Empirical Analysis of Hysteresis in Rural Labor Markets in a Developing Country: The Case of Bangladesh

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Abstract

This paper empirically investigates the relationship between commodity prices and wages in the rural labor markets of a developing country (i.e., Bangladesh). Given its basis on a theoretical justification for hysteresis, this empirical study provides a more complete method for investigating labor market hysteresis than previous research.

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I. Introduction

Background and Purpose

The relationship between commodity prices and wages is central to the question of social welfare in rural areas of developing countries such as Bangladesh. Given that rural laborers are often unable to produce sufficient food for their own consumption, they must supplement home production with goods purchased in the market. Furthermore, many landless laborers must obtain all of their food from market purchases. The necessary income to pay for such purchases will generally come from laboring on the larger farms of neighbors or even from farm work in other regions. The relationship between commodity price and wage income in the rural markets of Bangladesh is important because a sufficiently sluggish response of wages to price rises could have negative consequences for rural laborers. In fact, it has been argued that a "sizeable proportion of the excess mortality observed during famines in Bangladesh can be attributed to a shortfall in the food purchasing power of incomes, associated with higher prices." (Ravallion and Thamarajakshi, 1991).

Traditional economic theory of labor demand predicts that the effects of price rises on labor are tempered by the diminishing marginal product of labor. Two principles support this notion: (i) the marginal value product of labor (pf_l) equals the wage rate (w) in equilibrium and (ii) the marginal product of labor is diminishing with increases in labor ($f_{ll} < 0$). This theory predicts that if output prices rise, then a profit-maximizing farm owner will hire additional labor up until the point where the equilibrium condition holds. Note that even if fi$_{ll}$ = 0, there is no assurance that a one unit increase in prices will transmit to a one unit increase in wages unless fi$_{l}$ = 1.

This study asks if there are times in rural labor markets when hiring remains unchanged despite commodity price rises and despite the concomitant increase in the marginal value product of labor. If so, what motivates those farm owners who are potential demanders of labor to hold back on their production and hiring and, thus, cause some short-run stickiness in the relationship between prices and wages? In answering these questions, we may better understand why rural laborers may find it difficult to survive short-run rises in prices—problems particularly relevant to the rural markets of Bangladesh. What becomes an interesting and potentially enlightening direction of inquiry is to cast the problem within a framework of the farm owner's dynamic production and hiring decisions. Specifically, we seek to answer how the structure of adjustment costs in hiring and firing labor impedes the smooth and instantaneous change in labor use in response to output price changes.

The basis for our conceptual framework is the concept that labor is a quasi-fixed factor due to adjustment costs associated with hiring, training, and termination (Oi). Using this idea, we then resort to the recent literature on investment under uncertainty with sunk costs to form a theoretical foundation for the existence of a range of prices in which it is optimal for farm owners to leave their hiring decisions unchanged. If labor is quasi-fixed and farm owners face stochastic behavior by prices, then farm owners will balance sinking expenditures into labor hiring/firing against uncertain input and output price behavior in the future (Abel and Eberly; Dixit). In an environment with such adjustment costs in hiring and firing, demand encompasses

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three regimes: hiring, firing, and inaction. Alternatively, even if adjustment costs are simply assymetric but not sunk, there will still be assymetric, we can still speak of demand encompassing a hiring and firing regime where the firing regime exhibits a smaller responsiveness to price changes.

Organization of Paper

In developing this research, Section II discusses the previous literature on commodity and labor markets in Bangladesh in order to provide a stronger motivation for the current research. In Section III, we will provide an overview of the literature on quasi-fixity and decision making under uncertainty that will form the foundation for our conceptual model. In Section IV, we adapt Abel and Eberly's 1994 model in order to provide a foundation for rigidities in the price-wage relationship. Specifically, we argue that such rigidities arise from the dynamic decision-making process of farm owners who face adjustment costs in their hiring/firing of labor in an environment in which the output price is stochastic. In Section V, we discuss our empirical labor demand model which allows for price threshold(s) for the hiring and firing of labor. Furthermore, we calibrate a labor supply function using aggregate time series data and parameter estimates from a panel estimation of household labor supply. In Section VI, we use our aggregate labor demand model and our calibrated aggregate labor supply equation to simulate and analyze the equilibrium relationship between prices and wages. This research goes beyond previous studies (Palmer-Jones, R. and A. Parikh, 1998; Boyce, J.K. and M. Ravallion, 1991; and Ravallion, M. and R. Thamarajakshi, 1991) by basing the empirical study of price-wage rigidity on a sound theoretical foundation. It is hoped that this conceptual framework and the

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accompanying empirical findings can lead to improvements on policy with respect to food security among poor rural households in Bangladesh.

II. Literature on Bangladeshi Agricultural Commodity and Labor Markets

Bangladeshi rice and food markets have often been the focus of research related to spatial market integration and pricing efficiency (Ravallion, 1986; Das, Zohir, and Baulch, 1997). These studies have been performed with the idea that improved price integration will support a “well functioning market” and will “generate prices that truly reflect the scarcity value of the commodity” (Das, Zohir, and Baulch, 1997, 1). This line of research has intended to test for the existence of impediments to interregional trade and also, to some extent, address the question of market efficiency. Specifically, Das, Zohir, and Baulch address how liberalization of agricultural markets in Bangladesh has affected the trading between regions and generally found that market integration had improved due to reduced government intervention in such markets.

The previous studies give us some idea as to the nature and degree of commodity market integration across markets, but they tell us little about why some people are unable to feed themselves, even when there is not a fall in food supply. That is, these studies fail to heed Amartya Sen’s criticism that a “food-centred view tells us rather little about starvation.” (Sen, 1981) Even if markets are integrated and efficiently price agricultural commodities, this understanding does not explain how prices affect wages and thereby affect the ability of workers to obtain the food they need to survive.

To that end, Thamarajakshi and Ravallion (1991), Boyce and Ravallion (1991), and Palmer-Jones and Parikh (1998) have studied the relationship between prices and wages in Bangladesh. Nevertheless, while these works indicate stickiness in the transmission of prices into wages both in the short and long runs, one is still left with an unclear sense of the source of this stickiness. That is, despite the improvements in characterizing the degree of rigidity, we are still left with the question: What are the sources of such rigidities? Specifically, we investigate in this study the connection between the hiring decisions of farm owners and the slowness of wages to adjust to price changes in rural labor markets.

An early attempt at locating the source of the wage rigidity was made by Bardan (1979) who argued against the notion that agricultural labor markets are being driven by the interaction of demand and supply in a competitive environment. He notes that the emphasis of neoclassical economists on the equilibrating of the marginal value product of labor with wages has failed to explain the persistence of unemployment. Consequently, he proposes an imperfect markets model. Bardan's approach has been to focus on the purported monopsonistic or oligopsonistic power that employers exert in fixing the terms of a labor contract. He argues that this power derives from the unequal distribution of labor thereby leading to wages that do not fall or rise in step with changes in prices (Bardan, 1979, 486-7). Ravallion (1997, 1222-1223) also remarks that the neoclassical framework sits ill with respect to the persistence of underemployment.

However, Bardan's approach does not coincide with the finding of Palmer-Jones and Parikh (1998) that the wages in urban markets are transmitted to rural labor markets. That is, even if there are large or dominant landholders in a particular area, they are constrained, to some extent, by the larger economy to competitive levels of payment. Furthermore, as Richards and Patterson (1998) find, once farm laborers have moved to work in urban areas, they are unlikely to return even when wages in the agricultural sector rise to parity to the urban wage levels. This argument is based on the notion that these laborers have incurred a cost in the initial migration and the return would entail another round of sunk costs without long-run certainty that parity between urban and rural wages will persist. This insight further supports the argument that imperfect competition, even if it exists, is tempered by the wage dynamics in other sectors of the economy. Consequently, other factors may better explain these price-wage rigidities and would therefore have different policy implications than those of the imperfect markets model. So, while initial efforts have been directed at pinpointing the source of the rigidities, the rejection of competitive markets is only one part of the answer.

III. Quasi-fixity of Labor and Costs Associated with Changes in Labor Use

By asserting the quasi-fixity of labor we introduce an impediment to the "efficient" functioning of the labor markets in the Marshallian sense while at the same time allowing for the existence of competitive markets. Oi (1962) provides an argument that firms treat labor as a quasi-fixed factor in some ways. A quasi-fixed factor is defined as a factor for which the sum of its employment costs includes variable component such as wages and a non-wage component associated with adjusting the level of employment. While the wage costs of labor are the largest component, the firm must necessarily incur employment costs in hiring a specific stock of workers related to the training and initial oversight of new labor. Specifically, we will focus on what are called hiring and training costs in Oi's work. In the vocabulary of Oi, hiring costs include costs related to employment termination and layoffs. Training costs consist of time and effort spent in orienting and directing workers in their initial work assignments. Even in the context of the fairly unskilled labor needed in the agricultural markets of Bangladesh, these costs might still be of relevance. If a farm owner needs additional labor, he must spend some time, however small, in finding and hiring labor and paying for initial transport to the farm. Furthermore, even though such laborers may have the necessary skills, the farm owner must spend time in directing laborers as to exactly what work needs to be done and what are the expectations of the laborer during his employment with the farm owner.

We also argue that instability associated with weather and volatile markets implies that when work needs to be done, it must be done in a timely manner given the risk and costs which must be borne when there is a delay in an important farm activity. As a consequence, farm owners will desire to engage potential employees in some form of formal or informal contract thereby imposing some administrative costs. If farm owners choose not to involve themselves in such contracts, they must be aware of the potentially heavy recruitment cost related to last minute hiring (Bardan, 1979, 488). In terms of other adjustment costs found in agrarian labor markets, it has also been found in the case of the neighboring West Bengal India that large landowners provide workers with plots of lands, low interest salary advances for housing construction, and other forms of perquisites prior to the initiation of work. These costs amount to an adjustment cost associated with hiring of labor thereby supporting our argument that labor is a quasi-fixed factor (Bardan, 1979, 489).

Given the above support for our assumption that farm owners treat laborers as a quasi-fixed factor, the literature on investment under uncertainty provides valuable insights into the price-wage transmission in Bangladesh. The recent literature in agricultural economics and economics is replete with discussion regarding sunk costs and uncertainty providing a foundation for sluggish changes in quasi-fixed inputs used by firms. (Abel and Eberly, 1994; Chavas, 1994; Dixit, 1989; Dixit and Pindyck, 1994; and Lansink and Stefanou, 1997). Abel and Eberly (1994) extend the traditional adjustment-cost model under uncertainty by integrating three different costs into an augmented adjustment cost function: purchase/sale costs, traditional convex adjustment costs, and fixed costs in adjustment. In earlier research, Dixit (1989, 623) discusses a similar problem in terms of entry and exit decisions and points out that the rigidities we have alluded to earlier can be the consequence of even quite small sunk costs. Others have further argued that the existence of asymmetric adjustment costs (in our case a difference in hiring and firing costs) may underly the more rapid adjustment to long-run equilibrium levels of capital (labor) in investing (hiring) than when disinvesting (firing) (Lansink and Stefanou, 1997). As alluded to earlier, we have two possibilities: (1) sunk adjustment costs giving rise to a range of inaction and (2) assymetric adjustment costs leading to uneven responsivness to changes in relevant variables depending on whether a firm is in a hiring or firing phase. Based on this information, we can now look at how the quasi-fixity of labor can create a situation where hysteresis in the labor demand will occur under uncertainty.

IV. Conceptual Framework Explaining Hysteresis in Rural Labor Markets

A Theoretical Model Explaining Farmer Decisions in Hiring and Firing Labor

Drawing from Abel and Eberly's 1994 paper on investment under uncertainty, we now model the farm owner's decision to hire and fire labor. This work will lay the groundwork for an explanation of the stickiness and assymetric adjustment of labor employment discussed above. The evolution of labor stock is:

$$L_t = L_{t-1} + dl_t \qquad (1)$$

where L_t is the stock of labor at time t and dl_t is the amount hired ($dl_t > 0$) or fired ($dl_t < 0$) at time t . When the farm owner has L_t units of labor stock in place, the flow of output is $q_t = L_t^{\xi}A^{1-\xi}$. The term A corresponds to the amount of land used in production and is considered fixed, and without loss of generality, we assume that A = 1 for the remainder of this paper. The farm owner is assumed to be a price taker in the output market, and the stochastic output price is assumed to follow a geometric Brownian motion with drift:

$$(2) \qquad \frac{dP_t}{P_t} = \quad dt + s\ dz$$

where α is the trend rate, σ is the variance coefficient, and z is a standard Weiner process with dz $= \varepsilon_t \sqrt{t}$ and ε_t is distributed as N(0,1).

The farm owner's profit flow at t can be written as $P_t\, L_t^{\xi} - w_t\, L_{t-1} - h(d\mathbf{l}_t, w_t, L_{t-1})$ where w_t is the wage rate at t and $h(d\mathbf{l}_t, w_t, L_{t-1})$ is a modified version of Abel and Eberly's augmented adjustment cost function, including wage payment to the additional labor hired at time t (i.e., $w_t\, d\mathbf{l}_t$). The discussion of this augmented adjustment cost follows.

Augmented Adjustment Cost Function

Following Abel and Eberly, the farm owner is assumed to consider three types of costs in his labor hiring/firing decisions: (i) conventional adjustment costs, (ii) fixed costs in adjustment and (iii) a change in payroll due to hiring/firing. The conventional adjustment cost function [say, $\Psi(d\mathbf{l}_t, L_{t-1})$] is typically assumed to be strictly convex, twice differentiable with respect to $d\mathbf{l}$ and reaches a minimum of zero for $d\mathbf{l} = 0$ (Abel and Eberly, pp.1371-72). To allow for asymmetry in capital investment, Abel and Eberly consider also the possibility that the adjustment cost function may not be differentiable at $d\mathbf{l} = 0$. The fixed costs in adjustment are nonnegative costs incurred whenever $d\mathbf{l} \neq 0$. The cost associated with a change in payroll is the increase (decrease) in wage payments due to hiring (firing).[1] Abel and Eberly refer to the sum of these three cost components as the augmented adjustment cost function, which by construction is convex, and

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[1] Since the change in payroll can be either positive or negative, this third cost component is the labor market analogy to Abel and Eberly's purchase/resale costs of capital assets, as the farm owner only rents the laborers' time and does not own the laborers.

everywhere differentiable with the possible exception at $d\ell = 0$. This augmented adjustment cost function is presented as $h(d\ell_t, w_t, L_{t-1})$ above.

Since the conventional adjustment cost function [i.e., $\Psi(d\ell_t, L_{t-1})$] and changes in payroll (i.e., $w_t\, d\ell_t$) are both zero for $d\ell = 0$, and since the fixed costs are incurred for any nonzero value of $d\ell$, however small, the limit of the augmented adjustment cost function as $d\ell$ approaches zero has the interpretation of being the fixed cost of adjustment. This fixed cost will be denoted as $h(0, w_t, L_{t-1})$. Let $h_{d\ell-}(0, w_t, L_{t-1})$ and $h_{d\ell+}(0, w_t, L_{t-1})$ denote the left-hand and right-hand partial derivatives of the augmented adjustment cost function with respect to $d\ell$ evaluated at $d\ell = 0$. By convexity of the augmented adjustment cost function, $h_{d\ell+}(0, w_t, L_{t-1})$ is always positive and $h_{d\ell+}(0, w_t, L_{t-1}) \geq h_{d\ell-}(0, w_t, L_{t-1})$. Without considering payroll related costs, $h_{d\ell-}(0, w_t, L_{t-1})$ would be negative due to convexity; however, because of the reduction in payroll costs from firing, it is possible for $h_{d\ell-}(0, w_t, L_{t-1})$ to be zero or positive.

The Farmer's Decision Making Process

It is assumed that the farm owner is risk-neutral and chooses his labor usage to maximize the expected discounted profit flow over time.

$$(3)\quad V(P_t, w_t, L_{t-1}) = \max_{dl_{t+s}, v_{t+s}} \int_0^\infty E_t\{(P_{t+s} L_{t+s}{}^{x} - w_{t+s} L_{t+s-1}) - v_{t+s}\, h(d\ell_{t+s}, w_{t+s}, L_{t+s-1})\}\, e^{-rs} ds$$

where the maximization is subject to the evolution of L_t in equation (1) and that of P_t in equation (2), $r > 0$ is the discount rate, and v is a dummy variable with a value of 0 when $d\ell = 0$ and 1 otherwise. Since $h(0, w_t, L_{t-1})$ is a nonnegative fixed cost of adjustment, the dummy variable v is necessary to ensure that the augmented adjustment costs are zero when $d\ell = 0$. Equation (3) states that the value of the farm, V, should equal the maximum expected present discounted profits.

Following Abel and Eberly, the Bellman equation of the above maximization problem can be written as:

$$(4) \qquad rV(P_t, w_t, L_{t-1}) = \max_{dl_t, v_t} \{(P_t L_t^{\ x} - w_t L_{t-1}) - v_t h(d\ell_t, w_t, L_{t-1}) + \frac{1}{dt} E(dV_t)\}$$

This equation states that the required return on the farm is equal to the maximized expected profits and the expected "capital gain" represented by E(dV)/dt. Using Ito's lemma, one obtains:

$$(5) \quad E(dV) = [V_\ell d\ell + meV_e + \frac{1}{2} s\, e^2 V_{ee}\,]dt$$

Equation (5) states that the "capital gain" depends on the value to the farm of the additional unit of labor $(V_\ell d\ell)$ and the value to the farm of the evolution of price over time as represented by the last two terms in the above equation. Define $q \equiv Vl > 0$ as the marginal valuation of an additional unit of employed labor, and substituting this definition into (5), the expression in (4) becomes:

$$(6) \quad rV(P_t, w_t, L_{t-1}) = \max_{dl_t, v_t} \{(P_t L_t^{\ x} - w_t L_{t-1}) - v_t h(d\ell_t, w_t, L_{t-1}) + q_t\, d\ell_t + me_t V_e + \frac{1}{2} s e_t^2 V_{ee}\}$$

We can now solve the farm owner's problem of hiring and firing for any given planting season. As Abel and Eberly direct, let us first assume that v = 1 in order to solve the incremental problem when farms are in a hiring/firing regime. We then compare that solution with the solution associated with the case where v = 0 and choose the optimal v. To solve the maximization problem where v = 1, we note that the only terms in (6) involving the decision variable dl are –h(dl) and q; therefore, the optimal value of dl will solve the following maximization problem.

$$(7) \quad \max_{dl_t} \; [q_t d\ell_t - h(d\ell_t, w_t, L_{t-1})]$$

The solution for this conditional problem (i.e., conditioned on v = 1) can be found by solving the associated first-order condition that the marginal cost of hiring/firing equals the marginal benefit. That first-order condition is:

$$(8) \qquad h_{d\ell}(d\ell_t, w_t, L_{t-1}) = q_t$$

Recall that the augmented adjustment cost function h(.) may not be differentiable with respect to dl at dl = 0 and we denote the left-hand and right-hand derivative by $h_{dl}\_(0, w_t, L_{t-1})$ and $h_{dl}+(0, w_t, L_{t-1})$, respectively. Together with convexity, the non-differentiability of h(.) at dl = 0 means that the optimal condition (8) implies the following switching decision rule for labor hiring/firing (Abel and Eberly):

$$(9) \qquad d\ell_t^{conditiond} \quad \begin{array}{ll} < \; 0 & q < h_{dl}\_(0, w_t, L_{t-1}) \\ = \; 0 & h_{dl}+(0, w_t, L_{t-1}) \geq q \geq h_{dl}\_(0, w_t, L_{t-1}) \\ > \; 0 & q > h_{dl}+(0, w_t, L_{t-1}) \end{array}$$

The thresholds for hiring and firing are $h_{dl}+(0, w_t, L_{t-1})$ and $h_{dl}\_(0, w_t, L_{t-1})$, and $q \$ 0$ is the shadow value of labor. We noted in the previous section that, while $h_{dl}+(0, w_t, L_{t-1})$ is positive, $h_{dl}\_(0, w_t, L_{t-1})$ can be either positive or negative. Equation (9) dictates that it is optimal for the farm owner to restrain from additional hiring/firing if the shadow value of labor lies between the upper threshold defined by $h_{dl}+(0, w_t, L_{t-1})$ and the lower threshold defined by $h_{dl}\_(0, w_t, L_{t-1})$. As noted, this labor hiring/firing decision rule is conditioned on the assumption that the farm owner has already chosen to hire or to fire additional labor, i.e., $v = 1$. Clearly, the owner also has the option of simply doing nothing, i.e., choosing $v = 0$ at the outset. As such, the optimal labor hiring/firing rule in (9) has to be generalized to allow for this second alternative. In other words, since the hiring/firing rule is derived exclusively from the marginal condition in (8), it ignores the additional requirement that the value to the firm from adopting this policy should be at least as large as the value associated with choosing not to adjust the labor stock at all.[2]

As shown in Abel and Eberly, the modification results in an enlargement of the range of inaction. Denote the modified upper threshold by q_U (with $q_U \geq h_{dl}+(0, L)$) and the modified lower threshold by q_L (with $q_L \leq h_{dl}\_(0, L)$) and write the modified (unconditional) optimal labor hiring/firing decision rule as:

$$(10) \qquad d\ell_t^* \quad \begin{array}{llll} < 0 & q < q_L & (q_L \text{ can be positive or negative})^3 \\ = 0 & q_U \geq q \geq q_L & \\ > 0 & q > q_U & (q_U \text{ is positive}) \end{array}$$

Now, given that our goal is to find the impact of changing commodity prices on the farm owner's demand for rural labor and wage rates, we need to cast the decision rule in (10) into one pertaining to output prices. This can be done by noticing that the shadow value of labor q is, in part, a function of output prices. As such, one can obtain a mapping of the decision rule from the

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[2] A static model analogy of this concept is that while a profit-maximizing competitive firm should always produce at a point where the output price equal marginal costs, the firm would be better off shutting down the operation if the price is not high enough to cover the variable costs.

space of q to that of p (Chavas, 1994, 121). Denoting the corresponding upper and lower thresholds in the output space by p_U and p_L, respectively, (10) can be equivalently written as:

$$(11) \quad d\ell_t^* \quad \begin{array}{ll} < 0 & p < p_L \\ = 0 & p_U \geq p \geq p_L \\ > 0 & p > p_U \end{array}$$

Adjustment Costs and Equilibrium in the Labor Market

The above discussion provides the foundation for a model where wages adjust slowly in response to rises in output prices due to rigidity in labor demand. This model assumes that farm owners sell their agricultural output in a competitive market and the price of such commodity follows a stochastic process. In other words, the consideration of commodity's demand is embodied by the evolution of output prices, and the justification of this treatment lies in the dominance of international trade in determining local prices. Given that farm owners maximize profits subject to stochastic output prices, labor demand can be considered as having a range of inaction whereby increases in the output price will not affect or will be slow to affect the quantity of labor demanded. As such, this model argues that the rigidity between prices and wages will arise from the rational demand choices of farmers faced with uncertain future output prices and adjustment costs in hiring and firing labor. Using this framework, we can begin to investigate how stochastic output prices and adjustment costs associated with labor hiring/firing can cause stickiness and assymetry in wage responses to output price changes. While it can be shown that the introduction of imperfect input markets can lead to slowness in wage adjustments, the current model provides an alternative and compounding justification for such rigidities.

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[3] As pointed out in Abel and Eberly, if the lower critical value, q_L, is negative, then capital disinvestment (i.e., firing) is never optimal ($q > 0$) and investment (i.e., hiring) would appear to be irreversible to an outside observer.

V. Discussion of Data

We will employ two types of data: (1) aggregate time series data for estimation of the labor demand equations and estimation of the stochastic output price series and (2) household panel data for the labor supply estimation. The aggregate times series data are used to calibrate an aggregate labor supply equation using the panel estimation results. We have obtained time series data on agricultural labor force participation, agricultural wages, wholesale prices of rice and wheat, and producer prices for jute for the period from 1971/72 to 1998/99. We have also obtained time series data of output of rice, wheat, and jute for the same period. These data are used in the estimation of our threshold labor demand equations. The data used for estimating household labor supply come from three rounds of household surveys of approximately 750 households collected in 5 of the 6 divisions of rural Bangladesh.

Table 1. Times Series Variables[1]

Description	Variable Names
Agricultural Labor Force	l_t
Weighted Output Price Series	P_t
Nominal Agricultural Wages	w_t
Nominal Price for Urea	$P_{t,urea}$

1/ Please see Appendix I for full documentation of the sources and manipulations performed to obtain these series.

Panel Data

The data set used for the household labor supply estimation consists of data collected from three rounds of a household survey of approximately 750 households collected in seven thanas[4] in 5 of the 6 divisions of rural Bangladesh. The immediate purpose of the survey was to conduct a detailed study of the impact of the 1998 floods. Although these thanas were not selected to be

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[4] Thana is a political/geographic denomination much like a county for Bangladesh.

statistically representative of all of rural Bangladesh, because of their geographical representation, they give a very good indication of the situation of the rural labor market between October 1997 and October 1999. The actual data collection was carried out three times: in November 1998, April 1999 and November 1999. Using the observation from the different recall questions available in the three rounds of the survey we have the participation and wages of daily laborers at 7 different points of time. The number of workers and the monthly averages of the amount of time and wages earned for each of the period are reported in Table 2 below.

Table 2 - Summary of Survey Data By Period

	Jul.-Oct. 97	Jul.-Oct. 98	Oct.-Nov. 98	Jan.-Apr.99	Apr.-May 99	Jul.-Oct. 99	Oct.-Nov. 99
Observations	373	309	356	432	405	334	321
Hours worked per month	153.3	98.3	127.9	129.1	124.0	120.9	114.7
Days worked per month	17.8	11.0	14.8	15.1	13.8	13.9	13.2
Hours worked per day	8.5	8.6	8.5	8.6	9.0	8.7	8.6
Daily wage	55.6	56.6	57.4	59.4	66.2	59.1	60.9
Hourly wage	6.7	6.9	6.9	7.1	7.6	6.9	7.2

Source: FMRSP-IFPRI Household Survey 1998-1999

Notice that the lowest number of worker is found to be in the period of July-October 1998 that coincides with the flood period. After that period, the demand for labor increased due to the cultivation of several crops and the tending of rice cultivation and reaches the peek in January-April 1999. This is the time when the demand for labor is highest because of the preparation of the cultivation of the boro rice crop and the cultivation and harvest of wheat, potatoes and other vegetable crops. In the period between July and October 1999, the demand was higher than the previous year, but still lower than in the winter month because of the natural slowing down of economic activities due to a normal flood. In the following month the level of activity seems to be higher than the previous year, but still not too high, probably due to the increase of alternative job opportunities. Daily wages remained stagnant between 1997 and 1998, but after the flood they registered and increase, especially in the winter when demand for labor appears to be high due to the increase of labor activities.

VI. Empirical Procedures

Based on threshold estimation procedures discussed in Hansen (1999, 2000), the aggregate time series data are used to estimate labor demand equations characterizing the different hiring regimes discussed in the conceptual model. These estimations enable us to test for the existence and magnitude of output price thresholds in labor hiring and firing. In order to analyze the effects of uncertainty on rural labor market equilibrium, we derive a labor supply function in the following way. We first estimate a Heckman corrected supply function using panel data from rural household surveys in Bangladesh. Using the estimated supply elasticity and intercept, we then calibrate an aggregate labor supply equation use aggregate labor supply and wage time series. While we could have performed a standard simultaneous equation estimation of the labor supply function, we argue that the value of this procedure is that this method calibrates parameters that include household information and corrects for selectivity bias, as well as reduces the burden placed on the time series data in identifying the supply parameters.

As our ultimate goal is to consider how policies might mitigate the adverse effects of labor market rigidities through intervention in labor markets, we propose the following simulation procedure. First,we use the estimated supply and demand equations along with the output price and urea prices to obtain baseline equilibrium wages in the market as well as baseline equilibrium in the labor market. We then compare the impacts on equilibrium labor and labor income when there are labor, hiring, or production subsidies during times when price changes are particularly high. In particular, comparisons will involve the degree to which deviations of wage changes below price changes are mitigated by such subsidies. In addition, we perform a simple calculation to show the amount income increase to labor as a proportion of the cost of these various subsidies as well.

Estimation Procedure and Results for Labor Demand

Hansen (1999) develops a procedure for estimating and testing a threshold model in a least squares regression context. In this study, we follow a similar procedure and modify the Gauss code developed by Hansen to perform a threshold estimation of agricultural labor demand in Bangladesh. In accord with our conceptual model but with some reasonable modifications, we seek to estimate threshold model of the following form.

$$(12) \qquad \ell_t^* \begin{array}{lll} < & X_t\boldsymbol{\hat{a}_1} + \boldsymbol{\mathring{a}_t} & \quad p < p_L \\ = & X_t\boldsymbol{\hat{a}_2} + \boldsymbol{\mathring{a}_t} & \quad p_U \geq p \geq p_L \\ > & \mathbf{X_t}\hat{a}_3 + \mathring{a}_t & \quad p > p_U \end{array}$$

Instead of using the variables in level form, we estimate equations in terms of percentage change. We argue that it is sensible to use the percentage change form since it is the actual percentage increase or proportional increase over the previous decision period's prices that drives the decision makers choices. That is, the decision maker waits to consider additional hiring or firing until the percentage change in prices is above or below certain upper and lower threshold changes. Essentially, the nonstationarity of output prices in both real and nominal terms would preclude the possibility of level thresholds over time. Furthermore, we allow for the percentage change in labor to always be nonzero given that natural trend growth in aggregate equilibrium labor. Consistent with our conceptual framework, the hypothesized parameters on price and wage should be stronger in the regimes above and below the upper and lower thresholds and weakest in the intermediate threshold. Alternatively, if we reject the two threshold model (i.e., the model of inaction), we would hypothesize a greater responsiveness to price changes in the hiring regime (i.e., above the single threshold) than in the firing regime (i.e., below the single threshold).

Hansen's (1999) methodology allows us to test the presence of one and two thresholds, where a positive test of one threshold is an indication of asymmetry of responsiveness and two thresholds would be consistent with our model. Specifically, we estimate the following demand model in accord with equation (12) and consistent with a Cobb-Douglas production function where I is an indicator function.

$$(13)\ \ell^*_t = \gamma + \beta_{11}P_{urea,t} + (\beta_{21}w_t + \beta_{31}P_t)*I(P_t \leq P_L) + (\beta_{22}w_t + \beta_{22}P_t)*I(P_L < P_t \leq P_U) + (\beta_{23}w_t + \beta_{23}P_t)*I(P_U < P_t)$$

For given (P_L , P_U), equation (13) is linear in its slopes, so we proceed with an OLS estimation. Consequently, for any given threshold pair, the concentrated sum of squared errors can be calculated where (P_L , P_U) are sought to jointly minimize the concentrated sum of squared errors. Hansen (1999) remarks that such estimates might be overly cumbersome as they would required T^2 regressions for a time series model as is ours or $(nT)^2$ regressions if we had a panel of countries for which to estimate such a threshold model. Consequently, he draws from the multiple changepoint literature to illustrate a sequential estimation procedure that yields consistent estimates for the multiple threshold framework. In the first stage, one minimizes the single threshold sum of squared errors to define an initial estimate for $P^{est}{}_1$ where this preliminary threshold estimate is consistent for P_L or P_U depending on which effect dominates. Fixing the first-state estimate P_1, the second state criterion (i.e., the concentrated sum of squares) is of the form:

$S^{r}_{2}(P^{est}_{1}, P_{2})$ if $P^{est}_{1} < P_{2}$

(14) $S^{R}_{2}(P_{2}) =$

$S^{T}_{2}(P_{2}, P^{est}_{1})$ if $P_{2} < P^{est}_{1}$

Where $P^{r\text{-}est}_{2}$ is the argument which minimizes the above expression. It has been shown that while $P^{r\text{-}est}_{2}$ is asymptotically efficient, P^{est}_{1} is not because it is obtained from a sum of squared errors function which is contaminated by the presence of a neglected regime. Hansen shows that the asymptotic efficiency of P^{est}_{2} can lead to the improvement of P^{est}_{1} through a third-stage estimation according to the following refinement estimator. Fixing the second-stage estimate P^{est}_{2}, the refinment criterion becomes the following.

$S^{R}_{2}(P_{1}, P^{est}_{2})$ if $P_{1} < P^{est}_{2}$

(15) $S^{R}_{1}(P_{1}) =$

$S^{R}_{2}(P^{est}_{2}, P_{1})$ if $P^{est}_{2} < P_{1}$

where $P^{r\text{-}est}_{1}$ is the refined estimate which minimizes this expression. It has been shown that this refined estimate is efficient in the changepoint estimation; therefore, Hansen has argued that the same should hold in the threshold case.

In determining the number of thresholds, Hansen (1999) proposes an approximate likelihood ratio test $F_{2} = (S_{1}(P^{est}_{1}) - S^{R}_{2}(P^{r\text{-}est}_{2}))/((S^{R}_{2}(P^{r\text{-}est}_{2})/n(T-1))$ of one versus two thresholds, where the hypothesis of one threshold is rejected in favor of two thresholds if the ratio is large. He also constructs confidence intervals for the two threshold parameters such that the confidence intervals are the set of values of the threshold variable such that the likelihood ratio of that term (i.e., $F_{i} = (S^{R}_{i}(P_{i}) - S^{R}_{i}(P^{r\text{-}est}_{i}))/((S^{R}_{2}(P^{r\text{-}est}_{2})/n(T-1)))$ is less than the appropriate critical value for a given confidence level.

Empirical Results

The test statistics F_1 and F_2 and their asymptotic p-values are shown in Table 2. We see that the test for a single threshold F_1 is highly significant with a bootstrap p-value of 0.000, and the test for a double threshold F_2 is also strongly significant with a bootstrap p-value of 0.000. From this test and given our earlier criteria, we conclude that the double threshold model is more appropriate. With that in mind, we only report the parameter estimates for the double threshold model (see Table 4).

Table 3. Test for Threshold Effects

Test for Single Threshold	
F1	3.3024984
P-Value	0.00000000
5% Critical Value	3.3024984
Test for Double Threshold	
F2	617.87181
P-Value	0.00000000
5% Critical Value	8.0169495

In table 4, we observe that the estimate thresholds are 7.935124 and 30.607577, both with extremely 95% confidence intervals at [-17.841838, 30.607577]. Given the presence of a relatively high degree of multicollinearity among the variables used and the very small amount of data used. Notably, Hansen (1999) argues that since the null sampling distribution of F_2 depends on the threshold estimate as well as the regression parameters, one cannot expect to obtain as accurate critical values for the second estimation.

Nevertheless, by looking at Table 4, we can begin to see if our hypothesis are correct to some extent. Particularly, with regard to the responsiveness of labor demand to output price changes, we see that the hiring regime is most responsive to output price changes, and while the signs on our intermediate and firing regimes are negative, we note that the intermediate regime response is more negative than the firing regime response to price changes. Consequently, we have at some level validated the hypothesis that price changes yield their poorest response in the intermediate regime. Our standard errors are all quite large relative to our parameter estimates; however, given the strength of our likelihood ratio test, it is possible that this problem arises from the strong collinearity among our variables as well as limitations in variation because of the size of the dataset. In terms of the responsiveness of labor demand to wage changes, we note that hiring regime is most responsive to wage changes, the firing regime second most responsive, and the wage coefficient from the intermediate regime is positive, in fact. Additional time series data or the possibility of panel estimation across regions within a country would likely yield stronger results than we have here; however, we have nonetheless provided some support for our hypothesis of a range of "inaction" in which labor demand is not positively responsive to output price changes. Subsequent research will focus on obtain additional data as well as testing restrictions on the intermediate regime coefficients to provide stronger empirical support for our hypothesis.

Table 4. Double Threshold Estimation Results

Variable	Parameter Estimate (1)	White St. Error (2)
Regime Independent Parameters		
Constant	1.1545859	0.096303903
$P_{t,urea}$	-0.0032906098	0.0029557707
Regime Dependent Parameters		
For $P_t <= 7.935124$		
w_t	-0.0052486767	0.0088053668
P_t	-0.0020847713	0.0057060995
For $7.935124< P_t <= 30.607577$		
w_t	0.011390190	0.0080408105
P_t	-0.0046910976	0.0044753314
For $30.607577< P_t$		
w_t	-0.0089043340	0.010835107
P_t	0.0015645070	0.0033464961

Estimation of Household Labor Supply Function

In the model we estimate the total number of hours worked in a month by daily laborers as a function of the daily wage rate and the other individual and household characteristics. In particular: Ln(Hours per Month) = f[ln(daily wage), gender, age, age squared, categories of educational achievement, household size and dummies for location (thanas)]. To take into account any bias with respect to the participation in the market, we used the standard Heckman correction procedure. (Maddala, 1983) We first estimate the probability that an individual over the age of 15 and not engaged in other permanent activity will participate in the agricultural labor market during the period under consideration. We consider this probability to be a function of gender, marital status, number of dependents under 5, between 5 and 10 and over 55, categories of education achievement, age and categories of farm ownership. The coefficient of the wage variable represents the elasticity of the number of hours worked with respect to the daily wage earned by daily laborers in rural Bangladesh. The values of this elasticity vary from a high value of 49 percent in the first period (July-October 1997) to a minimum of 10 percent, two years later. In the majority of the estimations the coefficient of the inverse Mills ratio is significant thereby implying that it was necessary to correct for the participation bias in this preliminary labor supply estimation. The estimated slope and intercept coefficients are summarized in Table 4.

Table 5 – Wage Coefficients and Intercept Terms Obtained by Period

	Jul.-Oct. 97	Jul.-Oct. 98	Oct.-Nov. 98	Jan.-Apr.99	Apr.-May 99	Jul.-Oct. 99	Oct.-Nov. 99
Wage coefficient	0.46	0.35	0.12	0.26	0.26	0.22	0.10
z statistic	5.42	2.19	1.27	2.01	2.76	1.49	0.71
Constant	3.65	5.89	5.06	4.76	3.83	3.74	5.48
z statistic	5.47	6.08	7.71	6.12	5.96	4.09	5.45

Source: Author's estimation using the FMRSP-IFPRI Household Survey 1998-1999

Calibration Procedure for Labor Supply

Using these cross-sectional coefficient estimates and our aggregate labor market and output market data, we calibrate an aggregate labor supply function. Given that our cross-sectional estimates for labor supply are from panel data, are in log form, and are in terms of hours of labor supplied per day, we perform various manipulations and a calibration method. This procedure allows us to produce an aggregate labor supply function that is compatible with our aggregate labor demand equations. Please see Appendix II for a detailed description of the procedure used. From this calibration procedure, we obtain the following values for the labor supply slope and intercept terms respectively, 0.005854 and 1.0166251.

Simulation Exercise

Table 5 shows the parameters for our overall labor supply and demand model.

Table 6. Parameters to Be Used in Simulations

	Constant **(1)**	W_t **(2)**	P_t **(3)**	$P_{t,urea}$ **(4)**
Labor Supply:				
	1.0166250	0.0058540150	-	-
Labor Demand:				
Hiring Regime	1.1545859	-0.0089043340	0.0015645070	-0.0032906098
Intermediate Regime	1.1545859	0.011390190	-0.0046910976	-0.0032906098
Firing Regime	1.1545859	-0.0052486767	-0.0020847713	-0.0032906098
P_L	7.935124			
P_U	30.607577			

Our simulation exercise will allow us to investigate alternative policies to mitigate the wage-price rigidity. We first create a baseline estimation of equilibrium wages and labor given the data we have available on output prices and input prices as well as the parameters from our demand estimation and our supply calibration. Specifically, we equate aggregate labor supply equal to aggregate labor demand for each regime and solve for w_t for each of the periods of the sample. Abstracting from the threshold model for a moment, this formula would simply be the following:

$$(16)\qquad w_t = \frac{(\gamma_d - \gamma_s) + (\beta_p P_t + \beta_{urea} P_{t,urea})}{(\beta_{w,s} - \beta_{w,d})}$$

Where ã$_d$ and ã$_s$ are the intercept parameters for demand and supply respectively and â$_{w,d}$ and â$_{w,s}$ are the wage coefficients for demand and supply, respectively. In terms of our threshold model and its parameter estimates, we have Table 6 which illustrates the determination of wages for each of the regimes.

Table 7. Equilibrium Wage Formulae Under Different Regimes

For $P_t > P_U$

$w_t = [0.138 +(0.0017*P_t - 0.0033*P_{t,urea})]/0.0148$

For $P_U \geq P_t > P_L$

$w_t = [0.138 +(-0.0021*P_t - 0.0032906098*P_{t,urea})]/-0.0055$

For $P_L \geq P_t$

$w_t = [0.138 +(-0.0047*P_t - 0.0033*P_{t,urea})]/0.011$

Chart 1 shows a graphical presentation of the actual and estimated wage series along with output prices.

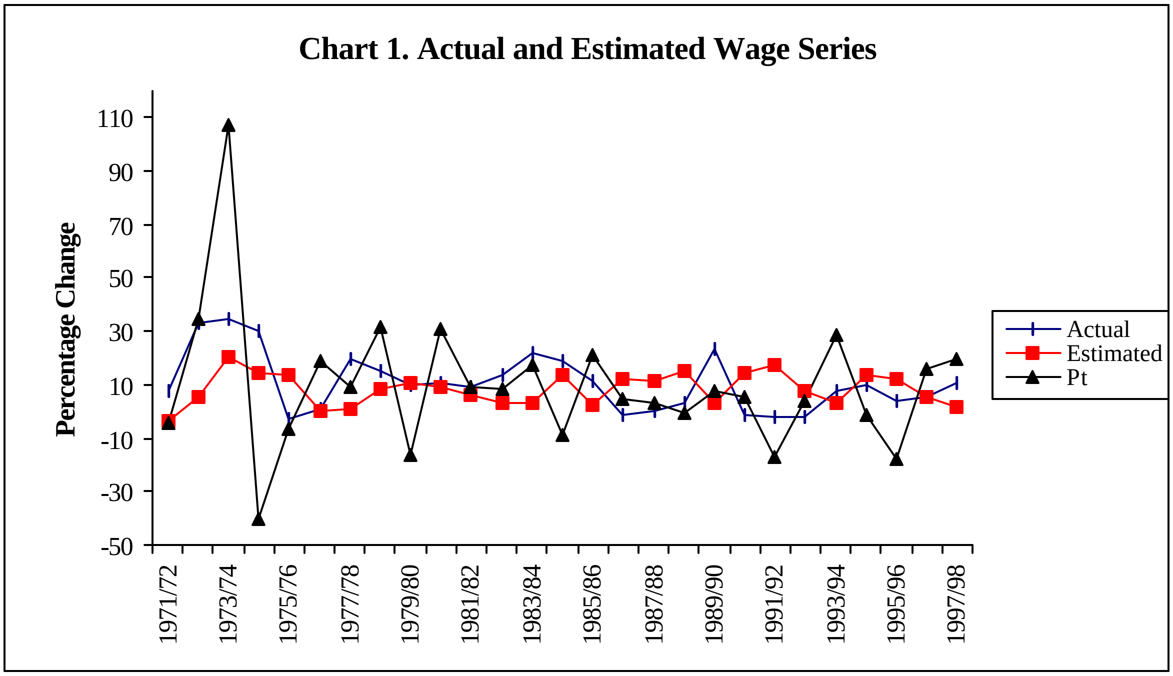


Chart 1. Actual and Estimated Wage Series

While the model tracks actual wage changes relatively well, we note that the estimated model is actually more rigid than the actual data appears in some locations and less rigid in others. Despite this issue, we can see clearly in this graphical presentation that there are periods when output price increases for primary commodities far outstrip percentage increases in wages. Consequently, this simulation exercise will now investigate alternative policies to mitigate this problem. We will draw some tentative conclusions as to some of the general policies available; however, we will not address actual implementation concerns.

Specifically, we will investigate three possible instruments for periods when percentage price increases are 20 percent or greater. Figure 3 illustrates the fact that it is when price increases reach these levels that purchasing power is significantly impaired by the rigidities we have hypothesized and tested for above. The three instruments are as follows: (1) a government payment to agricultural workers equivalent to the value of a 20% increase over the last periods wages, (2) a government payment to agricultural producers equivalent to the value of a 20% increase over the last periods wages, and (3) a price subsidy for producers equivalent to a 20% increase over the last periods prices for output. In terms of our wage formula, these subsidies enter the equation as follows.

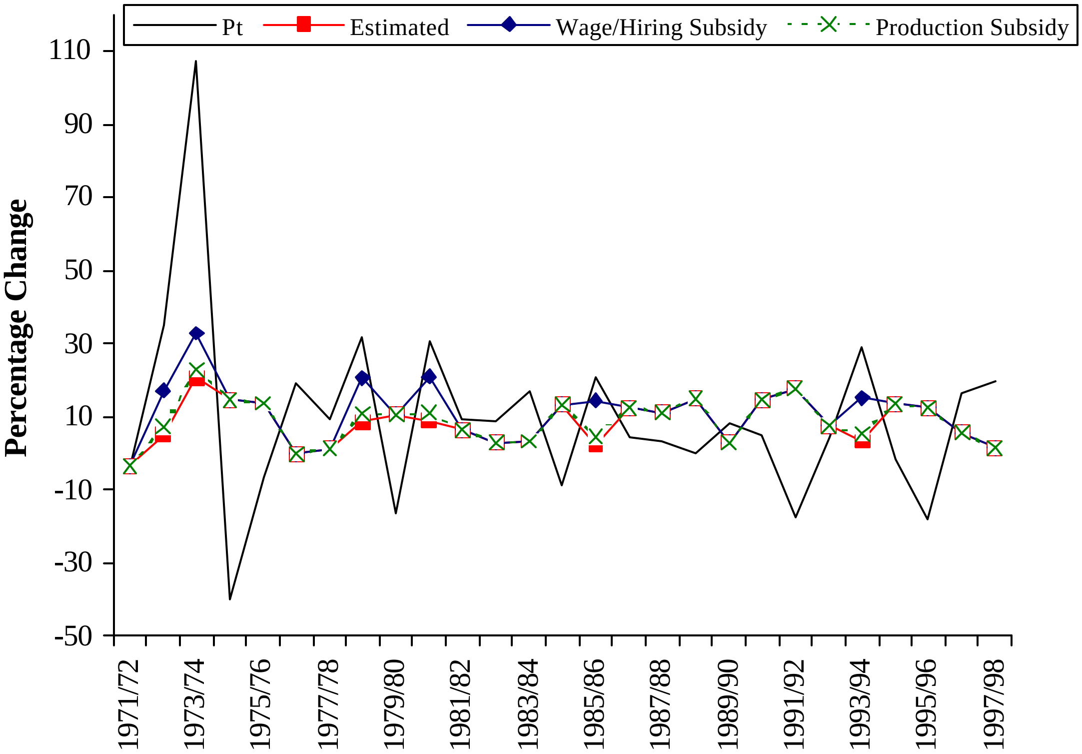
$$(17) \qquad w_t = \frac{(\gamma_d - (\gamma_s + 20 * \beta_{w,s})) + (\beta_p P_t + \beta_{urea} P_{t,urea})}{(\beta_{w,s} - \beta_{w,d})} + 20$$

$$(18) \qquad w_t = \frac{((\gamma_d - 20 * \beta_{w,d}) - \gamma_s) + (\beta_p P_t + \beta_{urea} P_{t,urea})}{(\beta_{w,s} - \beta_{w,d})}$$

$$(19) \qquad w_t = \frac{(\gamma_d - \gamma_s) + (\beta_p (P_t + 20) + \beta_{urea} P_{t,urea})}{(\beta_{w,s} - \beta_{w,d})}$$

Ignoring any output market effects, we calculate the above equations for the sample period to arrive and relative benefits from each of the regimes. The wage and hiring subsidies perform equally well and significantly better than the output subsidy. Notably, in equation (17) we note that the wage subsidy actually lowers the market equilibrium wages by inducing a greater quantity supplied of labor but the net effect is the same as the hiring subsidy illustrated in equation (18) which simply raises wages by increasing the demand for labor. Chart 2 shows a graph illustrating the relative performances of these policy measures in mitigating the effects of dramatic price increases.

Chart 2. Comparative Impact of Subsidies



As noted above, this chart indicates that the wage and hiring subsidies are significantly more effective in closing the gap between price increases and wage increases when there are price spikes; however, during the historic famine of 1974, even such fairly extreme subsidies would have been only marginally helpful. In order to make a final comparison between these methods, we perform some calculations to get a rough idea of the relative costs and benefits of such measures. Table 8 shows the results of these calculations.

Table 8. Calculations of the Benefits and Costs of Different Subsidy Programs

		Base Estimations
A	Average Positive Deviation over All Positive Deviations excl. 1974	18.438
B	Average Percentage Increase in Employment	1.229
C	Average Agricultural Employment for 1971-1999	32,074,107.143
D	Average Real Value of Daily Wages (in Taka) 1971-1999	45.717
E	(C)*(D): Average Total Payments to Agricultural Labor (in Taka)	1,466,346,564.105
F	Weighted Average Annual Value of Agricultural Production (in Taka)	4,037,842,189.166

		20 Percent Labor Subsidy	20 Percent Hire Subsidy	20 Percent Production Subsidy
G	Average Positive Deviation over All Positive Deviations excl. 1974	12.953	12.953	17.474
H	Increase over Base (G)-(A)	5.485	5.485	0.964
I	Average Percentage Increase in Employment	1.261	1.261	1.235
J	Difference In Employment Increase From Base (I) - (B)	0.032	0.032	0.006
K	Additional Workers (J)*(C)	1,029,862.791	1,029,862.791	180,948.687
L	Wages Paid to Additional Workers (1 + .01*(H))*(D)*(K) (in Taka)	48,885,751.429	48,885,751.429	8,221,162.966
M	Additional Wages Paid to Base Worker Workers .01*(H)*(E) (in Taka)	79,165,887.168	79,165,887.168	13,909,584.326
N	Total Additional Wages Paid to Labor L + M (in Taka)	128,051,638.597	128,051,638.597	22,130,747.291
O	Total Cost to Obtain Additional Wages (in Taka)	302,685,854.073	302,685,854.073	807,568,437.833
P	Difference Between Total Additional Wages and Total Cost (in Taka)	174,634,215.476	174,634,215.476	785,437,690.542
Q	Total Additional Wages Converted to Dollars	5,300,029.305	5,300,029.305	14,140,523.346
R	Total Daily Cost Converted to Dollars	3,057,845.113	3,057,845.113	13,753,013.961
S	Difference Converted to Dollars Q-R	1,386,194.684	1,386,194.684	243,556.822
T	Total Additional Wages/Total Cost (In Dollars)	0.262	0.262	0.017

The above table is simply intended to illustrate the costs and benefits of the different subsidy regimes relative to one another as well as relative to no policy. Rows A through F provide the base data for subsequent calculations of the different subsidy scenarios proposed. Row G shows the average positive deviation of a percentage increase in prices over the percentage increase in prices. This value was simply calculated by averaging the positive deviations of price over wage increases excluding the 1974 values because of their heavy influence on this average. Row H shows the degree to which this average deviation is reduced by the policy in questions. The labor and hire subsidies both elicit a reduction of 6.704 from 22.536 in the base estimation. This reduction in average positive deviation would correspond with a significant reduction in hunger by increasing the means of laborers to buy food in hard times. Notably, the production subsidy hardly affects the average deviation. Furthermore, the average percentage increase in labor during the same periods when there are high percentage price spikes is compared. Taking the difference from the base level and multiplying it by the average level of agricultural employment and we see in row K that this would amount to a million more laborers being able to find work during periods of price crises whe either the labor or hiring subsidy occurs. The production subsidy only allows for the addition of about 200,000 workers. Also, comparing the total additional wages to labor in the two schemes, we see that the labor and hiring subsides lead to an additional 128 million taka per day while the production subsidy only adds about 22 million taka per day (about 5 million dollars a day). Finally, the labor and hiring subsidies cost about one third the cost of the production subsidy so that the proportion of the total expenditures on the subsidy programs transmitting to labor in the form of wages is about 32 cents per dollar spent by government; while the production subsidy transmits only about 2 cents per dollar spent.

While there are clearly potential second-order effects on worker incentives or incentives for rent-seeking under such policies, this simulation exercise provides a starting point for such discussions away from the traditional commodity market focus. That is, rather than concerning ourselves with manipulating commodity markets to keep prices down, we look to methods by which we can cause wages to increase in step with price spikes. Given the apparent failure of traditional commodity control programs, this approach perhaps will allow policy makers to more directly affect the problem of short-term questions of extreme hunger.

X. Conclusions and Relevance

This research extends from previous models relative to the price-wage transmission in Bangladesh by looking more closely at the firm-level justification for inaction or "postponed" reaction in the face of price rises and falls. The analytical framework described provides the foundation for an empirical analysis of the Bangladesh labor markets. We estimate the labor demand equations via a threshold estimation procedure proposed by Hansen. These equations and threshold along with our calibrated supply allow us to empirically investigate the relationship between equilibrium price and wage changes in agricultural labor markets.our labor supply which can then be used in the simulation of labor market equilibria in the rural labor markets of Bangladesh. Our evidences provides weak support for the notion that wages are slow to react to output price increases because of our conceptual model. Notably, as we continue to develop the empirical model, we will incorporate a methodology which allows us to explicitly test for a range inaction. While assymetry labor demand may be an important determinant of the uneven response of wages to price changes, if we are able to find support for the range of inaction hypothesis, this result would provide even more valuable information as to the behavior of the labor markets in Bangladesh.

If we are finally able to fully test our conceptual model, further investigation of a household nature would be needed to find out what kind of sunk costs, if any, are incurred in the labor hiring/firing which create this rigidity. Results of such a study would increase confidence in the results presented in this paper as well as providing valuable information to policy makers. Ultimately, government or private forces might then attempt to address such issues in order to create flexibility in the system and alleviate the stress to lower income groups when prices rise or fall.

Appendix I

Time Series Data Names and Sources.

(1) Agricultural Labor Force (AGLAB) data come from the Food and Agriculture Organization's (FAO) Agricultural Database.

(2) From 1971/72 until 1977/78 nominal wage figures (NOMAGW) in taka[5] per day are obtained from Islam T and Taslim M.A., 1996 "Demographic Pressure, Technological Innovation, and Welfare: The Case of the Agriculture of Bangladesh" Journal of Development Studies, Volume 32, No.5, pp. 734-755. From 1978/79 onward, nominal wage data come from the Bangladesh Bureau of Statistics (BBS) Monthly Bulletin.

(3) Combined weighted average national wholesale price of HYV of coarse rice (NOMRICE) data are obtained from the Bangladesh Department of Agricultural Marketing. These prices are in taka per qintal where a qintal is one tenth of a metric ton.

(4) National average wholesale price of wheat (NOMWT) in taka per qintal were obtained from the Bangladesh Department of Agricultural Marketing.

(5) The producer prices of jute (NOMJT) in taka per metric ton were obtained from the FAO Agricultural Database. These price data were subsequently converted into taka per qintal.

(6) Production data rice (RICPROD), wheat (WTPROD), and jute (JTPROD) are obtained from the FAO Agricultural Database and are measured in metric tons.

Manipulations Performed on Data to Obtain Variables for Estimation
(Data are contained in Zip Disk 1 Bangdat10.xls Sheet 1)

(1) NOMRICE is missing a data point for 1971/72; therefore, a linear trend of the form NOMRICE = 39.565t + 209.68 was fit to the data in order to obtain that data point where t = 0 for the data point 1971/72.

(2) NOMWHT is missing some data points; therefore, a linear trend of the form NOMWHT = 29.488t + 156.25 where t = 2 for 1973/74, t = 1 for 1972/73, and t = 0 for 1971/72.

(3) NOMJT is missing data points for 1995/96, 1996/97, 1997/98, and 1998/99 and these figures are forecasted from an fitted trend line of the producer price of jute of the form, NOMJT = 113.91*($t^{.5683}$) with values of t = 25, 26, 27, and 28, respectively.

(4) Since the general forms of NOMRICE, NOMWT, NOMJT all follow similar patterns and are therefore strongly correlated, these series are collected into a single series in order to avoid serious problems of multicollinearity as well as avoid the unnecessary loss of degrees of freedom in estimation and testing. First, each price series is multiplied by its respective production for each year (where prices are multiplied by 10 to covert prices into price per MT as opposed to prices per qintal). The resulting series are the respective values of rice, wheat, and jute production in each year. We call the sum of these terms the value of total output. In each period, the weight of each product as a proportion of total value is obtained. These proportional value series are then used as weights to be multiplied by their respective nominal price series. We then obtain a weighted sum of the prices of the products (WPO) which is used as a foundation for our price series in our estimations.

(5) Now that we have our aggregated price series, we convert AGLAB, NOMAGW, and WPO into percentage change form PCHLAB, PCHNAG, and PCHOP. Consequently, PCHLAB is the percentage change in labor from one period (year) to the next, PCHNAG is the percentage change in nominal agricultural wages from one year to the next, and PCHOP is the percentage change in output prices from one year to the next. These series are those which are used in our threshold demand estimations. These data are shown in Appendix Table 1 below.

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[5] Taka is the name for the Bangladeshi currency.

Appendix II

Aggregate Labor Supply Calibration Procedure

The labor supply equation we seek is PCHLAB = ë$_1$ + ë$_2$PCHNAG (Appendix equation 1(A.1))where PCHNAG = ((wage$_{t+1}$-wage$_t$)/wage$_t$)*100; however, our estimated equation provides a labor-wage relationship of the form Ln(hours per month) = è$_1$ + è$_2$*LN(wage$_t$) (Appendix equation 2 (A.2)). In order to obtain the values for ë$_1$ and ë$_2$ we conduct the following calibration.

Step 1. Solve Appendix equations 1 and 2 for wage$_t$ to obtain the following equations.

A.1’. wage$_t$ = wage$_{t+1}$/{1 + [(PCHLAB – ë$_1$)/ë$_2$*100]}

A.2’’. wage$_t$ = exp[(ln(hrs) – è$_1$)/è$_2$]

Step. 2. Set A.1’ and A.2’’ equal to one another and solve for ë$_2$.

$$A3. \qquad l_2 = \frac{\exp\left[\dfrac{\ln(hrs)-q_1}{q_2}\right]*(PCHLAB - l_1)}{\left\{wage_{t+1} - \exp\left[\dfrac{\ln(hrs)-q_1}{q_2}\right]\right\}*100}$$

Step. 3. Setup

- Set ë$_1$ initially to 0

a. Initiatlly, let hrs = average of data on hours per month worked from panel estimation (see table 2).

b. Then, let hrs(t) = hrs(t-1) + (PCHLAB/100)*hrs(t-1). This modification allows the “estimated” wage$_t$ to have the same upward trend as exists in the data and which is in line with the upward trend in agricultural labor force data.

c. $\grave{e}_1$, $\grave{e}_2$ are weighted averages of those parameters obtained from the seven cross-sectional estimations of intercept and slope parameters based on household data. The weights are the ratio of each period's hours to the total hours worked over the seven periods of the cross-sectional data.

Step 4. With information derived in Step 3 and equation A.3 from Step 2, solve for $\ddot{e}_2$ for each period (call them $\ddot{e}_2(i,t)$ where i indicates the iteration number and t represents the period corresponding to the parameter).

Step 5. Insert this $\ddot{e}_2(i,t)$ into equation A.3, and solve for $\ddot{e}_1(i,t)$ for t = 1973 to 1999.

Step 6. Obtain the averages of $\ddot{e}_1(i,t)$ and $\ddot{e}_2(i,t)$ over t to obtain $\underline{\ddot{e}}_1(i)$ and $\underline{\ddot{e}}_2(i)$.

Step 7. Set $\ddot{e}_1$ in equation A.3. to equal $\underline{\ddot{e}}_1(i)$.

Steps 8 onward. Continue terate through Steps 4 through 7 until $|\underline{\ddot{e}}_1(i) - \underline{\ddot{e}}_1(i-1)|$ and $|\underline{\ddot{e}}_2(i) - \underline{\ddot{e}}_2(i-1)|$ are less than half a percent of the respective values for $\underline{\ddot{e}}_1(i-1)$ and $\underline{\ddot{e}}_2(i-1)$. Recall, i denotes the iteration value.

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