improve the well-being and socio-economic conditions of the population, it is essential for policymakers to create employment opportunities. However, rising food prices in recent years have created serious concern about rising poverty and food insecurity in the developing world (Barahona & Chulaphan, 2017). Against this background, there is also the view that farm households in developing countries, who are not only consumers, but at the same time food producers, could benefit from higher prices, yet the magnitude of such benefits is controversial (Ivanic & Martin, 2014). However, the projections of benefits for producers are based on the assumption that higher food prices one-to-one translate into higher wages.

In Bangladesh, the agricultural sector provides both food and employment for the population. In the fiscal year 2016-17, its contribution to the GDP was about 14%, with an annual growth rate of about 3% from 2015-16 (World Bank, 2018). The provisional estimates for fiscal year 2017-18 showed that the manufacturing and construction sectors had grown by about 13% and 10% in 2017, respectively (BBS, 2018). Most of the unskilled and semi-skilled laborers are involved in both agriculture and non-agriculture activities, i.e., providing manual labor in crop production and industries. In many developing countries, the responsiveness of wages to prices determines how the standard of living of the poor evolves (Boyce & Ravallion, 1991). The importance of the link between farm wages and food prices is also reflected by national statistics. In Bangladesh, the bottom 5% income group of the rural households spends 71.4% of their total consumption expenditure on food (Statistical Year Book, 2016) and in consequence, large spikes in food prices are a serious threat to this group (von Braun and Tadesse, 2012). Among the different food grains, rice alone is consumed by more than 90% of the population, and it covers 75% of the total cropped land (HIES, 2010). Rice farming is the largest activity in the agricultural sector, employs about 45% of the rural labor force, and also provides two-thirds of the caloric requirements of the nation. Thus, it is very likely that changes in rice prices will have a significant impact on agricultural wages, poverty, and food security.

The structural transformation process in many less-developed agrarian economies is characterized by strong changes in the agricultural sector. This can be both a cause for and consequence of market imperfections in food and labor markets (Timmer, 1988). However, the structural transformation of agrarian economies into industrialized and service-oriented economies is the key to sustainable development. The reallocation of labor from agriculture to other sectors of the economy is one of the aspects of economic growth. In this way, increases in urban wages may transmit to higher farm wages (Headey et al., 2012). Exploring the relationship between agricultural and non-agricultural wages as well as staple food prices is an important empirical issue in the blink of such a transformation of the economy for planning proper polices to support the poor. Soared food prices in the last decades caused government interventions, e.g., governments have launched rice distribution at a subsidized rate, controlled import duties, and subsidized production. These interventions are based on good intentions, but not always improve the situation in a sustainable manner (Kalkuhl et al., 2016). This signifies the importance of providing empirical evidence on the welfare implications of rising prices to support policymaking.

The determination of the welfare effect of increasing food price and wage changes in the less developed countries require the determination of wage-price elasticities of the rural poor. The quick or sluggish adjustment of wages to rice prices may have positive or detrimental effects on the poor because physical labor is the primal sources of their earning. Jacoby (2016) empirically estimated that rural wages in India respond to price increases, in particular, if the shares of the particular food crops, whose prices change, is large. In this way, increasing food prices may improve well-being. This finding is supported by Lasco et al. (2008) and Headey et al. (2014), who estimated wage-food rice price elasticities for Indonesia and Ethiopia. In both cases, the elasticity is close to unity. However, several studies (e.g., Ivanic and Martin, 2014) that estimate the poverty implications of rising food prices have some theoretical and conceptual limitations as they assume an instantaneous price-wage transmission in the general equilibrium framework. Ivanic and Martin (2014) assume a medium-run wage-rice price elasticity of 0.6 for Bangladesh. Further, they ignore the possibility of structural breaks in the relationship between wages in prices. The implication is that if wages respond inelastic to the change in rice prices, then rural workers, who offer their labor on farms and who are net buyers of rice, will not be able to purchase as much rice as prior to the price change. Conversely, net sellers of rice will be able to hire more labor for rice cultivation and realize greater net income. The opposite is true if the wage-price elasticity is elastic.

Bangladesh has experienced a structural transformation of its economy, and is projected to advance from the least developed country status to a developing country in 2024 (Zhenmin, 2018). Within the past ten years, this has contributed to a sharp increase in farm wages, which almost closed the gap between rural and urban wages. Earlier studies (Rashid, 2001; Zhang et al., 2014) suggest that neither the neoclassical theory of labor nor the efficiency wage hypothesis is consistent with the recent trends. Instead, unlike for many other Asian countries, the structural transformation in Bangladesh follows the prediction of the Lewis (1954) model which sketches a dual economy with unlimited labor supply. The Lewis turning point is reached when rural wages increase in consequence of labor migration to the industrialized sector.

The primary objective of this research is to understand the relationship between food prices, urban, and rural wages. This will enable us to comment on the extent the process of structural transformation in Bangladesh has advanced. Furthermore, we formally test the Lewis hypothesis by examining the existence of a structural break in the relationship between rural and urban wages, the so-called Lewis turning point. For these purposes, standard time series econometrics will be applied, which also allow us to answer central research questions such as: (i) does the agricultural wage rate respond to changes in rice prices?; (ii) are agricultural labor markets independent of urban labor markets?; and (iii) how fast is the adjustment in farm wage rates in response to changes in rice prices and urban wages?

Understanding the interlinkages between food prices and wages is of vital importance to the policymakers and development practitioners in a developing country like Bangladesh to set up appropriate policies to reduce hunger and poverty and to foster economic growth. This paper attempts to resolve the shortcomings of previous studies on the interlinkages between food price and wages in Bangladesh. Within the existing literature, little attention has been given to understanding the wage-price responsiveness at the subnational levels, which would be essential to investigate for properly assess related policy implications. In doing so, we also update early studies on wage formation in Bangladesh (e.g., Boyce and Ravallion, 1991; Rashid, 2001) by using a unique data series of prices and wages from 1994 to 2014. The utilization of such a long data series facilitates a reliable and meaningful interpretation of the changes in wage-price elasticities over time and their implications regarding the structural transformation of the Bangladeshi economy. Most of the existing literature is limited to a descriptive analysis (e.g., Zhang, 2013). Closely related to the present work, Zhang et al. (2014) discuss the structural transformation of labor markets in Bangladesh. However, their analysis focuses on the welfare implications of this fundamental transformation process, and they consider the drivers of the structural change within a conceptual framework without the help of econometric tools. We close this gap by exploring the present trend of staple food prices and agricultural wages in Bangladesh empirically. Findings from this study will therefore help to decide whether the rice price is still a significant determinant for rural welfare and poverty reduction, whether the government should continue to control the price to reduce rural poverty or whether it would be more beneficial to instead foster off-farm employment.

The remainder of the paper is structured as follows. Section 2 presents and discusses prevailing labor market theories and their implications for wage formation. After that, we give a brief overview of the structural transformation process in Bangladesh using descriptive statistics. In Section 4, the methodology and the data set are described. The presentation of the results and their discussion follows in Section 5. Section 6 concludes this paper and provides some policy recommendation.

2 Labor market in developing countries and basic theories of real wages

Over the past decades, there have been several theories on the formation of wages. Hereby, wages are defined according to ILO convention 95, under Article 1, as means of remuneration or earning, which are payable by an employer to an employed person for the work done based on an agreement between the two parties. Generally, it is possible to analyze labor markets from a macroeconomic or microeconomic perspective. From a neoclassical macroeconomic point of view, the level of employment and wages are determined by demand and supply assuming perfectly competitive markets. The slope of the supply curve is subject to the income and substitution effects, both of which increase wages. The more the substitution effect outweighs the income effect, the more elastic the labor supply is. The demand side of the neoclassical and Keynesian models are the same. Differences arise on the supply side since the Keynesian model features a horizontal labor supply at the subsistence level. This is in line with the models of Lewis (1954) and Leibenstein (1957) who assume that the wage rate needs to cover at least the expenditures for the food consumption to render the work effort, which is known as the efficiency wage hypothesis. Thus, at lower levels of employment, a shift in the demand for labor changes the level of employment, but wages remain stable at the subsistence level.

The earlier discussion concentrated on single labor and competitive labor markets. An economy, however, is typically characterized by multiple sectors, which implies that the labor market should be modeled as a number of segments; for instance, high-skilled and low-skilled, formal and informal, agricultural and industrial, etc. The dual-sector model by Lewis assumes such a labor market situation. In this theory, there is a subsistence sector and an industrialized sector, which could be a rural or urban sector. The main assumption is that there is a surplus of low-skilled workers in the subsistence sector. In the industrialized sector, wages are higher than in the subsistence sectors, but relatively rigid. Due to the surplus labor, the supply curve is horizontal at the subsistence level. Economic growth and technological progress will increase the demand for industrialized labor which is satisfied by labor force moving from the subsistence to the industrialized sector. Wages in the subsistence sector remain stable until the surplus labor is exhausted. After that point, an increase in the demand for labor raises the wages (Ray, 2010). This is known as the Lewis turning point and, in accordance with the model of structural transformation, after this point the gap between the two comparable economies will start to attenuate.

In general, in developing nations, the labor market consists of a small number of labor market segments linked to one another by the potential mobility of workers, i.e., formal and informal. Modeling the informal sector labor market, most of the models build on Lewis and Kuznet's view that people are working informally because there are not enough jobs in the formal labor market manifested in the crowding hypothesis (Kuznets, 1955). They agreed that economic growth marks the gradual shift of laborers out of the lower-paying sectors and into the higher-paying ones. Investment in human capital improve workers' skills, enabling them to work in different economic sectors and to earn more. In addition, it was established that even in the informal sector there is a fundamental duality as some people are employed in a lower rank or line as the entry to this line is more accessible, while others work in an upper tier into which entry is restricted due to human and financial capital prerequisites (Fields, 2011).

Understanding the individual worker also generates additional insights into wage determination and labor market characteristics in the developing country's context. In the Harris and Todaro (1970) model, rural and urban labor markets in developing countries are linked through costless rural-urban migration flows. Changes in urban employment opportunities will also incentivize rural laborers to migrate to the urban labor markets. Due to the rigidity of wages, additional labor supply will not affect urban wages, but generate urban unemployment. Thus, rural-urban migration will take place as long as the expected urban wage exceeds the wage in the agricultural sector. In the agricultural sector, wages are unaffected by price changes as long as the supply of labor is abundant. In this way, rural wages are closely linked to urban labor markets.

Furthermore, a major character of rural labor markets in developing countries is the relatively large share of self-employed workers who cultivate their farms or run their small-scale enterprises (Emran & Shilpi, 2018). In consequence, the effort of self-employed and off-farm laborers needs to be considered. The shadow wage of labor supply refers to the opportunity costs of the forgone output at the farm if the labor was not used on-farm. This means that off-farm wages need to be sufficiently high for workers to enter the labor market instead of working on their farms.

The nominal wage itself is not a very meaningful number in the context of developing countries characterized by large inflation rates. What matters is the purchasing power associated with the wage level. Real wages are adjusted by inflation considering the number of goods and services that are consumed, e.g., nominal wages divided by the consumer price index. Thus, consumer prices, in particular for necessity goods, become a main driver of subsistence wages. However, the sticky wage model postulates that wages do not adjust quickly when prices rise or fall. Thus, price inflation will always be associated with a fall in real wages that make labor becomes cheaper. But why are wages sticky? In the industrial sector, the wage contract fixes nominal wages for the period of the contract. Contracts in the firm sectors are usually longer than the farm sectors (at least 1-2 years). So even though economic conditions could change, the agreement is still in force and workers and firms accept the same wage fixed at the time of negotiating. That means that the wage is sticky throughout the agreement. From an agricultural point of view, contractual arrangements with manual laborers during the rice sowing and harvesting season are quite common. There are small groups of laborers (8 to 10 per group) who make an advanced contract with the producers for a certain service. For example, one month before harvesting rice, farmers make a contract with the leader of such a group under a fixed negotiated price. However, in farm activities, most of the labor requirements are seasonal which is why many households pursue relatively short periods of contracts (3-4 days) for a specific task, e.g., manual harvesting or threshing. Only large-scale farmers tend to hire labor on a contractual basis in which case the laborer will work all year round under a yearly payment (Gulesci, 2015). Wage or price stickiness means that the economy may not operate at its highest potential. Rather, the economy may operate either above or below potential output in the short-run. Correspondingly, the overall unemployment rate will be below or above the natural level. Moreover, sticky wages are contradictory to the assumption of a unity price elasticity of wages in the GTAP models developed by Ivanic and Martin (2015) for measuring the impacts of higher food prices on poverty (Kalkuhl et al., 2016).

Farm wage determination is always a debatable concept in developing countries (Hossain, 2008). Several theories explain wages, i.e., agricultural wages, and each different theory has strong advocacy in favor of its arguments under certain conditions. In the body of the economic literature, some groups of economists like Ravallion and Datt (2002) or Dollar and Kraay (2002) believe that prosperity brought by the green revolution in the 1990s has a trickle-down effect such that rural wages are positively affected by agricultural productivity. The hypothesis here argues that higher productivity means lower agricultural prices as well as higher employment, which in turn means a higher wage (Rahman, 2009). The basic wage models of Rahman (1993) and Ravallion (1990) were able to prove the trickle-down effect in the short run, but not in the long run. Another group of thought believes that when real wages stay for a longer cycle of time, then the economy has surplus labor, and wages and employment under such a condition are explained by the nutrition-based efficiency wage theory (Hossain, 2008). This theory of wage-efficiency describes the dependence of production on consumption and argues for paying a wage that covers the calorie requirement of the labor. However, studies by Rosenzweig (1980) for India and Ahmed (1981) for Bangladesh suggest that in labor-abundant countries agricultural wages started to exhibit long-term upward trends with fluctuations. Such trends and fluctuations in farm wages disfavor the nutrition-based wage arguments. Recently, the majority of the literature supports the Lewis dual economy model with unlimited labor supply to explain the higher agricultural wages in developing countries like Bangladesh. At the same time, the proposition of sticky wages in the Keynesian model is also subject to investigation. If wages rise (drop) with an increase (decrease) in food prices and if this is not adjusted shortly with a decrease (increase) in food prices, then it can be said that wages are sticky under certain circumstances. Thus, in short, different theories have separate views, and the debate is all about the shape of the labor supply schedule in a specific environment.

3 Structural transformation in Bangladesh

A country's economic development is strongly related to the structural transformation of the economy. In this process, the labor force moves from the primary, which includes the agricultural sector, into more productive industrialized sectors. In the course of this structural transformation process, the migration of workers to the non-agricultural sectors is said to reduce the pressure on farm wages (Nonthakot and Villano, 2008).However, there is not much support for this hypothesis looking at historical wage data for Bangladesh. Bose (1968) showed that real agricultural wages in Bangladesh reduced after the end of colonialization. Later studies observed a decoupling of rural wages from agricultural prices in the late 20th century (Boyce & Ravallion, 1991; Rashid; 2001). Figure 1 shows the share of Bangladesh's labor force between 1995 and 2015. It is apparent that the agricultural labor force increased until the 2002-2003 labor force survey. Thereafter, migration flows from agricultural into the manufacturing and construction sector can be observed. This shift of labor out of agriculture had positive effects on the development of rural wages (Zhang et al., 2014). In addition, agricultural wage growth was much faster than the growth in urban wages. Moreover, Figure 2 illustrates that the growth in wages was not accompanied by a similar increase in food prices. Hence, real wages also grew. The terms of trade between agricultural wages in rice, the most important staple commodity, doubled between 1995 and 2015.

Figure 1: Share of labor force above 15 years; source: Author calculation based on BBS data

In the meantime, rural wages in Bangladesh rose faster in the second half of the 2000s than before, i.e., the average (male) rural wage rose in real terms by 45% between 2005 and 2010 (Wiggins & Keats, 2014). Furthermore, the booming manufacturing sector also increases the wages of the urban laborers and admittedly attracts the surplus labor from the rural sectors. Since physical labor is the primary productive asset for the rural population, an increase in real wages is associated with an improvement in rural livelihood and poverty reduction. The recent estimate reveals that poverty dropped by 17% within the last decade (World Bank, 2013). This was mainly driven by the reduction of rural poverty. Zhang et al. (2014) examine the sources of the poverty reduction by using the household level data. According to their estimation, poverty would have decreased by only 7.3% if agricultural wages had not changed. Alongside the importance of remittances, rural wage growth was the main driver of poverty reduction in Bangladesh.

Before the 1990s, Bangladesh rice market was isolated from the international markets. Trade liberalization during the 1990s helped to reduce production cost and raised profitability of the rice sector (Ahmed, 1999). Private businesses played a great role in responding quickly to the market demands through rice imports, mainly from India. However, supported by the National Food Policy Plan of Action (2008-15) which, by providing farmers a support price higher than the cost of production, ensures that farmers do not produce at a loss, the public involvement in the rice markets remains substantial. The objective of the public foodgrain distribution system (PFDS) in Bangladesh is to build rice stocks for an emergency, like India's rice export ban in 2008, and to provide income support to farmers. The distribution works through a rationing system which has been introduced to distribute or collect rice at fair prices to protect the poor consumers and marginalized farmers. Safety net programs are essential instruments under the PFDS. In recent years, major programs, such as vulnerable group development (VGD), vulnerable group feeding (VGF), Open Market Sales (OMS) and food for work (FFW) target poor consumers (Alam & Begum, 2014). On average, 2 million households are eligible consumers who receive fair price cards that allow to purchase 20 Kilogram rice per month at a reduced price. VGF provides 20-30 Kilogram rice per month to 12.2 million families per year (Alam & Begum, 2014).

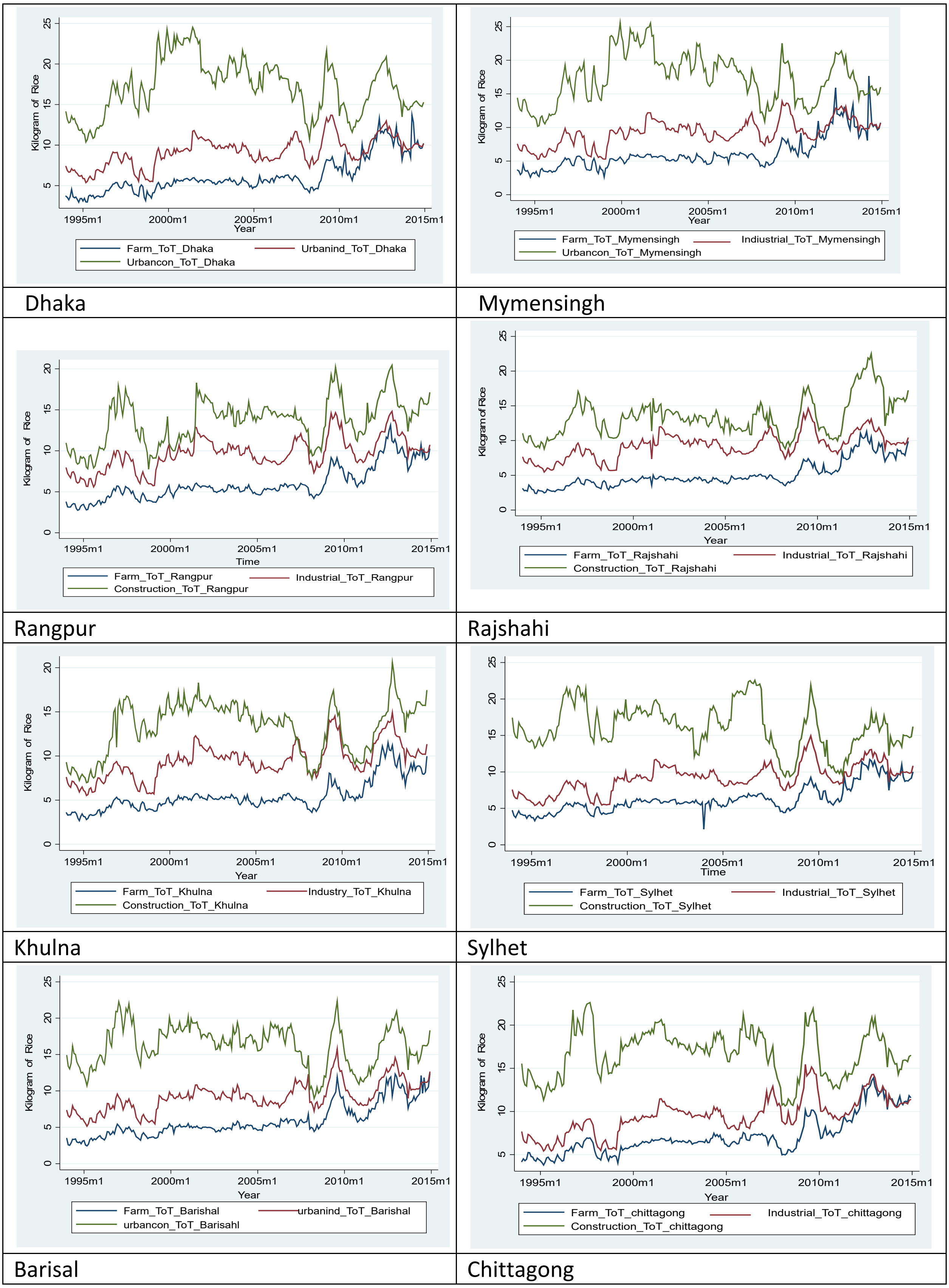

Figure 2: Terms of trade of rice per kilogram for rural and urban wage

Like many other countries, the world food crisis in 2007/2008 also had a dramatic impact on food security and poverty in Bangladesh. Since 2007, there have been two major price shocks (2008 & 2011) in the food markets in Bangladesh (Hossain, 2012). The terms of trade for rural and urban laborers in all divisions exhibit a sharp dip during this period as illustrated in Figure 2. However, in the aftermath of the global financial and economic crisis, rice prices went down to rise again in 2010 (Jayasuriya et al., 2012). From the very beginning of the liberalized trading, Bangladesh heavily imported rice from India, Thailand, and Vietnam (Akhter, 2017). Empirical analysis suggests a large transmission of international price shocks to domestic rice markets in Bangladesh (Murshid & Yunus, 2018)The recent decline in international food prices was 14% between 2013 and 2015, sliding into a five-year low, which consequently impacted food prices in Bangladesh because of the availability of cheaper imports (World Bank Group, 2015). Agricultural policies are intended to address these issues. This led to a substantial increase in public rice stocks. For instance, Open Market Sales (OMS) reached 13.8 million people by distributing 5 Kilogram Rice/Person/Day in subsidized rates during the price shock in 2008 (Grosh & Rodriguez, 2011).

Besides supporting low prices of staples, polices also addressed labor market issues. For instance, there are minimum wages for selective industries, most importantly the garment sector, currently amounting to $68 per month (Adnan, 2018)**.** However, since the wages are not updated regularly, there is little evidence on how wages in other sectors responded. Further, unemployment rates did not respond to increases in the minimum wage (Rabiul & Liton, 2018). The employment generation program (EGP) has been initiated to support the poor, unemployed rural people during the lean season since 2009. The program is implemented with support of the World Bank. The extent of such policies and strategies are ongoing, but their successful implementation may depend on the proper intervention at the proper place with efficient management.

4 Methodology

The main objective of this paper is the analysis of the development of farm wages and the wage-price pattern in the long- and short-run. For this purpose, we apply a standard time series econometrics approach, which includes the testing of the existence of a long-run relationship between the variables. The results of Johansen's rank test will then inform the way we model the wage-price relationship, either in error correction form or within the framework of an autoregressive distributed lag model. In order to compute comparable short- and long-run adjustment values, we use the ARDL model to compute pass-through coefficients for different periods. The procedure will be explained in detail in the following sections.

4.1 Empirical framework

A stochastic process is said to be stationary if its mean and variance are constant over time. However, most macroeconomic series are non-stationary. If the time series variables are non-stationary, fitting a regression model produces "*t*-ratios" that will not follow a standard *t*-distribution, and thus create spurious regression results (Engle & Granger, 1987). In less technical terms, a common underlying trend may create a statistical relationship even if there is no causal relationship between the variables. In consequence, normal regression methods like OLS are not applicable in the presence of unit root. Thus, in a first step, the stationarity of the time series needs to be examined (Maddala, 2007). In most cases, plotting the values against time will already provide valuable information regarding the general trend and the nature of the data. Eyeballing the trends in rural and urban wages as well as rice prices, which are shown in Figure 2 for all divisions (farm wage=blue line), cause us to strongly suspect non-stationarity in at least one of our variables of interest. By using the unit root test, this can be statistically tested. The lag lengths used in the test are determined by the information criteria AIC or BIC.

Two non-stationary series are said to be co-integrated if both series are integrated of the same order. If the unit root tests suggest the presence of unit root in the series, then we need to check the order of integration necessary to make the series stationary, which should be the first step to choose an exact model. The majority of the macroeconomic variables become stationary after observing their first differences which makes them integrated of order 1, written as $I(1)$. If all the variables under the considered function are integrated of order 1, then we can check for the cointegration rank. The co-integration relationship between the variables of interest is analyzed by the Johansen co-integration method. The rank test of Johansen relies on the relationship between the rank of a matrix and its characteristic roots. Once co-integration is established, a long-run relationship among a set of non-stationary variables exists which always brings the variables back into their long-run equilibrium path (Enders, 2010). Whenever the co-integration rank test confirms the existence of at least one rank, the vector-error correction framework should be used. Otherwise, the alternative option available is a simple vector autoregressive model (VAR). The VAR model is a natural extension of the univariate autoregressive model to dynamic multivariate time series in which case all the variables are assumed to be endogenous.

The simple form of vector autoregression (VAR) Y_t of *n* endogenous variables consisting of lags up to *k* is given below:

$$Y_t = \alpha_t + H_1 Y_{t-1} + H_2 Y_{t-2} + \cdots + H_i Y_{t-k} + \in_t \quad \text{...} (1)$$

Where Y_t is the $(nx1)$ vector and each H_i is a (nxn) matrix. α_t is a vector of constants and $\in_t$ is a vector of residuals.

The corresponding vector error correction model (VECM) is (Harris & Sollis, 2005):

$$\Delta Y_t = \alpha_t + \varphi_1 \Delta Y_{t-1} + \varphi_2 \Delta Y_{t-2} + \cdots + \omega_{k-1} \Delta Y_{t-k+1} + \theta_i Y_{t-k} + \Gamma + \in_t \text{ ....}(2)$$

Where $\varphi_1 = -(I - H_1 - H_2 - \cdots - H_i)$ $(i = 1, \ldots, k-1)$ and $\theta = -(I - H_1 - H_2 - \cdots - H_k)$. The above model consists of long-run and short-run information to changes in ΔY_t through estimated φ_1 and θ. In general, $\theta = \delta\beta^{/}$ is a square matrix where δ is the speed of adjustment and β is the matrix of coefficients generating long-run equilibrium (Patterson, 2000).

On the other hand, if some of the series are *I*(1) and some are *I*(0), it is suggested to use the ARDL model (Pesaran et al., 2001). However, the ARDL cannot be used if any of the series in the model has integration of order *I*(2). The autoregressive model (ARDL) for *k* month lags can be postulated as:

$$\Delta Wa = \alpha + \textstyle\sum_i^k \alpha_i \, \Delta Wa + \sum_i^k \beta_i \, \Delta P_{ti} + \sum_i^k \gamma_i \, \Delta WI_{ti} + \sum_i^k \delta \, \Delta WC_{ti} + \in_{ti} \text{ ....}(3)$$

Where, Wa stands for farm wages, P_{ti} is the rice prices, and WI_{ti} and WC_{ti} indicate industrial and constructional wages.

In addition to modeling the long- and short-run adjustment in the co-integration format, it is worth to compare the impact of changes in urban wages and rice prices on agricultural wages for different time horizons. Varying the lag structure allows doing so in the ARDL framework (Ianchovichina et al., 2014). ARDL models with alternating lag structure will be quite convincing to detect immediate pass-through effects. The respective pass-through coefficient for *k* periods can be computed from equation (3) as $\theta = \frac{\sum_i^k \beta_i}{1 - \sum_i^k \alpha_i}$.

For long-term time series, it is also essential to check whether the coefficients are constant throughout the whole period. Instead, long time series data is often subject to structural breaks. Structural breaks likely occur when a time series abruptly changes its mean or other parameters at a point in time (Campos et al., 1996). In a developing country context, like in Bangladesh, the main reasons for a structural break are related to changes in government policies, domestic or international shocks of both natural and human origin as well as structural changes in the economy. Ignoring the presence of structural breaks might influence the outcome of the unit-root test and steer incorrect parameter estimation (Akhter, 2017). The existence of a structural break is tested in two ways. Firstly, for all series of the eight divisions, we perform the Supremum Wald test for a structural break at an unknown break date. Secondly, we also perform a series of likelihood-ratio (LR) tests to verify the stability of the coefficient estimates in a time-series regression over different periods defined by possibly known break dates (Maddala, 2007).

4.2 Data sources

The statistical models of this study rely on a comprehensive database covering monthly data for the period between 1994 and 2014. At present, Bangladesh is divided into eight major divisions and sixty-four sub-divisions (districts). The Bangladesh Bureau of Statistics (BBS) collects data on wages at the district level on a regular basis and publishes them in the Monthly Statistical Bulletin. Rural wages represent daily agricultural wages (male and female without a meal) including key agricultural activities like harvesting or transplanting. We introduce two types of urban wages, industrial and constructional. Constructional laborer wage is estimated by considering the daily averages of carpenters, masons, and brick breakers. Industrial wage rates include the aggregate average of daily wage in cotton manufacturing, textile, and jute industries. We observe several missing values of urban wage series which have been replaced by the values of the nearest districts considering the geographical distance (Kilometers). However, estimation of the distance is based on the distance matrix by Road-Centerline Surveyed by Global Positioning System (GPS). Until 2010, the sample consisted of 23 districts only; only thereafter was the sample expanded. To maintain the same frequency, this analysis utilizes aggregated wages and prices for eight divisions which are shown in Figure 3.

The statistical bulletins also include information on the nation-wide consumer price index (CPI) which we use to deflate prices and wages. Rice prices are collected from the Food Planning and Monitoring Unit (FPMU) and the Department of Agricultural Marketing (DAM). We consider the coarse rice price that is available in the market during the respective rice marketing seasons (Aus, Aman, Boro)[1]. Unlike many related studies, the construction of the price series takes into account the seasonal market availability of a specific category of rice, i.e., coarse rice. Coarse rice varieties during "Boro" and "Aman" seasons are available in most of the months of a year, while the production in "Aus" season is only available during its season which is consistent with its low production rate all over the country. Missing values of rice prices are replaced by interpolation. The summary statistics (mean) of the major variables over the 24 years across the divisions are displayed in Table 1, which concisely indicate a shift

[1] Aus: rice sown in summer (May) during pre-monsoonal rains and harvested in autumn (July) is called as Aus rice. Aman: rice sown in the rainy season (July-August) and harvested in winter (November). Boro: rice sown in winter (November) and harvested in summer (March-April) is called Boro rice.

in wage and price regime after 2005. However, there are certain similarities as well as differences between the divisions. In general, the eight divisions are situated in eight different agro-ecological zones of Bangladesh (AEZ) with rates of poverty also varying among these regions. Household income and expenditure survey (HIES) data from 1991 to 2015 are utilized to obtain inside knowledge on the poverty situation at the sub-national level of Bangladesh. Complete data of the past poverty rates of the Sylhet division are not available for a couple of the survey rounds from HIES.

We find similarities between Dhaka and Mymensingh, Rajshahi and Rangpur, and Barisal and Chittagong in terms of wages and prices. In terms of general poverty, Rajshahi was the poorest division during the 1990s and then the poverty line reduced between 2005 and 2010. Farm wage is higher in the Chittagong and Dhaka divisions compared to the other regions. In contrast to the other divisions' average rice prices, urban wages are higher in Dhaka, Sylhet, and Chittagong. Nominal farm wage doubled between 2005 and 2010, and it has increased by 73% between 2010 and 2014. Real farm wages also jumped from 2005 to 2010, for example, from 87 Bangladeshi Taka to 125 Bangladeshi Taka in the Dhaka division. Both rural and urban wages experienced similar shifting between 2005 and 2010 with their pace of growth slightly diminishing between 2010 and 2014. Similarly, nominal rice prices increased significantly from 2005 to 2010. However, from 2009 up to 2014, the increase in rice price was low while the average rice price decreased from 17.56 Taka to 15.14 Taka in Dhaka.

From the Technical Appendix 1, it is clear that both upper and lower poverty lines are following a downward trend. For the Rajshahi division[2], the northern part of the country has the higher poverty rate than the others. Over the time, however, the lower poverty rate changes drastically for this northern region whereas the rate of poverty reduction was slow in Khulna during 1990 to 2005 2005. From Technical Appendix 8 it is evident that the country as a whole experienced a change of direction in poverty after 2005. Dhaka experienced a large poverty decline despite a decline of growth rate of real wages between 2000 and 2005. A large decline in head count ratio (HCR) and a large increase in wage was observed in Chittagong during 2005 and 2010. While Barisal experienced a small rise of wage and a small decline of poverty during 2005. Rajshahi experienced a small poverty decline although wages had fallen prior to 2010. Khulna experienced the second highest rise of wages and a decrease of poverty between 2000 and 2010 but the rate of poverty reduction has slowing down during 2010-15.

[2] The greater Rajshahi division later split into two, the Rajshahi and the Rangpur division.

Table 1: Wages and rice price over the 25 years in BDT (Bangladeshi Taka)

Divisions	1995		2000		2005		2010		2014	
	Nominal	Real	Nominal	Real	Nominal	Real	Nominal	Real	Nominal	Real
Dhaka										
Farm wage	43.56	*67.38*	63.91	*77.78*	84.63	*81.37*	188.71	*125.27*	334.83	*164.95*
Industrial wage	75.45	*117.39*	107.78	*132.84*	129.68	*278.12*	261.72	*176.67*	320.71	*160.50*
Construction wage	141.44	*220.31*	264.44	*325.97*	283.97	*187.23*	372.01	*255.48*	485.68	*243.48*
Nominal rice price	12.48	*19.22*	11.74	*14.13*	15.64	*14.92*	27.98	*17.56*	32.53	*15.14*
Mymensingh										
Farm wage	43.05	*66.67*	63.61	*77.38*	82.63	*79.43*	183.86	*121.97*	342.17	*168.62*
Industrial wage	75.45	*132.32*	107	*167.90*	129.68	*270.68*	261.35	*157.29*	321.24	*160.50*
Construction wage	139.68	*227.10*	235.48	*283.55*	285	*186.56*	370.42	*227.63*	464.41	*210.04*
Nominal rice price	12.72	*19.59*	11.70	*14.09*	15.23	*14.53*	28.21	*17.72*	31.58	*14.70*
Rangpur										
Farm wage	39.86	*61.63*	58.20	*70.08*	75.73	*72.79*	172.65	*145.47*	284.63	*140.17*
Industrial wage	75.45	*132.32*	107	*167.90*	129	*186.56*	260	*157.38*	298	*171.23*
Construction wage	104.81	*163.10*	124.09	*152.92*	218.54	*214.13*	343.61	*235.84*	462.06	*231.45*
Nominal rice price	11.86	*18.26*	11.21	*13.50*	14.90	*14.83*	26.74	*16.78*	29.69	*13.82*
Rajshahi										
Farm wage	33.96	*52.56*	50.70	*61.68*	67.96	*65.32*	152.45	*101.03*	258.90	*127.42*
Industrial wage	75.45	*132*	107	*167.90*	129	*186.56*	260.41	*157.58*	299.91	*170.10*
Construction wage	124.44	*193.62*	161.11	*198.55*	186.58	*183.21*	309.58	*212.55*	491.53	*246.36*
Nominal rice price	12.39	*19.03*	11.38	*13.70*	15.54	*14.21*	27.85	*17.59*	31.03	*14.44*
Khulna										
Farm wage	39.63	*61.30*	57.25	*69.64*	71.22	*68.47*	149.56	*99.16*	261.75	*128.92*
Industrial wage	75.45	*132*	107		129	*186.56*	263.91	*157.55*	309.83	*173.19*
Construction wage	95.62	*148.71*	179	*220.61*	207.54	*203.50*	289.30	*198.72*	473.58	*237.73*
Nominal rice price	12.02	*18.52*	11.37	*13.69*	15.11	*14.42*	27.98	*17.58*	30.15	*14.04*
Sylhet										
Farm wage	49.5	*76.56*	68.92	*83.84*	92.08	*88.49*	172.25	*114.38*	302.58	*149.04*
Industrial wage	75.45	*132.24*	107	*167.90*	129	*186.56*	256	*157.29*	320	*173.19*
Construction wage	184.22	*286.76*	213.33	*262.96*	286.52	*280.10*	334.17	*229.86*	472.93	*237.05*
Nominal rice price	12.98	*19.98*	11.81	*14.22*	15.45	*14.74*	27.48	*17.26*	32.35	*15.06*
Barisal										
Farm wage	40.08	*61.95*	59.17	*71.92*	80.25	*77.11*	195.75	*129.98*	309.92	*152.54*
Industrial wage	75.45		107.80	*167.79*	129	*167.90*	263	*157.55*	320	*180.38*
Construction wage	95.01	*148.24*	178	*220.64*	207.54	*203.50*	290	*198.72*	473.20	*237.15*
Nominal rice price	12.54	*19.32*	11.71	*14.10*	15.74	*15.02*	29.06	*18.24*	30.38	*14.15*
Chittagong										
Farm wage	55.10	*85.22*	73.42	*89.32*	100.57	*96.69*	197.80	*131.14*	339.28	*167*
Industrial wage	75.45	*132.25*	107	*167.90*	129	*186.56*	263.25	*157.29*	331	*180*
Construction wage	160.44	*249.53*	218	*268.60*	270.97	*265.74*	367.36	*252.23*	474.86	*238.01*
Nominal rice price	12.72	*19.58*	11.69	*14.08*	15.58	*14.87*	26.55	*16.69*	30.42	*14.16*

Source: Authors' calculation based on monthly bulletin by the BBS and report of FPMU.
Notes: The rural and urban consumer price index were used to estimate real wages and prices, 1 USD=69.70 BDT in 2010.

Figure 3: Divisions of Bangladesh

Source: own illustration.

5 Results

5.1 Unit-root test, structural breaks and possible reasons for such breaks

Before testing the existence of a unit root in the time series and the determination of the order of integration, it is essential to determine a structural break in the relationship among the variables. For each division, we consider four variables, namely farm wages, urban construction wages, urban manufacturing wages, and rice prices. The entire period spans over 21 years or 252 months from 1994 to 2014. The structural breaks detected by the Supremum Wald test are listed in Table 2. In this test, we include all four variables. As we are more interested in the response of the agricultural wages to the changes in the rice price and urban wages, we examine the unknown structural break in which the farm wage is the dependent variable.

The respective breaks are illustrated in Figures 4, 5 and 6, where the vertical red lines indicate the structural breaks.

Table 2: Structural break between the different divisions

Division	Unknown Structural break
Dhaka	2009M1
Mymensingh	2009M1
Rangpur	2008M12
Rajshahi	2008M12
Khulna	2007M1
Sylhet	2008M1
Barisal	2008M12
Chittagong	2008M12

All structural breaks lie between January 2007 (in Khulna) and January 2009 (in Mymensingh). The detected structural breaks appear to be consistent with structural changes in Bangladesh's economy. The international financial crisis and recession in the international market took place in 2008. At the same time, international rice prices peaked, followed by the rice export ban of India, Bangladesh's major trading partner. As a response to the economic turmoil, the hundred-day employment generation program was implemented in 2009 to control the short-term unemployment during the soaring food prices. In addition, the period was also characterized by political instability. Between 2006 and 2008, there was a caretaker government in power which handed over power to the elected government only in 2009. Lastly, the minimum wage of the garments workers has been raised twice in 2006 and 2010. Against this background, the existence of a structural break during this period appears to be very reasonable. The correlation matrix of the explanatory variables in their first differences are also reported in the Technical Appendix 2.

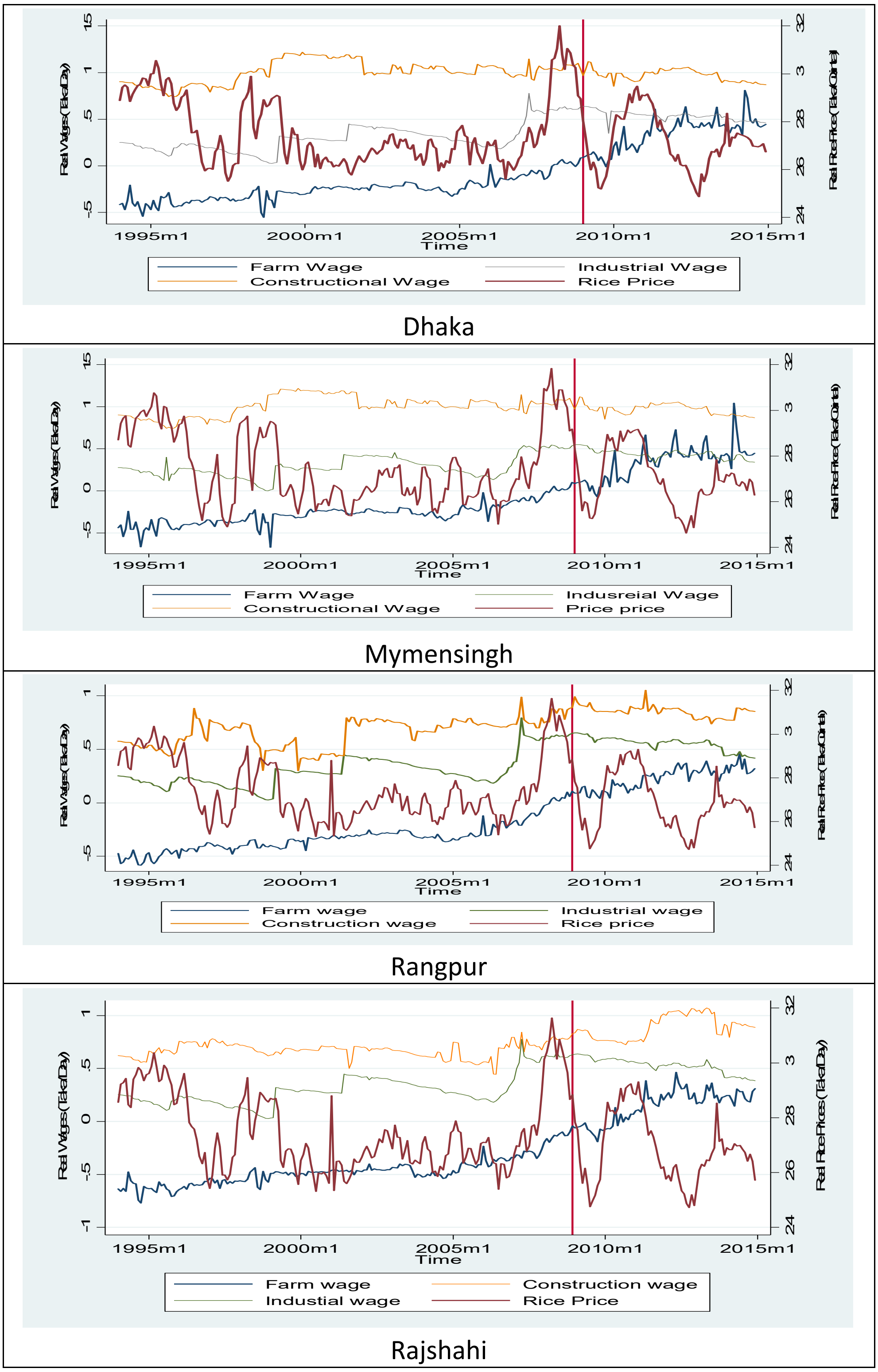

Figure 4: Structural breaks of the Central and Northern divisions of Bangladesh

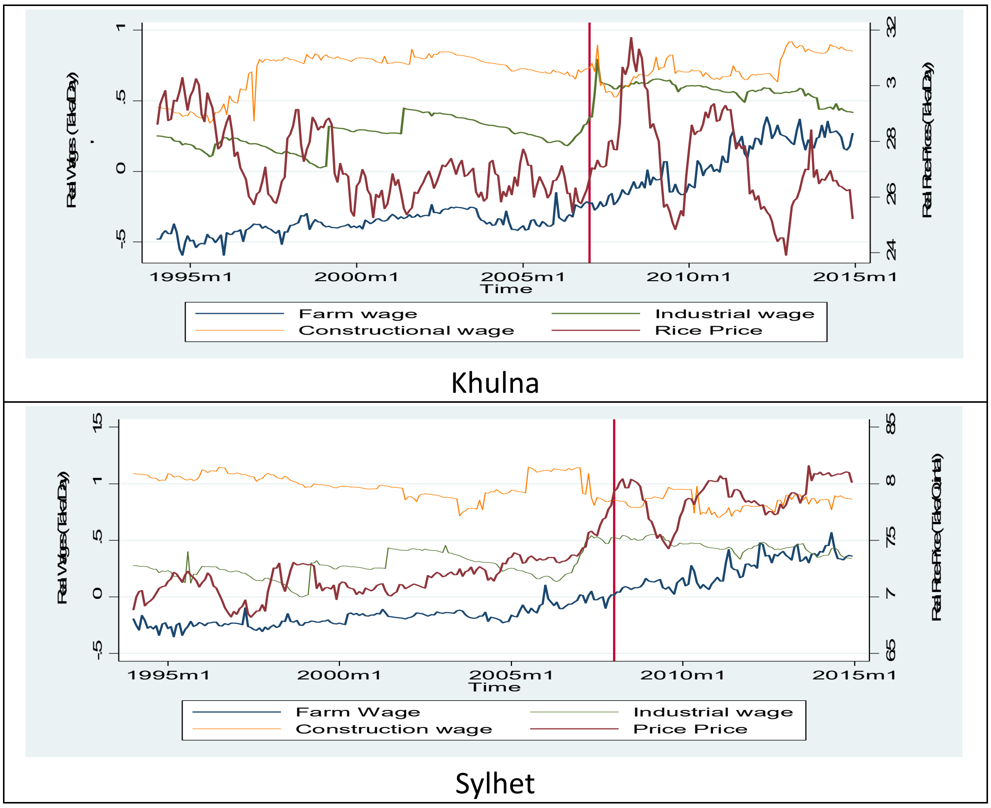

Figure 5: Structural breaks of Eastern and Western divisions of Bangladesh

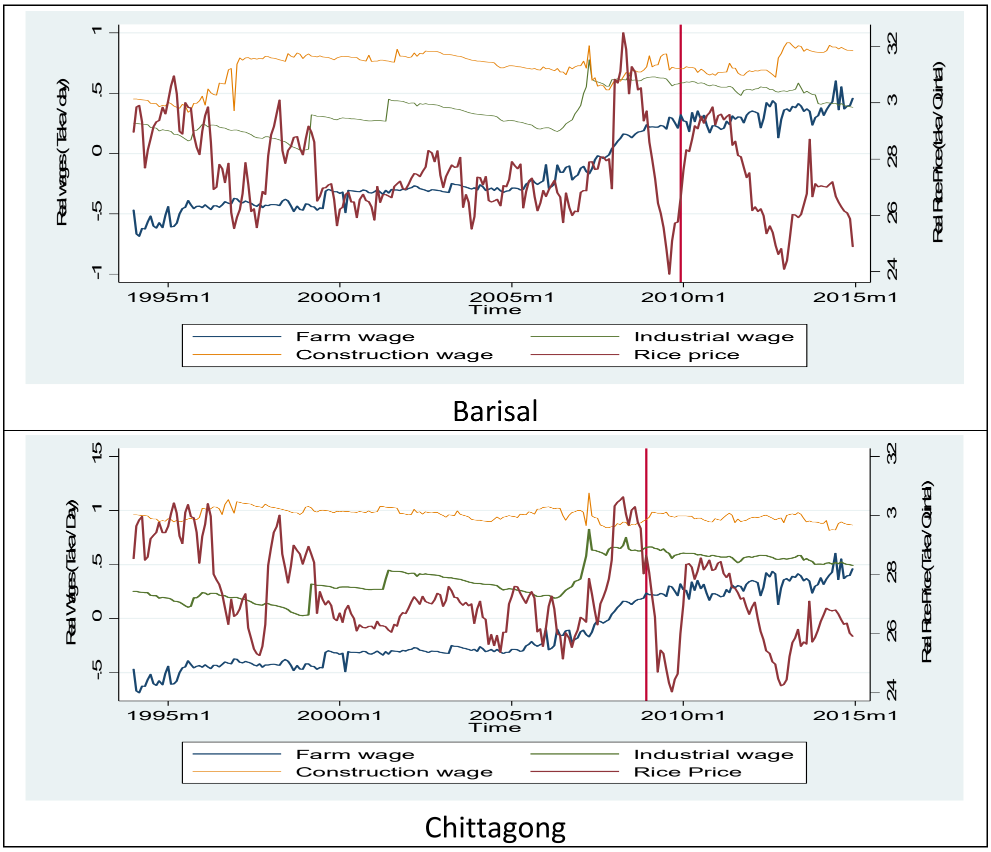

Figure 6: Structural breaks of Southern divisions of Bangladesh

Table 3: Regular Unit root test (Data in level)

Division	Unit Root Test	Ln W_a	Ln F_p	Ln W_m	Ln W_c	Break point	Ln W_a	Ln F_p	Ln W_m	Ln W_c
		Before break					After break			
Dhaka	ADF	2.481 (0.11)	2.583 (0.10)	0.914 (0.78)	2.482 (0.16)	2009M1	0.28 (.053)	1.98 (0.29)	3.77 (.043)	0.31 (0.16)
	GLS ADF	3.18	2.76	0.173	0.216		2.575	1.448	2.317	1.697
	KPSS	0.459	1.000	0.442	1.350		0.351	0.315	0.175	0.474
Mymensingh	ADF	3.209 (0.06)	2.801 (0.07)	1.833 (0.36)	2.312 (0.16)	2009M1	3.209 (0.02)	2.002 (0.28)	1.605 (0.48)	2.363 (0.15)
	GLS ADF	3.33	3.30	1.674	2.08		3.25	1.654	2.630	1.697
	KPSS	0.462	0.914	0.412	1.35		0.286	0.310	0.239	0.472
Khulna	ADF	3.62 (0.06)	2.668 (0.07)	1.663 (0.45)	2.452 (0.12)	2007M1	1.867 (0.34)	1.493 (0.53)	3.065 (0.05)	2.291 (0.17)
	GLS ADF	1.507	3.30	1.674	2.08		3.420	1.760	0.738	2.511
	KPSS	0.564	0.547	0.731	1.59		0.352	0.165	0.364	0.331
Sylhet	ADF	3.169 (0.02)	2.448 (0.13)	2.801 (0.06)	1.902 (0.33)	2008M1	2.166 (0.21)	1.771 (0.39)	2.370 (0.15)	5.281 (0.00)
	GLS ADF	2.918	3.061	2.007	1.220		3.40	1.823	1.674	1.495
	KPSS	0.222	0.914	0.698	0.988		0.218	0.184	0.166	0.375
Rajshahi	ADF	1.261 (0.65)	2.981 (0.04)	0.340 (0.03)	2.312 (0.16)	2008M12	2.305 (0.17)	1.891 (0.33)	0.293 (0.92)	1.754 (0.40)
	GLS ADF	2.242	2.520	1.699	3.303		2.636	2.365	2.201	1.590
	KPSS	0.680	1.010	0.431	.512		0.546	0.267	0.325	.455
Rangpur	ADF	0.679 (0.85)	3.082 (0.02)	0.857 (0.80)	2.619 (0.08)	2008M12	2.617 (0.06)	1.980 (0.07)	0.808 (0.36)	3.561 (0.00)
	GLS ADF	1.604	2.638	1.824	2.857		2.92	1.542	1.842	2.51
	KPSS	0.764	1.02	0.45	0.41		0.261	0.290	0.363	1.89
Barisal	ADF	0.457 (0.90)	0.893 (0.79)	0.893 (0.02)	2.858 (0.06)	2008M12	4.347 (0.04)	1.616 (0.47)	0.293 (0.92)	1.667 (0.44)
	GLS ADF	1.631	2.84	1.699	1.532		4.13	2.28	2.205	1.75
	KPSS	0.826	0.833	0.431	1.76		0.101	0.287	.325	.534
Chittagong	ADF	0.559 (0.87)	2.535 (0.09)	0.835 (0.80)	3.609 (0.03)	2008M12	3.270 (0.03)	2.101 (0.24)	1.78 (0.41)	2.530 (0.10)
	GLS ADF	1.665	2.90	1.76	2.47		2.943	2.113	2.481	2.767
	KPSS	0.868	0.867	0.480	0.641		0.107	0.307	0.193	0.245

Note: Tests are conducted on natural log of wage and price series. W_a, W_m, W_c F_p stand for agricultural, industrial, constructional wages and food prices respectively. Results are in absolute values. The ADF and KPSS critical values at the 5% level of significance are -3.07 and 0.463, respectively. The critical value for the ADF test is taken from MacKinnon (1991). The GLS-ADF critical value at 5% in lag 2 is 3.486.

Table 4: Regular Unit root test (1st differenced data)

Division	Unit Root Test	Ln W_a	Ln F_p	Ln W_m	Ln W_c	Break point	Ln W_a	Ln F_p	Ln W_m	Ln W_c
		Before break					After break			
Dhaka	ADF	16.29 (0.00)	11.95 (0.00)	13.72 (0.00)	2.31 (0.16)	2009M1	10.34 (0.00)	7.721 (.00)	13.77 (0.00)	15.16 (0.00)
	GLS ADF	14.28	7.462	9.423	10.73		9.847	3.578	9.674	5.288
	KPSS	0.016	0.025	0.041	0.039		0.016	0.101	0.022	0.038
Mymensingh	ADF	18.01 (0.00)	11.21 (0.00)	17.60 (0.00)	15.16 (0.00)	2009M1	10.69 (0.00)	6.829 (0.00)	6.792 (0.00)	9.534 (0.00)
	GLS ADF	13.11	7.308	9.48	10.37		9.391	4.341	4.615	5.281
	KPSS	0.011	0.020	0.047	0.039		0.286	0.310	0.239	0.472
Khulna	ADF	17.51 (0.00)	11.95 (0.00)	11.75 (0.00)	18.94 (0.00)	2007M1	11.57 (0.00)	8.775 (0.00)	9.811 (0.00)	13.84 (0.00)
	GLS ADF	12.41	6.550	7.615	15.10		9.268	5.020	3.745	6.271
	KPSS	0.018	0.028	0.068	0.031		0.020	0.089	0.066	0.038
Sylhet	ADF	18.50 (0.00)	13.05 (0.00)	17.04 (0.00)	15.74 (0.00)	2008M1	9.913 (0.00)	9.221 (0.00)	7.789 (0.00)	17.40 (0.00)
	GLS ADF	8.128	4.723	9.108	12.51		8.963	3.421	4.861	9.121
	KPSS	0.012	0.061	0.058	0.043		0.017	0.076	0.036	0.039
Rajshahi	ADF	16.67 (0.00)	15.03 (0.00)	13.62 (0.00)	16.54 (0.00)	2008M12	12.47 (0.17)	8.84 (0.33)	8.254 (0.92)	9.809 (0.40)
	GLS ADF	11.45	7.420	8.450	12.58		7.714	4.221	6.371	6.201
	KPSS	0.030	0.021	0.051	0.027		0.028	0.097	0.039	0.076
Rangpur	ADF	17.62 (0.00)	15.03 (0.00)	12.92 (0.00)	16.21 (0.00)	2008M12	11.92 (0.00)	9.789 (0.00)	8.490 (0.00)	12.92 (0.00)
	GLS ADF	4.970	7.481	9.511	11.01		7.790	4.021	5.061	9.04
	KPSS	0.043	0.023	0.048	0.021		0.018	0.095	0.048	0.028
Barisal	ADF	14.15 (0.00)	17.15 (0.00)	13.69 (0.00)	21.54 (0.00)	2008M12	14.19 (0.00)	8.705 (0.00)	8.230 (0.00)	8.980 (0.00)
	GLS ADF	9.082	7.720	8.453	14.15		7.13	4.705	6.37	4.35
	KPSS	0.035	0.017	0.052	0.033		0.017	0.097	0.03	0.08
Chittagong	ADF	17.12 (0.00)	12.43 (0.00)	13.10 (0.00)	20.40 (0.00)	2008M12	14.19 (0.00)	8.248 (0.00)	8.769 (0.00)	9.704 (0.00)
	GLS ADF	3.820	5.220	8.865	13.74		7.134	4.118	5.115	6.051
	KPSS	.0365	0.026	0.048	0.016		0.017	0.079	0.034	0.035

Note: Tests are conducted on natural log of wage and price series. W_a, W_m, W_c F_p stand for agricultural, industrial, constructional wages, and food prices, respectively. Results are in absolute values. The ADF and KPSS critical values at the 5% level of significance are -3.07 and 0.463, respectively. The critical value for the ADF test is taken from MacKinnon (1991). The GLS-ADF critical value at 5% in lag 2 is 3.486.

We perform several standard test procedures, namely the Augmented Dickey-Fuller (ADF), the Kwiatkowski–Phillips–Schmidt–Shin (KPSS) and the modified Dickey-Fuller *t*-test (ADF–GLS). All are common to test the presence of a regular unit root. The null hypothesis of the ADF and the ADF-GLS is that the data series is non-stationary. By contrast, the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests the null hypothesis of stationarity. We omit the detailed test statistics at different lags, which are available on request, and present the results in Tables 3 and 4. From the results, it is evident that all the log series exhibit a unit root. To ensure the level of integration of the series, we again tested for a unit root for the differenced time series which confirms the existence of *I*(1) processes in the original series. In addition to that, we also tested the presence of seasonal unit roots. The respective results are presented in the Technical Appendix 3. From these results, we reject the systematic existence of seasonal unit roots.

5.2 Long-run relations among the series and speed of adjustment

Based on the results of the structural break test above, we treat the periods before and after the structural break separately. The time series is tested for the existence of co-integrating equations by using trace statistics and eigenvalues. The lag length is chosen according to standard lag length selection procedures using the information criteria. The results are reported in the Technical Appendix 4. The respective test statistics of the Johansen's co-integration test procedure are shown in the Technical Appendix 5. The presence of co-integration indicates a long-run relationship between the tested series. Using the critical value of the 5% level of significance as the criterion, we find one co-integrating vector for all the eight divisions before the structural break. Since we are most interested in the determination of farm wages, we focus on this equation. Table 5 shows the respective VECM estimates for farm wages as the endogenous variable. The results of the estimated VECM parameters indicate that farm wages are integrated with the other series which can be seen by the statistically significant error correction term and its negative sign. Before the break around 2008, farm wages among all the divisions have significant long-run relationships with the rice prices. The same holds true for urban wages since in each division one of the two urban wages was positively associated with farm wages indicating a significant long-run relationship.

Similarly, after the break, the Johansen test statistics suggest one co-integration relationship for all divisions. However, by contrast, farm wages exhibit a significant long-run relationship with rice prices in only three divisions (Dhaka, Mymensingh, and Barisal). After the break, the long-run farm wages in all divisions (except Barisal) are significantly influenced by urban wages. These results are in accordance with the findings of Rashid (2001), who projected more than a decade ago that the urban wage rate would become the most influential factor for farm wage determination. However, the relative effect of the rice price on farm wages is slowly diminishing over time despite the remarkable increase of the rice due to the advent of new draft and salt tolerant varieties. The economic growth boosted up and poverty reduction became significant between 2000 and 2014 despite the declining trend of the terms of trade of agriculture and the relative price of rice such that the increased rice price did not affect the poor in the rural area. If there are any possible negative impacts of increased rice price on the income then it will only affect the people of Dhaka and Mymensingh. A further discussion of such regional diversity in elasticities is given in the upcoming sections. Table 5 also presents the speed of adjustment for any deviation from the long-run equilibrium. The error term coefficient represents the speed of adjustment. We expect a statistically significant and negative coefficient of the error correction term to conclude that the system converges back to its equilibrium relationship. The exact value of the coefficient tells us the portion of the correction happening during the period of adjustment. It is apparent from Table 5 (columns 6 and 13) that the models behave as expected indicated by the negative sign and the statistically significant coefficient (at the 1 % of significance) of the error correction term for both periods. These results also show that the models considering farm wages on the left-hand side of the co-integration equation are well specified. For instance, before the structural break, we find quick adjustment periods for Mymensingh (20 months), Sylhet (22 months), and Dhaka (23 months). Intuitively, this implies that in Mymensingh, it will take 20 months to retain the long-run equilibrium condition, while in each month the error correction term corrects the previous period's disequilibrium at a speed of 58.2% to reach the steady state level. By contrast, the adjustment happening in Chittagong (68 months) and Barisal (61 months) is rather sluggish. After the break, the lowest adjusted period is evident for Barisal (14 months) and the highest adjustment period is found for Khulna (55 months). All the models are checked and diagnosed for the stable coefficients of the estimated parameters (cf. Technical Appendix 6).

Table 5: Long-run relation between farm wages, rice price, industrial and constructional wages

Farm wages (Dependent variable)	Break point	Rice Price	Industrial wage	Construction wage	Error Correction (Adjustment to the disequilibrium of Farm wage)	R-square	LM test (lag 2) $P>\chi^2$	After break	Rice Price	Industry wage	Construction wage	Error Correction (Adjustment to the disequilibrium of Farm wage of Farm Wage)	R-square	LM test (lag 2) $P>\chi^2$
		Long Run Coefficient							Long Run Coefficient					
Dhaka	2009M1	.130*** (.048)	0.222*** (0.062)	0.070 (0.061)	-.512*** (23 months)	0.265	.107		.541** (0.100)	.285** (0.101)	1.86*** (0.19)	-.694*** (17 months)	0.328	.125
Mymensingh	2009M1	.104** (.047)	.275*** (.061)	.100*** (0.069)	-.581*** (20 months)	0.287	.241		.444** (.140)	.655* (.440)	1.63*** (0.304)	-.800*** (15 months)	0.402	.301
Rajshahi	2008M12	.201*** (0.06)	.065 (0.08)	.805*** (0.140)	-.249*** (48 months)	0.169	0.106		.469 (.128)	.608 (0.38)	1.22*** (0.191)	-.444*** (27 months)	0.223	0.292
Rangpur	2008M12	.196** (0.085)	.350*** (0.110)	.188** (0.104)	-.238* (50 months)	0.139	0.969		.124 (.081)	.106** (0.314)	1.53*** (0.213)	-.278** (43 months)	0.113	0.592
Khulna	2007M1	.135** (0.079)	.194** (0.801)	.303*** (0.062)	-.294*** (40 months)	0.201	0.897		.105 (0.102)	1.34*** (0.277)	.441** (0.205)	-.216*** (55 months)	0.192	0.144
Sylhet	2008M1	.111** (0.04)	.240*** (0.054)	.301** (0.061)	-.532*** (22 months)	0.278	0.119		.110 (0.065)	.690** (0.304)	.170 (0.162)	-.570*** (21 months)	0.215	0.412
Barisal	2008M12	.548***	.271*	.371**	-.195*** (61 months)	0.104	0.861		-.101* (0.104)	-.210 (0.280)	.101 (0.101)	-.858*** (14 months)	0.440	0.208
Chittagong	2008M12	.743*** (0.131)	.528*** (0.125)	1.83*** (0.349)	-.175** (68 months)	0.402	0.789		.118 (0.108)	1.48** (0.749)	.621 (0.531)	-.436*** (27 months)	0.197	0.387

5.3 Rice price pass-through coefficients

In order to better understand the transmission of shocks of rice prices and urban wages on farm wages, we also compute pass-through coefficients. The magnitude of the rice price passes through on-farm wages and allows us to explicitly test the sticky wages theory of Keynes. The pass-through coefficients, as computed by the formula from equation (3) for different time horizons, are shown in Table 6. We find that the pass-through coefficients vary across divisions and over time, specifically before and after the break. We find significant pass-through in Dhaka and Sylhet before the break and in Mymensingh after the break for the three months' time horizon. Six out of eight divisions exhibit a significant pass-through after six months in the period before the structural break, but all of them become insignificant after the structural break. Only half of the divisions, namely Rajshahi, Rangpur, Sylhet, and Chittagong, are estimated to have significant pass-through elasticities before the break for the 12-month horizon. With regard to the 12-month pass-through, except for Barisal, we did not find any significant pass-through after the break.

Table 6: Real farm wage response to real rice prices

	Three months pass-through coefficients		Six months pass-through coefficients		Twelve months pass-through coefficients	
	Before Break (2008)	After Break (2008)	Before Break	After break	Before Break	After break
Dhaka	**.163*** **	.102	**.216*** **	-.044	.113	-.058
Mymensingh	.055	**.395** **	.121	.191	.071	.100
Rajshahi	.037	.091	**.169*** **	.215	**.238** **	.307
Rangpur	-.019	-.053	**.106* **	-.034	**.216** **	-.066
Sylhet	**.084* **	.186	**.119** **	.297	**.178* **	-.004
Khulna	.030	.066	**.112* **	.050	.178	.156
Barisal	.002	-.0506	.095	-.083	.116	**-.140* **
Chittagong	.013	-.132	**.127** **	-.017	**.239* **	-.327

Hence, it is clear that the importance of rice prices in the determination of farm wages has significantly declined after the structural break in 2008/2009. Moreover, all pass-through coefficients are below 0.4 which indicates that the price elasticity of wages in Bangladesh is not close to unity, even for relatively long-time horizons. The picture for the urban wage pass-through is somewhat different. The details are shown in the Technical Appendix 7. Generally, the amount of significant pass-through coefficients is limited. Yet, once the pass-through coefficients are significant, the magnitude is much higher for urban wages than for rice prices.

5.4 Regional differences

In general, we observe a common trend for all divisions which indicates that the importance of rice prices for farm wage determination has declined over time, while urban wages in the construction and industrial sectors remain important. However, we also record regional differences. Before the break, farm wages are more responsive to rice price changes in both Chittagong and Barisal than in the other divisions. Precisely, the magnitude of the rice-price coefficient varies greatly between 0.743 in Chittagong and 0.111 in Sylhet. There are several factors that might influence such variability including demographic characteristics, the volume of rice production, the number of agricultural households, the cropping intensity, labor migration issues, the adoption of on-farm machinery as well as the overall poverty situation. For example, Chittagong and Sylhet, that used to be a single division in the past, today differ in several ways. Chittagong is the largest among Bangladesh's eight divisions and a large portion of land is used for rice production as well as for the cultivation of other hilly crops (cf. Technical Appendix 9). Sylhet's agricultural activities, again, concentrate on tea production although they also comprise a significant rice production. As land preparation for rice demands a lot of manual labor in absence of machine power, low adoption of machinery services would lead to a greater positive relationship between farm wages and rice prices. Figures from the 2008 Agricultural Census indicate that the share of people owning a power tiller was lowest in Chittagong (0.23) and Barisal (0.24) (BBS, 2010). In addition to that, poverty rates are among the highest in Barisal (cf. Technical Appendices 1 and 8) which could induce labor supply at lower wage rates. Thus, farm wages, in absence of other employment opportunities, are more responsive to rice prices than in other regions. Looking at the simple changes, we find that there was a significant increase in coarse rice prices in Barisal, for example an increase of 23% from 2000 to 2005. In the meantime, the poverty decrease rate in 2005 was slower than in the previous five years (1995-2000). The Barisal division also experienced two consecutive natural hazards in 2007 and 2009 that may have influenced the labor and commodity market. It is furthermore noteworthy that the farm mechanization rates in Barisal and Chittagong were lower compared to the other areas (Mottaleb et al., 2016). A more detailed discussion of the cross-division differences would require further analysis, including the utilization of additional counterfactuals, and is beyond the scope of the present study.

We also observed some changing trend of wage-price elasticities in northern areas following the break. For example, Rajshahi and Rangpur, are traditionally rice producing divisions where many peoples are involved in agricultural activities, compared to other divisions (Khandker & Samad, 2016). It is evident that a large portion of the cultivated rice area belongs to the Rajshahi and Rangpur division (cf. Technical Appendix 9) and at the same time a major fraction of the rural labor force of these areas is involved in selling their labor (Khandker & Samad, 2016). In these divisions, rice prices have been very important for farm wage determination in the absence of non-farm employment opportunities. However, with the structural transformation of the economy, the effects of rice prices became less pronounced compared to constructional and industrial urban wages. This is of particular importance in Rangpur where seasonal famines (called ''Monga''), which were partly due to the lack of lean season farm activities, became less frequent. However, a 10% increase in rice price, increased farm wages in Dhaka and Mymensingh by 1.9% and 4.4%, respectively. In all the other divisions wages do not respond to rice prices. In Barisal, we find that rice prices and wages are negatively correlated after the structural break. This is counterintuitive but could be explained by the incidence of a natural disaster, the cyclone Aila, in 2009. Barisal is prone to natural disasters like cyclones due to its location close to the sea and its multiple river deltas. After the 2009 cyclone, agricultural productivity decreased dramatically due to the influx of salt water into the rice fields, while rice prices increased due to low supply levels. Whenever employment opportunities decrease, disaster related migration decouples labor and product markets.

In the provinces of the largest commercial centers Dhaka and Chittagong, industrial wages are the driving force for rural agricultural wages following the structural break, while construction wages are not important in explaining changes in farm wages. This may be due to the importance of the garment industry in these divisions, which attracts rural workers to the urban centers. Specifically, around 1,000 textile factories and 7,000 readymade garments (RMG) are clustered at the outskirts of the capital city of Dhaka and the city of Chittagong where Bangladesh's largest port is located (Morshed, 2016). We observe a similar trend in Khulna and Sylhet, where industrial wages have a much stronger influence on farm wages than wages in the construction sector. On the other side, farm wages in Mymensingh and Rangpur are highly sensitive to wages in the construction sector which may be due to many new infrastructural development projects, especially the construction of new roads and highways, which have been implemented in these divisions. Rangpur has been declared a separate division in 2010 only and, following its independence, massive development projects worth an equivalent of $4302.16 million have been initiated. This led to a massive improvement in infrastructure and communication networks in Rangpur (BSS, 2018).

6 Conclusion and scope of further research

Rural wages and food prices are major determinants of rural livelihoods in Bangladesh. Rising food prices during the end of the 2000s have created additional threats to poverty reduction and rural welfare although increasing food prices also generated opportunities for net sellers of the respective commodity. The main objective of this study is to examine the drivers of farm wage formation and to increase the understanding of its implications for rural welfare. In this regard, it is also important to take into account the ongoing structural transformation of Bangladesh's economy towards manufacturing and services, thus including one of the world's largest garment industries. It is believed that the increase in agricultural prices has led to higher farm wages. Higher farm wages have general welfare effects like increasing the agricultural income of workers but they also lower income from fixed capital resources, such as land, due to increasing costs of labor (Jacoby, 2016). To measure such effects and to obtain welfare implications of changing terms of trade, which is the real agricultural wage, requires an estimate of the relevant wage-price elasticities. In this study, we applied standard time series econometrics to analyze how the agricultural wage rate responds to changes in rice prices and urban wages. In addition, we tested for the stability of these relationships over time. In this way, we formally verified the Lewis turning point after which the rural wage formation changes. Before the turning point, agricultural wages are merely determined at the subsistence level. Afterwards, labor supply becomes elastic, and prices increase when labor migrates into the other sectors of the economy.

We find strong empirical evidence for a structural break in the labor-food market relationship in the period between 2007 and 2008. This change might be associated with the adoption of labor-saving technologies in agriculture and subsequent higher labor productivity as results of the structural transformation of the economy which led to increased linkages between rural and urban labor markets and in consequence to rural-urban migration. Although the structural break is observed for all eight divisions, we find substantial differences in labor-food market integrations across the eight divisions of the country. For instance, after the structural break around 2008, rice prices are significantly correlated with farm wages only in Dhaka, Barisal, and Mymensingh. Except for Dhaka, Mymensingh, and Barisal, farm wages in all other divisions are either influenced by industrial or constructional wages, but not by rice prices. These findings suggest strong evidence in favor of the Lewis turning point.

But if rice prices have little influence on the agricultural wage rate, then an increase in the price of rice will have little effect on wage rates, and will thus not lead to poverty reduction. However, rising rice prices do not only increase the income of the daily laborers, but also inflate the production cost of rice. To ensure food security in the face of increasing rice prices, policymakers need to guarantee that rising production costs of rice are accompanied by increases in labor productivity. Agricultural mechanization, previously considered to be associated with the risk of labor substitution, could be promoted to compensate for a decreasing agricultural labor force and to enhance agricultural production. Alternatively, government policy could aim for a control of rice price movements through the national rice price stabilization scheme to maintain the balance between labor income and rice prices. To avoid large fiscal interventions, target programs like “the rice for the ultra-poor”, selling rice at 10 Taka/ Kilogram to low-income families in 2016, and the fair price card provisions should be preferred.

Nonetheless, the growth in the non-agricultural sector is the real driver of rural agricultural wages. Rising demand for labor due to growing industries in urban areas (garments and construction sector) significantly push farm wages, which also has major implications for long-term poverty reduction. At present, farm workers are no longer in abundant supply. Such a transformation of the economy calls for a reorientation of agricultural policies. Therefore, more importance needs to be given to non-farm employment opportunities, especially in the five divisions (excluding Dhaka, Mymensingh, and Barisal) where farm wages do not respond to increasing rice prices to raise the purchasing power of agricultural laborers in the long run. Policy programs, such as the employment generation program for the poor (EGPP), could be a viable means; yet evaluating different policy options goes beyond the scope of this work. Moreover, any other policy aiming at enhancing rural labor income by increasing domestic rice prices (e.g., import tax) needs to be evaluated in the view of limited transmission of rice prices changes to farm wages in both the short term and the long term.

The results of the present study provide a better understanding of the welfare effects of staple food price changes for rural agricultural laborers, which need to be addressed by policy-making. Apart from rice prices and urban wages, rural labor markets are determined by multiple other factors, such as labor productivity, remittances, price stabilization policies, and weather conditions. Since we are mainly interested in the price-wage nexus, we opt for the co-integration framework which makes it difficult to include further endogenous variables, partly due to their mixed frequency nature. The inclusion of such variables in the time series model might however help to improve the understanding of the causal relationship between the variables and should be subject to future research.

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Technical Appendix 1

Table 7: Upper poverty line

Division	Year					
	1991	1995	2000	2005	2010	2015
Dhaka	58.7	52	46.7	32	30.5	16
Barisal	42	59.9	53.1	52	39.4	26.5
Chittagong	46.5	44.9	45.7	34	26.2	18.4
Khulna	59.9	51.7	45.1	45.7	32.1	27.5
Rajshahi	71.8	62.2	56.7	51.2	29.8	28.9
Sylhet			42.4	33.8	28.1	16.2

Table 8: Lower poverty line

Division	Year					
	1991	1995	2000	2005	2010	2015
Dhaka	42.3	33	34.5	19.9	15.6	7.2
Barisal	59.7	43.9	34.7	35.6	26.7	14.5
Chittagong	24.6	32.4	27.5	16.1	13.1	8.7
Khulna	47.2	32.2	32.3	31.6	15.6	12.4
Rajshahi	59.7	41.6	42.7	34.5	16.8	14.2
Sylhet			26.7	20.8	20.7	11.5

Technical Appendix 2

Table 9: Correlation matrix of the explanatory variable

Divisions		Rice price	Industrial wage	constructional wage
Dhaka	Rice price	1		
	Industrial wage	0.0466	1	
	constructional wage	0.0838	0.2366	1
Mymensingh	Rice price	1		
	Industrial wage	0.0307	1	
	constructional wage	0.1078	0.0188	1
Rajshahi	Rice price	1		
	Industrial wage	0.0257	1	
	constructional wage	-0.0596	0.2162	1
Rangour	Rice price	1		
	Industrial wage	-0.0116	1	
	constructional wage	0.0614	0.0022	1
Khulna	Rice price	1		
	Industrial wage	0.0173	1	
	constructional wage	0.0173	0.2226	1
Sylhet	Rice price	1		
	Industrial wage	0.0338	1	
	constructional wage	0.0077	0.0154	1
Barisal	Rice price	1		
	Industrial wage	0.0553	1	
	constructional wage	0.0533	0.2366	1
Chittagong	Rice price	1		
	Industrial wage	0.0727	1	
	constructional wage	0.0802	0.4015	1

Technical Appendix 3

Seasonality and unit root of the respected series

Sometimes both seasonal unit roots and seasonal heterogeneity are common in time series data. The HEGY (Hylleberg, Engle, Granger, & Yoo, 1990) test is the common tool for detecting the seasonal unit roots. For all the series, considering the structural break, we check the possibility of a regular unit root along with the seasonal unit root test. The results are displayed in Table 10.

Table 10: HEGY test of regular and seasonal unit root

Division	Stages of unit root	Farm wage	Food Price	Industrial Wage	Construction Wage
Dhaka	Zero frequency (non-seasonal)	yes	yes	yes	Yes
Khulna	4 months per cycle	No	No	No	No
Sylhet	2.4 months per cycle	No	No	No	No
Rajshahi	12 months per cycle	No	No	No	No
Rangpur	3 months per cycle	No	No	No	No
Chittagong	6 months per cycle	No	No	No	No

Technical Appendix 4

Optimal lag length selection

Using both the Schwarz criterion (SBIC) and Hannan-Quinn information criterion (HQIC) we estimate the optimal lag length. Most of the models have two periods of lags before the structural break; after the break, they have one period break. In case of different lag structures suggested by the selection criteria, we go for the maximum lag (cf. Technical Appendix 2).

Table 11: Lag selection

Division	SBIC	HQIC	SBIC	HQIC
	Before structural break		After structural break	
Dhaka	1	2	3	3
Khulna	2	1	2	2
Sylhet	1	2	1	1
Rajshahi	1	1	2	1
Rangpur	2	2	1	1
Chittagong	2	1	1	1
Barisal	1	1	1	1
Mymensingh	1	1	1	1

Technical Appendix 5

Table 12: Rank of the cointegration vectors

Dhaka division:

Sample: 1994m2- 2009m1

Johansen tests for cointegration

Trend: trend Number of observation = 180

Lags= 1

Rank	parameters	Lower Limit	eigenvalue	Trace statistic	5% critical value
0	8	1181.3154	.	85.2426	54.64
1	15	1211.8282	0.28754	24.2170*	34.55
2	20	1217.7479	0.06366	12.3775	18.17
3	23	1222.0576	0.04676	3.7581	3.74
4	24	1223.9367	0.02066		

Sample: 2009m1 - 2014m12

Trend: constant Number of observation =72

Lags = 3

Rank	parameters	LL	eigenvalue	Trace statistic	5% critical value
0	36	543.42742	.	50.4449	47.21
1	43	555.8777	0.29238	25.5444*	29.68
2	48	562.90283	0.17728	11.4941	15.41
3	51	567.08708	0.10973	3.1256	3.76
4	52	568.64989	0.04248		

Mymensingh division

Sample: 1994m2 - 2009m1

Johansen tests for cointegration

Trend: trend Number of observation =180

Lags = 1

Rank	parameters	Lower Limit	eigenvalue	Trace statistic	5% critical value
0	8	1095.6838	.	94.1350	54.64
1	15	1130.0022	0.31704	25.4982*	34.55
2	20	1136.6158	0.07085	12.2711	18.17
3	23	1140.9768	0.04730	3.5490	3.74
4	24	1142.7513	0.01952		

Sample: 2009m1 - 2014m12

Johansen tests for cointegration

Trend: trend Number of observation = 72

Lags = 1

Rank	parameters	Lower Limit	eigenvalue	Trace statistic	5% critical value
0	8	475.10086	.	91.7361	54.64
1	15	499.757	0.49586	42.4238	34.55
2	20	513.7699	0.32243	14.3980*	18.17
3	23	518.45609	0.12206	5.0256	3.74
4	24	520.96891	0.06742		

Rajshahi division

Sample: 1994m2 - 2008m12

Johansen tests for cointegration

Trend: constant Number of observation = 179

Lags = 1

Rank	parameters	Lower Limit	eigenvalue	trace statistic	5% critical value
0	4	1188.4872	.	49.0389	47.21
1	11	1200.1637	0.12231	25.6859*	29.68
2	16	1208.4743	0.08868	9.0647	15.41
3	19	1213.0066	0.04938	0.0002	3.76
4	20	1213.0067	0.00000		

Sample: 2008m12 - 2014m12

Johansen tests for cointegration

Trend: constant Number of observation =73

Lags = 1

Rank	parameters	LL	eigenvalue	trace statistic	5% critical value
0	4	528.00304	.	43.7180*	47.21
1	11	545.08094	0.37368	9.5622	29.68
2	16	548.17395	0.08125	3.3762	15.41
3	19	549.81788	0.04404	0.0884	3.76
4	20	549.86206	0.00121		

Rangpur division

Sample: 1994m2 - 2008m12

Johansen tests for cointegration

Trend: constant Number of observation = 179

Lags = 1

rank	parameters	Lower Limits	eigenvalue	Trace statistic	critical value
0	4	1479.3173	.	54.7868	47.21
1	11	1493.0245	0.14200	27.3722*	29.68
2	16	1502.0746	0.09617	9.2720	15.41
3	19	1506.4267	0.04746	0.5678	3.76
4	20	1506.7106	0.00317		

Sample: 2008m12 - 2014m12

Johansen tests for cointegration

Trend: constant Number of observation = 73

Lags = 1

Maximum rank	parameters	Lower Limits	eigenvalue	Trace statistic	5% critical value
0	4	690.3545	.	76.0560	47.21
1	11	711.30603	0.43674	34.1530	29.68
2	16	723.85719	0.29098	9.0507*	15.41
3	19	727.28525	0.08964	2.1945	3.76
4	20	728.38252	0.02961		

Khulna division:

Sample: 1994m2 - 2007m1

Johansen tests for cointegration

Trend: constant Number of observation = 156

Lags = 1

Rank	Parameters	Lower Limits	eigenvalue	Trace statistic	5% critical value
0	4	1086.3155	.	61.6325	47.21
1	11	1104.3586	0.20652	25.5463*	29.68
2	16	1112.5871	0.10012	9.0892	15.41
3	19	1116.1435	0.04457	1.9764	3.76
4	20	1117.1317	0.01259		

Sample: 2007m1 - 2014m12

Johansen tests for cointegration

Trend: constant Number of observation = 96

Lags = 2

Rank	parameters	Lower Limits	eigenvalue	Trace statistic	5% critical value
0	20	616.01467	.	51.9195	47.21
1	27	630.93556	0.26718	22.0777*	29.68
2	32	638.06755	0.13807	7.8138	15.41
3	35	641.1161	0.06154	1.7167	3.76
4	36	641.97444	0.01772		

Sylhet division:

Sample: 1994m2 - 2008m1

Johansen tests for cointegration

Trend: constant Number of observation = 168

Lags = 1

Rank	parameters	Lower Limits	eigenvalue	Trace statistic	5% critical value
0	4	1185.2475	.	60.6645	47.21
1	11	1207.9192	0.23654	15.3211*	29.68
2	16	1212.3872	0.05180	6.3851	15.41
3	19	1214.8763	0.02920	1.4069	3.76
4	20	1215.5797	0.00834		

Sample: 2008m1 - 2014m12

Johansen tests for cointegration

Trend: trend Number of observation = 84

Lags = 1

Maximum Rank	parameters	Lower Limits	eigenvalue	Trace statistic	5% critical value
0	8	613.5093	.	62.0804	54.64
1	15	627.11719	0.27675	34.8646	34.55
2	20	638.3337	0.23437	12.4316*	18.17
3	23	642.29597	0.09003	4.5071	3.74
4	24	644.54951	0.05224		

Barisal division:

Sample: ***1994m2-2008m12***

Johansen tests for cointegration

Trend: trend Number of observation =179

Lags=1

Maximum Rank	parameters	LL	eigenvalue	trace statistic	5% critical value
0	8	1145.356	.	59.2268	54.64
1	15	1161.5122	0.16516	26.9145*	34.55
2	20	1169.1994	0.08231	11.5400	18.17
3	23	1173.7575	0.04965	2.4239	3.74
4	24	1174.9694	0.01345		

Johansen tests for cointegration

Sample: ***2008m12 - 2014m12***

Trend: constant Number of observation = 73

Lags = 1

rank	parameter	LL	eigenvalue	trace statistic	5% critical value
0	4	525.86371	.	54.2192	47.21
1	11	547.70948	0.45037	10.5277*	29.68
2	16	551.39695	0.09609	3.1528	15.41
3	19	552.97318	0.04227	0.0003	3.76
4	20	552.97333	0.00000		

Chittagong division:

Sample: **1994m3 - 2008m12**

Johansen tests for cointegration

Trend: rtrend Number of observation = 178

Lags = 2

rank	parameter	Lower Limits	eigenvalue	trace statistic	5% critical value
0	20	1291.0138	.	72.7879	62.99
1	28	1311.5107	0.20571	31.7942*	42.44
2	34	1319.784	0.08877	15.2475	25.32
3	38	1325.6048	0.06331	3.6059	12.25
4	40	1327.4078	0.02005		

Johansen tests for cointegration

Sample: 2008m12 - 2014m12

Trend: rtrend Number of observation = 73

Lags = 1

rank	parameter	Lower Limits	eigenvalue	trace statistic	5% critical value
0	4	578.19634	.	83.3993	62.99
1	12	599.40935	0.44076	40.9733*	42.44
2	18	612.02041	0.29214	15.7512	25.32
3	22	617.83221	0.14720	4.1276	12.25
4	24	619.896	0.05497		

Technical Appendix 6

Stability test

Post-estimation of the VECM model requires to check whether the co-integrating equations are stationary. This process requires to compute the eigenvalues of the companion matrix and count the number of unit moduli in the whole system. If the number of the unit moduli (k) is less than the number of the endogenous (T) variables after subtracting the number of co-integrating vectors (r), that means $k < T\text{-}r$, then the co-integration equation is stationary. Also, the Lagrange multiplier (LM) test for autocorrelation provides evidence whether the residuals of the vector error-correction models (VECMs) are autocorrelated or not. The Wald and Lagrange multiplier test finds no autocorrelation of the residuals at the selected lags. Normality of the residuals is also examined. However, one minor limitation of the models is that they passed the examination of the stationarity and autocorrelation, but marginally failed to form a normal distribution of the residuals.

Technical Appendix 7

Price transmission in the short-run

Table 13: Real farm wage response to real industrial wages

Division	Three month pass-through coefficients		Six month pass-through coefficients		Twelve month pass-through coefficients	
	Before Break	After break	Before Break	After break	Before Break	After break
Dhaka	-0.083	**0.548****	0.030	0.599	0.033	-0.010
Mymensingh	-0.025	**0.855****	0.048	**1.11****	0.024	0.510
Rajshahi	0.001	0.222	0.155	0.231	0.212	0.399
Rangpur	0.071	0.072	0.057	0.011	0.0901	-0.30
Sylhet	-0.032	0.291	0.157	0.242	0.2574	-0.32
Khulna	0.009	-0.219	0.081	-0.23	0.089	**-0.90****
Barisal	-0.113	0.373	-0.155	0.282	-0.353	0.129
Chittagong	0.085	0.126	-0.179	0.320	0.249	-1.0

Table 14: Real farm wage response to constructional wages

Division	Three month pass-through coefficients		Six month pass-through coefficients		Twelve month pass-through coefficients	
	Before Break	After break	Before Break	After break	Before Break	After break
Dhaka	0.063	**0.766****	0.082	0.112	0.061	-0.011
Mymensingh	0.125	0.697	0.141	1.18	0.108	0.381
Rajshahi	0.0859	**0.949****	0.069	-0.202	0.112	-0.638
Rangpur	-0.033	0.317	0.0791	-0.683	0.175	-0.282
Sylhet	0.0339	-0.034	0.039	0.4842	0.107	0.796
Khulna	0.003	0.463	0.097	0.2582	0.138	**1.27****
Barisal	-0.003	0.242	0.138	-0.54	**0.234***	-0.813
Chittagong	-.021	0.630	**0.169***	-0.136	**0.313****	-1.92

Technical Appendix 8

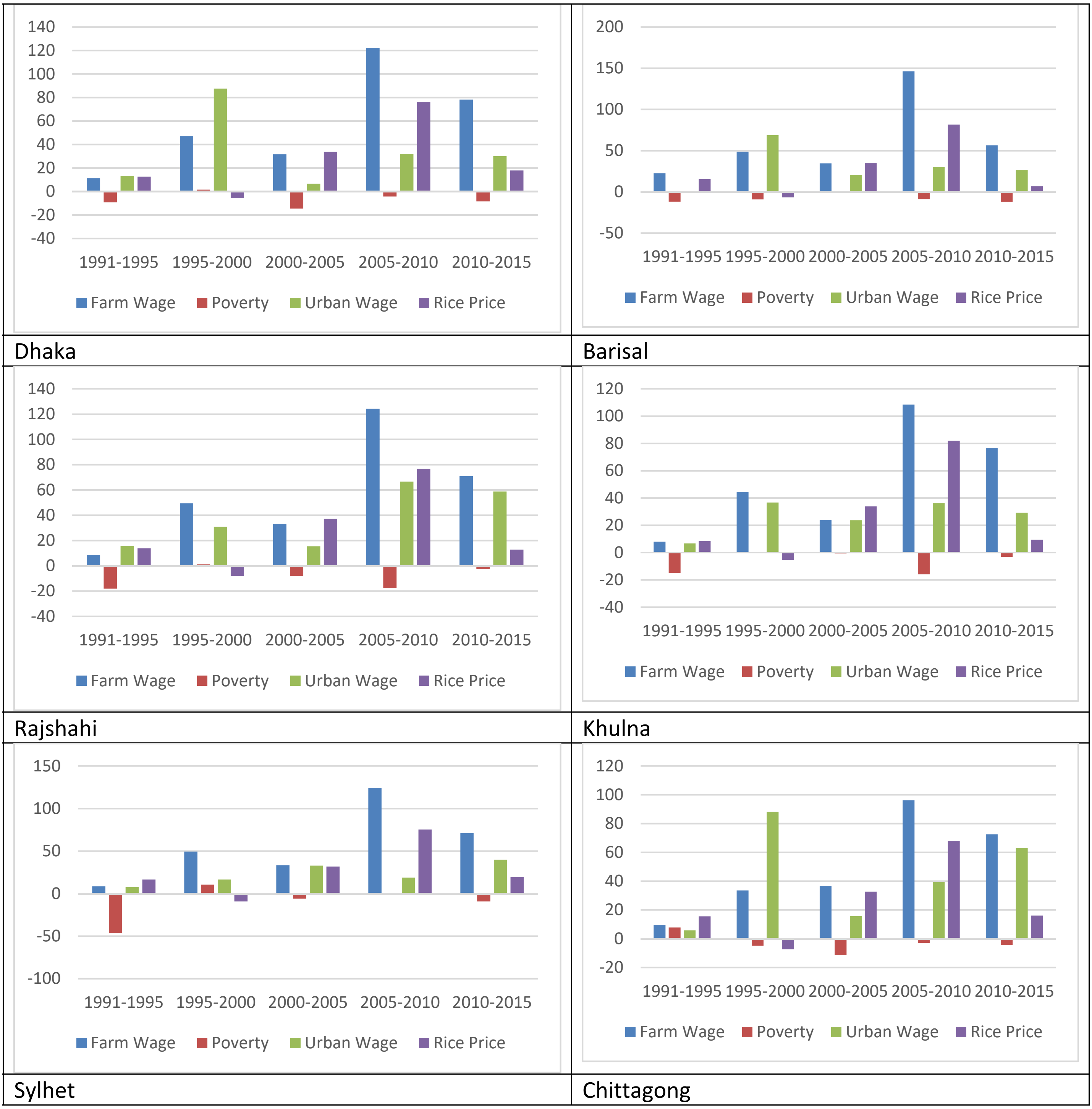

Figure 7: Percentage change of wages, prices and poverty; source: HIES from (1991 to 2015)

Technical Appendix 9

Table 15: Summary of long- and short-run elasticities and labor demand

Magnitude	Long-run elasticities of farm wages							Pass-through (2008-2014) elasticities in the short run			Labor demand
Divisions	Rice	Industry	Construction	Break	Rice	Industry	Construction	Rice	Industry	Construction	Cultivated area
Dhaka	**+++**	**++++**	+		**++++++**	**++**	+		x	x	*****
Mymensingh	**+**	**+++++++**	**++**		**++++++++**	**+++++**	**+++++++**	x		x	****
Rajshahi	**++++++**	+	**+++++++**		+++++++	++++	**+++++**		x		********
Rangpur	**+++++**	**++**	**++++++**		++	**+**	**++++++**				*******
Khulna	**++++**	**+++**	**+++**		+	**+++++++**	**++++**		x	x	***
Sylhet	**++**	**+++++**	**+++**		++++	**++++++**	+++				*
Barisal	**+++++++**	**++++++**	**+++++**		+++	+++	++	x			**
Chittagong	**++++++++**	**++++++++**	**++++++++**		+++++	**++++++++**	++++++++				******

Note: "**+**" signs are ordered in ascending order (bold sign means significance at 1%-10%); "x" indicates significant transmission of the price shocks to farm wage; "*" indicates the area of rice cultivation in ascending order for Aman and Boro