Wages, Prices, and Agriculture
How Can Indian Agriculture Cope with Rising Wages?

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Abstract: We study the impact of rising wages on crop agriculture in India using the framework of variable profit function. Farmers respond to rising agricultural wages by decreasing crop output. In the short run, to compensate for this the government could increase the output price level, with an 80% to 140% rise needed depending on whether only the agricultural wage rises, or the rural non-farm wage also rises. Because non-land assets respond positively to the non-farm wage, in the medium term this increase reduces to 74%. Growth in non-land assets, the labor force, education, and technology have easily compensated for the wage increases observed in the period of investigation, and probably also for the accelerating wage growth since then. Focusing on growing these shifter variables is a better policy option than raising prices. Policy makers can be optimistic about the ability of the Indian crop sector to deal with rising wages.

1. Introduction

Over the past two decades, the Indian economy has started to grow rapidly. Real wages have begun to rise and during the period of 2007-12 India experienced the fastest growth in real farm wage by 6.8 % per year since 1991 (Gulati et. al, 2014). As Indian economic growth accelerates again, wages are likely to rise faster than before and, all other things being equal, the farm sector will experience a profit squeeze. In addition, farm sizes have been declining, adding another element to the profit squeeze. Food supplies would be reduced. There are a number of ways to compensate for this: farmers can mechanize, government can invest more in productivity enhancing research, irrigation and infrastructure, and in education of the work force. In addition, it can raise food prices, or it can increase imports of tradable food grains.[1] In this paper, we analyze most of these options, except for the rise in imports that is not in line with government's past and present priorities.[2]

In particular, we explore the question whether, in order to maintain aggregate crop output and support farmer incomes, the rising wages could be offset by an increase in aggregate crop prices. This

[1] Many horticulture and livestock products are perishable and therefore import options are more limited than for food grains. These products are included in the analysis

[2] Parikh et al. (2016), among other options, considers the possibility of larger imports of food grains and show that if under rapid growth agricultural productivity growth could not be accelerated, by 2025, under alternative assumptions, the country would have to import 60 to 100 million tons of food grains, which is an unlikely option to be accepted by the government.

could be achieved via a combination of increased support prices and import tariffs. These are the policies that many OECD countries have pursued when confronted with rapid rises in wages that were a consequence of the economic booms which started shortly after World War II. These have led to the high rates of protection that these countries have for their agricultures (Anderson et al., 2010), which have harmed their consumers and, on account of reduced international prices, depressed impaired export options of developing countries. In addition, they have led to surpluses that were disposed of by subsidizing exports, further disrupting markets. Therefore, the high protection rates have accelerated agricultural growth in the OECD countries at the expense of the agricultural sectors of developing countries. Since the Uruguay round of WTO negotiations the high and low income countries have tried to overcome these adverse legacies of the OECD wage booms. However, progress has been limited, as tariff bindings beyond which tariffs may not rise have been set at very high levels (Anderson, 2009). In recent years, the EU and other OECD countries have been changing agricultural support policies to get out of the predicaments they created. Typical policies have been to replace agricultural subsidies on prices, and replace them by fixed payments and other measure of supports in the green window of the WTO. However, progress in doing so has been varied among the different regions and countries. There are, therefore, many reasons why India should consider very carefully whether to engage in such a set of policies, only to find itself with similar adverse legacies.

To address the questions of the paper, the framework of variable profit functions is used, which leads to estimation equations that include aggregate agricultural crop supply and variable factor demand, as well as quasi-fixed factors. The variable factors include the use of hired and family labor, fertilizers, and hired machinery days. In India, most farms are too small for their farmer to own their own modern machinery. They therefore mechanize primarily by increasing their machine rentals, in this case at the rate of 2.43% during the period of investigation, which we therefore treat as a variable factor. However, as a proxy for the availability of machines, the tractor density in the village is used, even though tractors may also be hired from outside the village which rose at the rate of 2.3%, almost twice as fast as the HYV coverage in the village.

The quasi-fixed factors include the family labor force, land owned, and non-land assets, which comprise an aggregate of machinery and implements (including irrigation equipment), livestock, and other assets, such as farm buildings. We use the variable profit function model to analyze output supply and factor demand, and reduced form equations to estimate the changes in quasi-fixed factors. Instrumental variable techniques are used to deal with the endogeneities arising in such a system. It turns out that non-land assets are very powerful boosters of output and respond strongly to changes in wages, which has a strong impact on the analytical results of the paper.

The short-run elasticities estimated in the output supply and factor demand equations consider only the responses of output and the variable factors to changes in prices, wages and the fertilizer price, while the medium-term responses include the responses via changes in the quasi-fixed factors. We consider the elasticities of the quasi-fixed factors as a medium-term response rather than a long term response because it is unlikely that over the period of eight years covered in the study the quasi-fixed factors would have fully adjusted to the price and wage changes. Of the quasi-fixed factors only the non-land assets were responsive to the output price and the wage rate, and strongly so.

The wages considered for this study are the agricultural wage, the rural non-farm wage, and the urban wage, the impacts of which on output supply, factor demand and investment in quasi-fixed factors are estimated separately for each wage. It is not just the response of output to the agricultural wage that may be important, but also the response to the non-farm. The agricultural and rural non-farm labor market are closely related. As most migration in India takes place within states, the states have an integrated labor markets and the growth of the state level urban wage is influencing the agricultural and the non-farm wage. In the policy analysis both the responses to rising of the two individual wages and to a rising wage level, an equi-proportional increase in all wages, are analyzed.

To estimate how much aggregate crop prices would have to rise to keep agricultural output constant in the face of an increase wages we use the intermediate term elasticities that take account of the impact of prices and wages on the growth of investment in non-land assets. The resulting estimate of the medium-run aggregate crop supply elasticity with respect to its price index is 0.33, twice as high as the short term elasticity. The corresponding supply elasticity with respect to the agricultural wage is -0.23, meaning that the output price increase would have to be 80% of the rise in the wage to keep crop output constant. This makes increases in the output price a very unattractive policy option for stemming the rise in wages. When considering rises in both rural wages, the required compensation rises to 140%, even less attractive, but reduces to an imprecisely estimated 74% if the rise in investment in non-land capital triggered by the rise in the non-farm wage is factored in. Pursuing policies that accelerate investment in non-land capital, education and agricultural technology emerge as much better policy options.

During the period under investigation (1999-2007) the agricultural wage still grew slowly and therefore did not cause much of a loss in the growth rate of crop output of 1.17%. However, it then accelerated sharply to grow at the rate of 10% in the period in the period 2008-2011 (Gulati et al., 2014), which would have induced an output loss of 2.7 percent. If the growth in non-land assets, the labor force, education and the other shifters had continued, such a crop output loss could also have been compensated for without an increase in agricultural prices.

By treating the input of hired labor separately, a new labor dynamic is included in the analysis, in addition to the impact of the supervision costs of hired labor that leads to the negative farm-size productivity relationship. When non-farm opportunities increase, family labor is reallocated to the non-farm sector, while hired labor is not. This is because access to the non-farm wage sector is largely limited to young males with some education, while hired labor includes many older men and women (Lanjouw and Shariff, 2004). In addition, entering into non-farm enterprises requires some capital, also rarely available to landless workers. A rise in the agricultural wage leads to an increase in the cash constraint of the farmer and therefore leads to reduced investments in non-land assets and also reduces machine rental in the short run. On the other hand, a rise in the non-farm wage leads farmers to increase their involvement in the non-farm sector, leading to an increase in their income both via the higher non-farm wage and the additional allocation of labor to the non-farm sector, and therefore relaxes the cash constraint, allowing for more investment into non-land assets, and more use of rented machinery.

The output supply and factor demand equations also include a limited number of shifter variables including the number of tractors available in the village and the village adoption rate of high yielding varieties. As emphasized by Mundlak (2000), much of the technical change in agriculture is likely to be embodied in non-land assets, tractors and seed.[3] What is not included in the analysis is technical change that is not embodied in these factors. In addition, there are other potential shifter variables such as roads or access to markets and banks, but these variables generally were not significant, even though in the literature based on district data they were quite important (Binswanger et al. 1985).

We use farm level data to estimate supply and factor demand equations, and therefore our estimates are less likely to suffer from possible aggregation bias, compared with prior work in India that used panel data that relied primarily on district level data (Binswanger et al., 2014, Fan et al., 2000). A methodological question pursued in the paper therefore is whether the analyses based aggregated data have led to different elasticity estimates than those obtained from the micro-data, and therefore might have suffered from aggregation biases. We find that price elasticities estimated are remarkably similar to those estimated with more aggregated data.

The paper uses the all-India household level panel data of the NCAER-ARIS-REDS survey from the 1999 and 2007 rounds of survey. The data cover 17 major states and all agro-climatic zones of India, and the balanced panel contains 2944 farm households.

The remainder of the paper is organized as follow. Section 2 reviews the relevant literature. Section 3 describes the analytical frame. Section 4 deals with the estimation strategy, endogeneity issue in the estimation, and discusses the limitation of our approach. Section 5 presents the data and descriptive

[3] The non-land assets include the tractors of the few farmers who buy them, but the adoption of tractors and the associated machines is mostly done through rental markets. The tractor density in the village is a proxy for the supply of these services.

results. The empirical results are presented in section 6 and section 7 provides a summary and conclusions.

2. Literature review

To date, there is a dearth of literature evaluating the impact of rising wages on aggregate agricultural or crop output using household level panel data. Otsuka et al. (2013) used panel data from 107 countries between 1980 and 2010 to evaluate the impact of rising wages on use of tractors, labor, and cereal yields, and then evaluated the impact of yield growth on food self- sufficiency. They used log-linear equations to estimate the determinants of machine use, labor use, and cereal yield as a function of average farm size, farm size dummy variables for countries with average farm size over two acres, GDP per capita, the real wage rate of agricultural labor, years of schooling of the adult population, and equation-specific conditioning variables. Using interaction terms, they were able to distinguish the impact of the key independent variables separately for countries with average farm sizes below and above two acres. All equations used country-fixed effects and year dummies. The key result was that the mean partial effect (MPE) of wages on machine use was positive (0.16) for countries with larger farm sizes, but not for countries with smaller farm sizes. The MPE of wages on labor use was negative for the smaller households, which perhaps indicated a response to migration to the off-farm sector or to urban areas. Finally, at the mean of the dependent and the independent variables the partial effect of wages on yield was not significant, but became positive at larger farm sizes for both country types. The self-sufficiency ratio responds positively to a rise in wages, with an elasticity of 0.16. There were no estimates of the elasticity of the self-sufficiency ratio with respect to wages via the yield equation. Therefore, the impact of rising wages on food self-sufficiency, a proxy for aggregate cereal output, was not analyzed.

Estimated elasticities for short-run aggregate supplies of agriculture with respect to its price are generally very low (Binswanger, 1989). A key issue in the literature has been the question of the size of the long-run elasticity of aggregate agricultural or crop output with respect to its price. Studies that used cross-sectional data within countries or across countries typically found very high long-run elasticities. For example, Peterson (1979) analyzed data from 53 different countries from the 1960s and found elasticities of aggregate cereal yields per acre with respect to price of 1.27 to 1.66. However, such cross-sectional studies suffer from severe unobserved variable biases. Rao's 1989 literature review found that estimates of long-run elasticities, using time series studies within countries with lagged dependent variables, ranged from 0.1 to 0.3, although Reca (1976) found that such estimates ranged from 0.42 to 0.53 for Argentina a country with abundant agricultural resources. Most importantly for us, Krishna

(1982) found that the long-run elasticity of aggregate crop output with respect to its price was 0.3, at the upper end of the range suggested by Rao (1989).

However, Mundlak (2000) and others have challenged the approach using the lagged endogenous variable approach, arguing that it neglects to fully capture the long-run effect of price on capital investment into agriculture and labor migration. McGuirk and Mundlak (1991) used a general equilibrium model for Punjab agriculture for the period 1960 to 1979 with endogenous capital accumulation in agriculture, as well as inter-sector migration and land expansion. An upward shift in the prices led to an adjustment of the desired stocks of capital, labor, and land. Due to constraints on investment, and inter-sector migration and land expansion, these stocks adjusted gradually. They econometrically estimated these three equations and built the result into the general equilibrium model. The authors estimated a one-year elasticity of aggregate agricultural output (including livestock output) for Punjab agriculture. The short-run price elasticity of agricultural output (including livestock) is near zero, while the response after 20 years rose to 0.18. Mundlak et al. (1988) also used a general equilibrium model for Argentina with the accumulation of agricultural capital and the inter-sector allocation of labor being endogenous and econometrically evaluated. They estimated a one-year elasticity of aggregate agricultural output (including livestock output) to price of 0.07. The progressive adjustments to the desired capital stocks, land, and labor force were slow, but persisted in the long run. Their price elasticity increased to 0.36 in five years, which is the period closest to the 7-year period used in this paper. As shown below, their price elasticity is slightly higher than the long-run estimate of 0.28 that we obtained, which may be because land in Argentina could expand over the entire period of analysis, while it cannot expand in India. The elasticity rose to 0.42 over 10 years. A persistent response of the actual capital stock, the labor force, and land resulted in a rise to 1.78 after 20 years.

Therefore, in this paper, land owned, the family labor force, and non-land agricultural assets are also treated as endogenous, and are taken account of in the medium to long run elasticities of aggregate output to prices and wages. However, our data covered only the two years of 1999 and 2007, and it is unlikely that capital and the family labor force fully adjusted to price and wage changes within these periods. The resulting final elasticities, therefore, will be considered as intermediate elasticities. The literature review has not found any results of the impact of rural wages on aggregate agricultural or crop output.

Jacoby (2016) uses a general equilibrium model and district level data to analyze the impact of rising food prices on agricultural and non-farm wages in India and finds that wages respond quickly to rising food prices, thus rendering landless workers better off than before. We endeavored to replicate these results using the village real wage and output prices and could not replicate the result. Since we do not regress output prices on wages such a relationship would not have created any endogeneity problems.

3. Conceptual framework

3.1 Output supply and factor demand

The structure of a farmer's choice about the output and variable input levels can be defined by a variable normalized profit function in terms of the output and factor prices, and in terms of household and village characteristics. The profit concept used in this framework is the value of total production, net of all variable inputs. These profits are the agricultural return to the quasi-fixed factors, family labor, land, and non-land agricultural assets (i.e. it is the return to the household's endowments).[4]

The farmer maximizes profits with respect to the aggregate output price $\boldsymbol{p}$ and the variable factor price $\boldsymbol{w}$. His or her constraints include the quasi-fixed factors of family size, land owned, and the stock of non-land assets, summarized in the vector **k**. Shifter variables **x** include household characteristics, and village variables. Homogeneity of degree zero of the profit function in prices and capital costs can be imposed by defining a normalized profit function with respect to the prices of an omitted variable factor, in this case other variable inputs. Doubling of all prices in the system simultaneously then leaves total normalized profits and all factor allocations unchanged. The normalized profit function π is written as

$$\pi = \prod (p, w, k, x) \qquad (1)$$

After taking first derivative of the profit function with respect to output prices, factor prices and vector of shifter gives the output supplies equation

$$\frac{\partial \pi}{\partial p} = y\ (p, w, k, x) \qquad (2),$$

The demand equation for factor variables

$$\frac{\partial \pi}{\partial w} = -d\ (p, w, k, x) \qquad (3),$$

and The equation of return to land owned and non-land assets

$$\frac{\partial \pi}{\partial k} = r\ (p, w, k, x) \qquad (4)$$

Equation 4 cannot be estimated because the values of r, the returns to land owned, labor force and non-land assets are not known.

[4] These variable profits are not the same as net profits used for other types of analyses. For example, net profits in cost of cultivation studies (that are used in India to guide the government procurement prices) subtract the opportunity cost of family labor and of capital. Or the analysis of the farm-size-productivity needs to subtract the opportunity cost of family labor, as decisions to rent in or rent out land take account of that opportunity cost (Foster and Rosenzweig, 2011).

3.2 Quasi-fixed factors: Household labor force, land owned, and non-land assets[5]

Because we observed the farms over an 8-year period, we can also estimate the response of quasi-fixed factors to the same variables already included in Equation 2. The household could make investments in land, increase or decrease its labor force or invest in non-land assets. This provides an opportunity to analyze a longer response of supply to prices and quasi-fixed factors in Equation 2. However, it is unlikely to be a true long-run response of the quasi-fixed factors, which would have to be estimated using an investment model that takes into account all of the prices in the intervening years. Based on these prices, farmers would form a desired capital stock to which the actual capital stocks adjust. Adjustments of the capital stock or labor force to the desired stocks at new price levels may be slow for a number of reasons, but especially because of credit constraints for capital and slow responses of migration or changes in labor force due to demographic changes. The responses of the quasi-fixed factors may, therefore, be a medium-term response.

In a two period analysis, it is not possible to analyze the structure of the investment decisions. Therefore, we use reduced from equations to analyze the net changes in capital stocks and the labor force as follows:

$$k = a\ (p, w, k, x) \qquad (5)$$

The households invest more in land and agricultural assets when agricultural prices are higher. Similarly, the household may invest less in non-land assets when agricultural wages are higher (because this reduces farm profits) and when the rural non-farm wage is higher. Moreover, these decisions are also expected to depend on the urban wage that, for given rural wages, might affect migration. Therefore, for these equations, the vector W includes the agricultural wage, the rural non-farm wage, and the urban wage. Land owned may respond positively to a larger household labor force and, conversely, the labor force may respond positively to the land owned. Land owned may also respond to prices and shifter variables, not in the aggregate, but for individual households. Finally, if a household splits between survey rounds, the descendent households are likely to own less land, at least initially. The equations account for household splits, and include predicted value of household split in the **vector x** for households that have split between the two rounds.

3.3 Short and medium term elasticities

[5] The classification is to invest in quasi-fixed factors depend on the entire expected future income stream they contribute to, rather than on the expected annual income, as for decision about variable factors.

The approach of estimating both the output and variable factor responses, as well as the responses of the quasi-fixed factors, enables the estimation of both the medium term elasticities of supply and factor demand; this approach also allows us to estimate the longer run elasticity that includes the responses via the changes that are triggered in the levels of the quasi-fixed factors. Let b_{ij} be the elasticity of variable i with respect to the variable j. And let b_{ij}^{*} be the respective long-run elasticity that takes into account the impact of variable j on the quasi-fixed factors. Output is y, its price is p, the labor force is r, the land owned is n, and the non-land capital is k. Then, given

$$b_{yp}^{*} = b_{yp} + b_{yl}\, b_{lp} + b_{yr}\, b_{rp} + b_{yk}\, b_{kp} \qquad (6)$$

and similarly for all the other medium term elasticities. Because b_{lp} and b_{rp} turned out to be zero, the first and second term dropped out, with only investments in non-land assets differentiating short and medium term elasticities

A key question of this paper is the size of the elasticity of output with respect to a rise in the national wage level, dΩ, which corresponds to an equi-proportional rise in the two rural wages and the urban wage. Let w be the hired labor wage, s the non-farm wage, and u the urban wage. The short-run elasticity of output with respect to the national wage level is $b_{y\Omega} = b_{yw} + b_{ys}$, the sum of the hired and the family labor elasticities. Taking the results into account that neither the family labor force nor owned land respond to any of the wage rates, and non-land capital does not respond to the urban wage, the medium-term elasticity with respect to Ω can be estimated by equation 7,

$$b_{y\Omega}^{*} = b_{y\Omega} + b_{yk}(b_{kw} + b_{ks}) \qquad (7)$$

4. Estimation strategy

We have panel data from the 1999 and 2007 rounds of the REDS survey of NCAER for thousands of households across India. To control for fixed household and village effects, we will estimate all equations in their first difference form. Let lower case variables stand for the difference in any variable between the 2007 and the 1999 round. We chose the normalized quadratic profit function for this enquiry.[6] Let π stand for the difference between profits in the two years, and q is the column vector of differences in right-hand side variables, so that q = (p, w, k, x), where the notation is as before. In matrix form then the profit function is written as follows:

$$\boldsymbol{\pi = \alpha_0 + \alpha' q + \tfrac{1}{2} q' B q + \varepsilon} \qquad \textbf{(8)}$$

[6] Compared to the Translog function, the advantage of using the normalized quadratic function is that symmetry constraints can be imposed globally. Note that both the Translog and the normalized quadratic are almost ideal indexes, as Diewert (1973,1977) showed long ago.

subject to the following constraints

$$b_{ij} = b_{ji} \qquad \forall \quad i \neq j. \qquad (9)$$

Convexity of the profit function in prices is tested by checking whether the submatrix of B corresponding to the square and interaction terms is negative semi-definite. Homogeneity of degree zero in all prices is imposed by the normalization of the profit function. If some prices are missing, they may of course vary independently of those included. That will create unexplained variation, but not invalidate the homogeneity constraint across the included factors. For the normalized quadratic profit function, symmetry of the cross price terms can be imposed globally.

Let x be the vector of first derivatives that includes all four variable factors. Output enters this equation as a positive quantity, while all variable inputs enter as a negative quantity.

$$\mathbf{x} = \boldsymbol{\alpha} + \boldsymbol{\beta}'\mathbf{q} + \boldsymbol{\varepsilon} \qquad (10)$$

where β is the column of coefficients of the variables, α becomes the time trend for each equation, and ε the error term. Because we use fixed-effects regression we assume that the remaining error term is normally distributed with identical variance. In the output supply equation, α is an estimate of the output increase associated with all variables that result from variables not included in the regression, including technical change that is not embodied in the non-land capital and high yielding varieties. The three equations for the quasi-fixed factors are also included in the system (8), and the whole system is estimated using 3SLS.

4.1 Endogeneity issues

To overcome issues of unobserved or unobservable variables we applied the fixed-effects technique.[7]The endogeneity issue arose because over eight years, both the variable allocations and the quasi-fixed responded to prices and to exogenous shifter variables. Two solutions were applied: (i) Output prices received by a household may depend on its own actions in terms of choice of quality of the product it produces. It was replaced by village prices (that were computed excluding the price observation of the household), which are exogenous to the household. Similarly, household farm and non-farm wages were replaced by the village wages. (ii) We used an instrumental variable approach to first predict the quasi-fixed factors and then we entered their predicted values of the quasi-fixed factors into output supply and

[7] The random effects model could not be used because the critical assumption of random effects is that the unobserved individual effects are not correlated with the regressors in the model (Green 2008). This assumption cannot hold in our case for variables such as education.

factor demand equations the variable allocation equations. The instrumental variables must influence the quasi-fixed factors, but not the variable allocations.

The identification restrictions imposed on the system are as follows: The urban wage is assumed to influence the size of the household, but not investment in land and non-land capital. For owned land we used the inherited land as the instrument. Predicted household splits enter both the land and the non-farm capital equation. If a household split between the two periods, its quasi-fixed factors would have declined. The probability of such spits between 1999 and 2007 was 19.1%. However, the timings of household splits were also household decision variables and cannot be considered exogenous. Foster and Rosenzweig (2002) predicted the probability of a household split between the 1982 and the 1999 rounds of the ARIS-REDS using a variety of household characteristics that would make them prone to split. To predict the household splits between 1999 and 2007, we used a similar approach, with the estimated equation included in the online annex.[8] A similar argument can be made for the labor force and total non-land assets that were also split up at the time of inheritance.[9] In addition, the urban wage was used to identify the household labor equation, as it did not affect directly the farm decisions made by the household, urban wage only affected the labor force.

4.2 Limitations

As emphasized by Binswanger and Rosenzweig (1986), Binswanger et al. (1993), and Foster and Rosenzweig (2010, 2011), rural credit markets are highly imperfect: how much a household can borrow depends on its characteristics, credit history, how much it has already borrowed, and the amount of land and other assets owned that can be used as collateral or serve as a collateral substitute. Credit is rationed specifically to each household. In addition, household labor has a supervision cost advantage. The opportunity costs of capital and labor vary across households, depending on their labor force and variables that determine borrowing ability, such as land owned that can be used as collateral or as a collateral substitute, and the prior credit history. A village-level user cost of capital cannot be an adequate representation of the capital cost faced by the households in Equations 1 to 4. Similarly, the opportunity cost of labor varies across households, but in our analysis, we have taken them both respond to village

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[8] The variables included are the head's age and age square, land owned, mean, maximum and variance of household schooling, number of male and female children, income growth in 1999-2007, total number of claimants, number of departed married daughters, and number of departed sons.

[9] It would have been nice to use the household splits as an instrument for all three variables, but the estimation process of the 2SLS system did not converge. Based on endogeneity tests, we included household splits in the labor force and the non-land capital equation, but used inherited land directly as the instrument for the land equations.

wages. However, the inclusion of non-land assets makes the credit or cash constraint highly relevant for the farmer's behavior in somewhat unexpected ways.

Another qualification is emphasized by Barnum and Squire (1979) and Singh et al. (1986): Production decisions are likely to be affected by consumption decisions of the household, rather than to be separable decisions. However, in the data used here, on average, the households allocated only 42% of their labor force to agriculture, with the remainder in non-agriculture and education (computed from table 1). When such a large share of labor is allocated to non-farm activities it is more likely that the separability constraint is satisfied.

Systems estimates including the non-land asset equation could not be estimated, and that equation was therefore estimated outside of the system, using predicted variables for land and the labor force that came from the first stage of the systems estimates.

5. The data and descriptive statistics

The last two rounds of the ARIS-REDS surveys conducted by National Council of Applied Economic Research New Delhi are used in this analysis. The survey covers about 238 villages from 17 major states in India, consisting of village and household data bases. The first round of the survey of complete village and household information is available in the 1971 Additional Rural Incomes Survey (ARIS), which included 4527 households in 259 villages; this was meant to be representative of the entire farm population of India, including landless workers, residing in 17 major states.[10]

In this survey round, all of the surviving households in the 1982 survey were surveyed again in 1999 and 2007[11]. The sample included all split-off households residing in the village, plus a small random sample of new households. Because of household division and the households added in 1999, the number of households in the 1999 round increased to 7474. The split households of the 2007 round were re-aggregated to the parent household in 1999. The balanced panel data set that encompassed the 1999 and 2007 rounds of the survey included 5725 households.

Each round of the survey had three components. The first component was the village community questionnaire, which had detailed information on the village economy, governance, village finances, employment, history of the village, etc. This information was canvassed from a range of sources from

[10] The original sampling frame was a stratified design that included the following: (i) One district in each state that was part of the Intensive Agricultural District Programme (IADP), an extension and input provision program placed in areas thought to have high potential for crop productivity growth. (ii) A random sample of other districts. There are 100 districts represented in the 1971 ARIS.

[11] The survey was done in different point in time. It started in 2006 with listing all households in a village thus known as REDS2006. We use year 2007 for REDS2006 throughout the text because, other than the household listing data, the households in REDS were surveyed during the period of 2007-08.

both within and outside of the village. The second component was a listing of the village households. It located, identified, and collected information on heads of household, split-offs, out-migration, etc. Households in the listing sheets of each successive round can be traced across rounds. These first two components were collected in 2007. The third component consisted of the household questionnaires, which were mainly canvassed in the agricultural year 2007-2008, with some late questionnaires added in the subsequent two years. The relevant time interval for most households was 8 years. Nominal prices were deflated by the state level consumer price indices for rural agricultural labor.[12]

Crop output price is a Fisher index at village level using various crops grown in the. The wage rates are village wage rate, asked for directly in village questionnaire. Fertilizer use is the sum of the value of nitrogen, phosphorus and potassium, as well as organic fertilizer, while the price is a village level weighted average. The data for machine rental is in days, while the machine rental rate is the village level rate of hiring machines such as tractors. Land and inherited land refer to the owned area of the household, while the labor force includes all individuals in the household between age 14 and 64 years old. Predicted non-land assets are the aggregate of outputs that contains draft and milk animals, machines and implements, and farm buildings. Education is measured as the average years of schooling of the members of the labor force. The number of tractors, HYV coverage and Panchayat welfare expenditures come from the village schedule. Household splits are the probability of a household dividing residence and assets during the period 1999-2007, which is predicted using the approach of Foster and Rosenzweig (2002).[13]

Tables 1 and 2 summarize the data used in this paper.[14] Between the two rounds, the agricultural years 1999/2000 and 2007/2008 household size decreased at the rate of -2.23%, just a little slower than area owned per household at -2.40%. Therefore, the number of household members per owned acre, rather than increasing sharply, increased only moderately at 0.75%,

[12] Since the survey was rolled out over more than two years, we matched the survey period in each state with the average of the respective months of the CPI for rural agricultural workers.

[13] Variables used in prediction of household splits are head's age, square of head's age, land owned, mean schooling of the household, maximum schooling of household, variance in schooling, number of male children, number of female children, income growth during 1999-2007, interaction of income growth and schoolings, number of claimants, no of departed daughters and number of departed sons. All variables except growth in income are from 1999 data. Regression is included in online appendix.

[14] A more detailed description of the agricultural data used in this paper, their transformations, and the trends they show over the 8 years is provided in Binswanger et al. (2014).

with the increase being not statistically significant. The number of workers per owned acre increased at the faster rate of 1.3%, suggesting that the proportion of working age adults in the households increased. The share of the workforce in agriculture declined at the rate of 1.3%, while the share allocated to non-agriculture grew by 1.4%. Household labor was reallocated from agriculture to the non-farm sector, in line with national trends. The shift from farm to non-farm employment in India accelerated in the 1990s and continues until today (Binswanger, 2012).

The slight increase in farm profits per acre combined with the rising wages in the non-farm sector and the reallocation of labor to that sector to produce an increase in per capita income of 8.9%. A large share of the increase of cultivators' incomes came from increases in non-farm self-employment income, the most rapidly growing component of famers' income (Binswanger, 2012). The share of workers that were in education more than doubled, which indicated the increased importance of education to households.

The aggregate crop output and crop prices rose at the annual rates of 1.17% and 1.48 which means that total revenue rose by more than the total real cost of production, leaving a profit growth of 0.60 %. Family labor input was more than twice as large as the hired labor input, but hired labor grew almost twice as fast as family labor, at the rate of 5.22%. This rapid growth in the use of hired labor occurred notwithstanding the rise in agricultural wages at the rate of 0.9%, and despite the rapid rise in machine rental. Together with other results the paper shows that the increase in hired labor was to compensate for family labor moving into the non-farm sector and to education. This was partly a consequence of the faster growth of the nonfarm wage rather than of the agricultural wage. The urban wage which grew at only 1.37%, which suggests that the incentives for the labor force to migrate to urban areas were far lower than those to shift to the non-farm activities without having to migrate. This is consistent with the findings of Binswanger (2013), who showed that the main driver of employment in India had become the rural non-farm sector.

In India most farms are too small to own their own modern machinery such as tractors etc. They therefore mechanize primarily by increasing their machine rentals, in this case at the rate of 2.43%. However, as a proxy for the availability of machines, the tractor density in the village is used, even though tractors may also be hired from outside the village. It rose at the rate of 2.34%, almost twice as fast as the HYV coverage in the village. In many regions of India, the coverage of HYV has reached the saturation point, while during the decades of the 1990s and

2000s land preparation by tractors virtually replaced by draft animals in India. Land preparation and threshing are power-intensive and tend to be mechanized even if wages are low, while control-intensive operations such as rice transplanting, weeding, sowing, and harvesting of crops is only mechanized when wages start to rise (Binswanger, 1986). It is only in the last 10 to 15 years that rising rural wages have driven the mechanization of control-intensive operations. The pattern of mechanization is similar to China, and in both countries harvest combines for rental have become common despite the small plot sizes. To reap their economies of scale, the harvest combines are moved from region to region, following the harvesting seasons.

The non-land assets include all machinery and tools owned, including for irrigation, livestock owned, of which the most important ones are milk animals and decreasingly draft animals, orchards and farm buildings. Investment in these assets grew very fast at the rate of 5.8 percent during 1999-2007.

6. Econometric results

6.1 Short and medium term elasticities: output, labor, and hired machinery

Table 3 deals with the responses of the quasi-fixed factors to output prices and wages, as well as other right hand side variables, while Table 4 deals with output supply and variable factor demand. From row 1 in Table 4 we see that the aggregate estimated crop supply elasticity is 0.15, well within the range of aggregate crop supply elasticities that in the literature range from 0.05 to 0.3 (Binswanger, 1989).[15] In the short run the extra output is produced by raising all variable inputs with elasticities ranging from 0.04 for rented machines to 0.12 for hired labor and fertilizer. Hired labor appears to be more responsive to the output price than family labor is, but the difference is not statistically significant.[16] Increases in non-land assets also lead to significant increase in output, with elasticity of 0.74.

Medium term elasticities are computed according to equation 6 and summarized, along with the short run ones in Table 5, Because the elasticities of the household labor force and owned land with respect to prices and wages are zero (Table 3), it is only the response of non-land assets that influences the medium term elasticities. Taking it into account raises the medium term output price elasticity to 0.33. This close to the long term elasticity of 0.30 found by Krishna (1982), using a Nerlovian approach with national data.

[15] There has been very little work been done on aggregate agricultural supply since 1989.
[16] Test for difference is not significant with p value 0.59

Since we estimate the agricultural and rural non-farm wage at the village level, the state urban wage is exogenous to them. In appendix Table A2, we find that the urban wage has a strong impact on the aggregate rural wage with elasticity of 0.37. Both rises in the agricultural and the non-farm wage reduce output in the short term, with elasticities of -0.12 and -0.09[17]. How much price change is necessary to offset a given wage rate depends on whether only the agricultural wage rises, or both the agricultural and non-farm wage, i.e the rural wage level rise. To compensate in the short run for any negative agricultural wage effect on output, given the output supply elasticity of 0.15, would require an increase of the output price by 80% of the rise in wages. That is an unattractive option because it would be harmful to net consumers, many of whom are poor. The short term elasticity of output with respect to the non-farm wage is also negative at -0.08. Since the cross-elasticity between hired and family labor is zero, the elasticity of output with respect to a rise in the wage level is the sum of the two wage elasticities, i.e. -0.21, requiring an even higher compensatory price increase of 140 percent.

However, the impact of price policy on crop output is better considered in the medium term. The medium term elasticities are calculated using Equation (9). The apparent increase in non-land investments when the agricultural wage rises means that the resulting capital investment partially compensates for the negative output effect of the wage rate rise, and the medium term in the elasticity of output with respect to wages reduces to -0.01 (Table 5). However, given the lack of significance of the investment elasticity with respect to the agricultural wage, there is very high uncertainty about this medium term elasticity. [18]

The elasticity of output with respect to the non-farm wage, on the other hand, reduces non-land investments with a statistically significant elasticity of -0.19, and therefore the resulting medium term elasticity rises to -0.23. The price compensation for a rising non-farm wage required in the medium term therefore reduces to a more favorable 70 percent. Combining the impact of the two medium term wage elasticities leads to an estimate of the medium term elasticity of -0.24, and a resulting compensatory price increase of 73%. However, given the uncertainty about the medium term elasticity of output with respect to the agricultural wage, this estimate is much less precise than the other ones are. It is safe, however, to conclude that the compensation for a wage level rise in the short run is very high at 140%, but that in the medium term it is very likely to be significantly much lower, somewhere in the neighborhood of 0.70.

Higher wages also affect the composition of the variable input use (Table 4). A higher agricultural wage leads to a large decline in the use of hired labor with an elasticity of -0.49. This is close to the estimate of Evenson and Binswanger, (1984) who used a panel of farm group averages from the Studies in the Economics of Farm Management data sets. A higher non-farm wage leads to a similar

[17] Test for difference in not significant with p value 0.58

[18] Because the non-land equation was estimated outside the system, we, unfortunately cannot calculate standard errors about the medium term elasticities.

reduction in family labor applied to agriculture with a lower elasticity of -0.43. Family and hired labor are seen to be very different inputs, as the cross elasticities between their respective quantities and wages are both zero. This implies that the rural labor market is segmented, with farm workers not being able to respond to a rise in the nonfarm wage by moving to the nonfarm sector, while family labor is able to do so. This finding is consistent with Himanshu and Shariff (2004) who found that it is mainly young male workers with some education who participate in the non-farm sector. Older male workers therefore can join the non-farm sector only with great difficulty, as can women of any age.

Both the wage rises are partially compensated for by the application of more fertilizers, especially if non-farm wage increases, with an elasticity of 0.29, more than twice the elasticity of fertilizers with respect to the agricultural wage.[19] The greater non-farm wage would lead to an increase in the income of the agricultural households. If this higher income were to relax a cash constraint of the household, they would be able to buy more fertilizer. On the other hand, an increase in the agricultural wage would reduce the household income and aggravate the cash constraint, and therefore the rise in fertilizer use would be much smaller than in the case of a rise in the non-farm wage. These findings are therefore consistent with a cash constraint.

Machine hire responds negatively to investments in non-land assets with one of the largest elasticities found in the paper of -1.08. There are two routes: The increase in own machines that are contained in non-land assets allows for a reduction in machine hire, and the shift to greater investment into animals, (that are also contained in non-land assets), reduces machine rental because animals such as milk cows are mainly tended by family labor that cannot be substituted by machines.[20]

A higher agricultural wage should normally lead to a substitution of rented machines for labor,[21] but this wage elasticity is negative and significant, at -0.06 in the short run and -0.09 in the medium term. This result is most unexpected. However, it could again be consistent with farmers being cash constrained and having to cut machine hire to offset the higher labor costs. On the other hand, in the short run, machine rentals rise when the non-farm wage increases with an elasticity of 0.04, which is an expected effect of the reallocation of family labor to the non-farm sector.

The remaining elasticities of interest relate to the responses of non-land assets to prices of output and variable factors, and the responses of non-land assets to the two wages, which are responses that arise in the medium term. The highest elasticity is that of output with respect to non-land assets, at 0.70, while machine hire responds with an elasticity of -1.08, probably because non-land assets include machines. The other note-worthy aspect is the reversal of the elasticity of non-land assets with respect to the

[19] Test for difference is highly significant with the Chi2 statistic at 14.46.
[20] That would change with the introduction of milking machines, but these were not common in 2007.
[21] Few farmers own their own machines, but rely on rented tractors and other machinery.

agricultural and non-farm wage from 0.15 to -0/19, the latter of which is probably caused by the shifts of assets out of agriculture to the non-farm sector in response to higher payoffs there.

While there is little surprise about the supply and labor demand elasticities, and therefore the unattractiveness of raising prices a higher wages, the separate treatment of hired and family labor leads to some unexpected results. This arises both because the cross-elasticities between hired and family labor on the one hand and the agricultural and non-farm wage on the other hand is zero, suggesting that these two types of labor are different. That is consistent with the supervision cost of hired labor that does not arise in the case of family labor (Binswanger and Rosenzweig, 1986). It is also consistent with the higher ease of young male family workers to shift to the non-farm sector than that of landless workers. Finally, the segmentation may also arise because a rise in hired labor costs increases the cash constraint on farm households, while an increase in the non-farm wage reduces it.

6.2 How can Indian Agriculture deal with rising wages

In Table 6 the medium term elasticities of output with respect to the independent variables is repeated and multiplied by the observed growth rate in the variable to compute the growth contribution of the variable to output. The actual growth rate in output was 1.17% per annum. The modest rise in the agricultural wage rate alone would have had virtually no impact on crop output in the short and medium term. The much larger rise in the non-farm wage would have reduced output -0.23% and -0.43% in the short and medium term, respectively, and therefore what happens to non-farm wages may be more important for agricultural policy than what happens to the agricultural wage itself.

Among the quasi-fixed factors, non-land assets and the labor force have the highest elasticities with respect to output, at 0.74 and 0.49 respectively.[22] The education of the labor force and the coverage of HYV have elasticities of 0.16 and 0.13, respectively, while tractors have no impact on output, consistent with Binswanger (1978) and (1986). However, these shifters do not capture the full impact of technical change on crop output, as the only technology variables included are tractors and HYV. This leaves all the technical change not embodied in these two factors unaccounted for. Therefore, technical change has a larger impact on crop growth than captured here.

Except for tractors, all of the shifter variables made positive contributions to agricultural output growth, of which the most significant is from the rapid rise in non-land assets at 4.74%. Contributions of

[22] An increase in owned land reduces crop output per acre with an elasticity of -0.34, which is consistent with the negative farm-size productivity relationship. Since the availability of agricultural land in India has stopped increasing long ago, this coefficient is not considered in the subsequent analysis.

the order of 0.5% were also made by the increase in the household labor force and its average level of education. Clearly during the period of investigation rising wages were no threat to agricultural output growth.

Gulati et. al (2014) published a farm wage series from 1991 to 2011 based on observed wages for five farm operations that accounted for 93% of the hired labor input in Indian agriculture. The period under our consideration (1999 – 2007) was one of slow agricultural growth and it experienced a growth rate in farm wages at 0.90 % per annum. For the period 2008-2011 at the annual rate agricultural wage growth was 10%. However, if in the second period the non-farm wage had also increased by 10%[23] it would have reduced output by 0.9% in the short run and 2.3% in the medium term.

Whether the changes in the output price and the shifters (non-land agricultural capital, human capital, the labor force, and disembodied technical change) would have been enough not only to restore the loss from the rising wages, has yet to be analyzed.[24]

7. Summary and Conclusions

The application of the variable profit function framework with quasi-fixed factors to Indian agriculture generated a number of expected results. The aggregate crop output supply elasticity with respect to its price is 0.15 in the short term and 0.33 in the medium turn, with the rise being a consequence of the significant response of non-land assets to the output price. These estimates are in line with other estimates of short and long run output supply elasticities from national or district level data in India, and the same is the case for the fertilizer demand elasticity. For the demand for hired labor the estimated elasticity is also close to estimates that used panels of groups of households from the Studies in the Economics of Farm Management data sets. These similarities suggest that aggregation problems may not be a serious source of bias in coefficients when more aggregated data are used for the estimation of response elasticities in Indian agriculture.

Both rises in the agricultural and the non-farm wages reduce output in the short term, with elasticities of -0.12 and -0.09[25]. To compensate in the short run for any negative agricultural wage effect on output, given the output supply elasticity of 0.15, would require an increase of the output price by 80% of the rise in wages, which is an unattractive policy option. The combined effect of a rise in both wages would require an even higher compensatory price increase of 140 percent, which is even less attractive.

[23] Data on changes in the non-farm wage are not available.

[24] The reason is that data on investment into non-land assets and on the non-farm wage are only available for the period under investigation from the ARIS-REDS, but not from secondary data.

[25] Test for difference in not significant with p value 0.58

However, in the medium term the higher wage rates affect investments in non-land assets, leading to an output gain that reduces the price increase required to compensate for the rising wages to 74%, still an unattractive policy option.

During the period of investigation, agricultural wages rose by 0.9% while the rural non-farm wage rose by 2.3%. As a consequence of the low estimated medium term output elasticity with respect to the agricultural wage, it is only the rise in the rural non-farm wage that would have affected output negatively by -0.49%, which would have been aggravated to -0.81 as a consequence of the rapid rise in machine rental rates. However, the rapid growth of non-land assets alone would have been sufficient to more than offset these negative impacts. The growth of household labor and of the education of the labor force also contributed significantly to crop output growth. Whether these changes would have continued to 2011 (when the agricultural wage series ends), and would have been able to compensate for the much higher subsequent growth rate in agricultural wages, has yet to be analyzed.[26]

The markets for hired labor and family labor are found to be segmented with the cross-elasticities of hired and family labor with respect to the agricultural and non-farm wages being zero. There are probably three reasons for this: First is the well-known impact of the higher supervision cost of hired labor on the relative attractiveness of hired versus family labor. Second is the fact that family labor, especially young men, can more easily move to non-farm employment than hired workers can. Third is that rises in these two wage rates have opposite impacts on the cash constraints of farmers, with a rise in the hired wage rate reducing farmer income and increasing the cash constraints, while a rise in the non-farm wage, via the reallocation of family labor to the non-farm sector, increases non-farm income and reduces the cash constraint. The segmentation of the labor market may be the reason why during the period of investigation the agricultural and the non-farm wages changed at rates that differed considerably. Such differences imply that policy makers need to look at both scenarios, one in which the rise in wages is confined to the agricultural wage, and one where the non-farm wage rises at the same rate.

The investigation surprisingly found a negative elasticity of hired machinery with respect to the agricultural wage, while this elasticity with respect to the non-farm wage was positive. A possible explanation is that a rise in agricultural labor expenditures aggravates the cash constraint of households while the opposite is the case for a rise in the non-farm wage, although there also could be estimation issues.

[26] The reason is that data on investment into non-land assets and on the non-farm wage are only available for the period under investigation from the ARIS-REDS, but not from secondary data.

Non-land agricultural capital is the most responsive quasi-fixed factor of production to price and wage changes, and to an increase in family labor. Its increase also had the largest output effects among the three quasi-fixed factors. Non-land assets are also a strong complement to fertilizers, further boosting the impact of increases in non-land assets on crop output. If rapid investment in non-land assets continues, there will be little worry about the negative impact of rising rural wages on aggregate crop output. The growing labor force and higher educational achievements of the rural labor force also contributed significantly to output growth. With continued rural population growth, the first will continue to rise for a long time, while the second one will also rise because of the rapid recent rise in school attendance of both boys and girls. There is therefore optimism about the capacity of Indian agriculture to adjust to higher wages.

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Table 1: Key characteristics of farm households and villages

Variables	1999-00	2007-08	Annual growth rate (%)	t-test
Characteristics of households				
Household size	7.01 (3.83)	5.76 (2.81)	-2.23	***
Household size/owned area	3.15 (2.83)	3.34 (3.79)	0.75	
Education of household head	4.16 (3.62)	5.25 (4.57)	3.28	***
Average education of labor force	4.62 (2.83)	5.77 (3.79)	3.11	***
Workers per owned acre	1.82 (3.42)	1.99 (5.16)	1.17	*
Of which in agriculture	0.76 (1.35)	0.69 (1.61)	-1.15	
Of which in non-agriculture	0.94 (2.41)	1.03 (2.83)	1.20	
Of which in other (mainly students)	0.12 (0.47)	0.25 (1.53)	13.54	***
Land and non-land assets				
Land owned per households	6.07 (8.76)	4.86 (6.76)	-2.49	***
Land operated per household	5.98 (8.41)	4.99 (6.90)	-2.07	***
Value of non-land agricultural assets	7080.80 (34846.96)	10707.66 (24484.62)	6.40	***
Village tractor density (number/100acres)	16.75 (10.06)	19.88 (18.34)	2.34	**
Village adoption rate of HYV	0.52 (0.47)	0.57 (0.46)	1.20	***
Panchayat welfare expenditures (‘000’)	186.6 (465.2)	381.9 (727.2)	13.05	***
No of observations	2944	2944		

Standard deviations are in parentheses. Values of non-land assets are in per acre, while the number of tractors is recorded per 1000 acres. All values and prices are at 1999 prices.

Table 2: Summary statistics of household income, outputs and inputs, prices and wages

Variables	1999-00	2007-08	Annual growth rate (%)	t-test
Aggregate crop output per acre	12185.57	13326.76	1.17	***
	(25290.59)	(10754.21)		
Price index of aggregate crop output	1.00	1.12	1.48	***
	(0.00)	(0.36)		
Total cost of production per acre	4967.01	5884.38	2.31	**
	(4969.87)	(4031.41)		
Total profit per acre	7303.28	7656.38	0.60	*
	(60573.64)	(112634.50)		
Hired labor days per acre	14.38	20.38	5.22	***
	(21.88)	(27.24)		
Family labor days per acre	40.49	47.46	2.15	***
	(68.16)	(79.59)		
Agriculture wage per day	45.52	48.77	0.90	**
	(17.37)	(14.68)		
Nonagricultural wage per day	56.25	65.99	2.16	***
	(19.65)	(18.82)		
Urban wage per day	105.12	116.65	1.37	***
	(29.96)	(27.15)		
Fertilizer cost per acre	176.59	176.94	0.02	
	(146.84)	(183.81)		
Fertilizer price (Rs/Kg)	9.39	8.94	-0.60	
	(10.31)	(21.25)		
Share of household uses machine	62.04	74.10	2.43	***
	(42.11)	(38.90)		
Machine rental per day	149.58	206.57	4.76	***

	(95.64)	(88.81)		
Total per capita income	10570.63	18098.20	8.90	***
	(21477.68)	(124258.60)		
No of observations	2944	2944		

Standard deviations are in parentheses. All values and prices are at 1999 prices. Growth rate in agriculture wage is 1.80[a]. [a] Average of agricultural and non-farm wage weighted by the mean shares of hired and family labor in total labor over the period

Table 3: Estimates of investment, output supply and variable factor demand equations

	Quasi Fixed factor		
	(1)	(2)	(3)
VARIABLES	Labor force	Land	Non land assets
Output price	0.003	-0.032	0.242***
	(0.032)	(0.034)	(0.071)
Agriculture wage	-0.032		0.153
	(0.040)		(0.127)
Non agriculture wage	0.026		-0.193***
	(0.034)		(0.053)
Predicted land	0.121***		0.238***
	(0.021)		(0.070)
Gender of the head	-0.060	0.014	-0.491***
	(0.042)	(0.045)	(0.146)
Age of the head	0.185***	0.256***	0.372**
	(0.043)	(0.044)	(0.153)
Edu of labor force	0.383***	-0.019	-0.049
	(0.017)	(0.020)	(0.065)
No of tractors	0.015		0.062
	(0.013)		(0.048)
Panchayat welfare expenditure	-0.001		0.004
	(0.002)		(0.008)
Predicted household split	-0.304***		-0.334***
	(0.023)		(0.079)
Share of HYV area	0.022	0.021	0.016
	(0.019)	(0.020)	(0.065)
Predicted labor force		0.076***	0.431***
		(0.023)	(0.064)
Inherited land		0.542***	
		(0.012)	
Fertilizer price			-0.052
			(0.049)
Machine rental rate			-0.090**
			(0.035)

Price of non-land assets			-0.498***
			(0.107)
Urban wage	0.012		
	(0.069)		
Constant	-0.797***	-0.162***	0.594***
	(0.045)	(0.016)	(0.223)
Observations	2,944	2,944	2,944
R-squared	0.245	0.461	0.074

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4: Estimates of investment, output supply and variable factor demand elasticities

	Output and variable factors				
	(4)	(5)	(6)	(7)	(8)
VARIABLES	Output	Hired labor	Family labor	Fertilizer	Machine rental
Output price	0.151***	0.121***	0.085**	0.123***	0.037***
	(0.047)	(0.046)	(0.039)	(0.019)	(0.014)
Agriculture wage	-0.121***	-0.490***	0.064	0.134***	-0.063***
	(0.046)	(0.094)	(0.055)	(0.032)	(0.024)
Nonfarm wage	-0.085**	0.064	-0.433***	0.290***	0.044**
	(0.039)	(0.055)	(0.064)	(0.024)	(0.018)
Fertilizer price	-0.123***	0.134***	0.290***	-0.530***	-0.117***
	(0.019)	(0.032)	(0.024)	(0.036)	(0.024)
Machine rental rate	-0.037***	-0.063***	0.044**	-0.117***	-0.170**
	(0.014)	(0.024)	(0.018)	(0.024)	(0.068)
Predicted land	-0.337***	-0.188***	-0.683***	-0.231***	1.086***
	(0.041)	(0.069)	(0.053)	(0.071)	(0.187)
Predicted labor force	0.451***	-0.660***	0.177*	-0.524***	0.045
	(0.085)	(0.140)	(0.107)	(0.138)	(0.363)
Predicted non land assets	0.741***	0.359*	0.358**	0.448**	-1.078**
	(0.112)	(0.183)	(0.141)	(0.178)	(0.464)
Edu of labor force	0.157***	0.226***	0.057	0.264***	0.149
	(0.032)	(0.054)	(0.040)	(0.056)	(0.150)
Gender of the head	0.322***	0.251*	0.022	0.129	-0.460
	(0.079)	(0.132)	(0.099)	(0.138)	(0.366)
Age of the head	-0.238***	0.005	-0.220**	-0.150	0.343
	(0.076)	(0.129)	(0.097)	(0.135)	(0.358)
No of tractors	0.011	-0.020	-0.148***	0.180***	0.480***
	(0.020)	(0.034)	(0.025)	(0.036)	(0.097)
Share of HYV area	0.128***	0.008	0.195***	0.313***	0.688***
	(0.026)	(0.044)	(0.033)	(0.048)	(0.127)
No of village shocks	-0.084***	-0.040	-0.026	-0.115***	-0.256**
	(0.022)	(0.038)	(0.028)	(0.040)	(0.108)
Constant	-0.389***	0.063	-0.175*	-0.774***	1.723***
	(0.073)	(0.123)	(0.092)	(0.125)	(0.328)

Observations	2,944	2,944	2,944	2,944	2,944
R-squared	0.040	0.039	0.273	0.110	0.036

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 5: The key elasticities: Short and medium term

Elasticities	Short term	Medium term[a]
Output with respect to its price	+0.15	+0.33
Output with respect to agricultural wage	-0.12	-0.01
Output with respect to non-farm wage	-0.09	-0.23
Output with respect to the rural wage	-0.21	-0.24
Output with respect to fertilizer price	-0.12	-0.15
Output with respect to machine rental rate	-0.17	-0.13
Hired labor with respect to agricultural wage	-0.49	-0.43
Family labor with respect to non-farm wage	-0.43	-0.50
Machine rental with respect to agricultural wage	-0.06	-0.09
Machine rental with respect to non-farm wage	+0.04	+0.14
Output with respect to non-land assets		+0.74
Non-land assets with respect to agricultural wage		+0.15
Non-land assets with respect to non-farm wage		-0.19
Hired labor with respect to non-land assets		+0.36
Family labor with respect to non-land assets		+0.36
Machine rental with respect to non-land assets		-1.08

Notes: All elasticities are statistically significant. a: Calculated according to equation 6

Table 6: Elasticities, growth rates, and growth contributions

Variable-	**Medium term Elasticity of output with respect to**	**1999-2006 (REDS)**	
		Growth rate	**Growth contribution**
Output	**Na**	**1.17**	**1.17**
Output price	0.3	1.48	0.44
Agricultural wage	-0.45	0.9	-0.25
Non-farm wage	0.09	2.16	0.19
Rural wage level	-0.13	1.8	-0.23
Fertilizer price	-0.32	-0.6	0.19
Machine rental rate	-0.17	2.43	-0.41
Labor force	0.48	1.17	0.56
Education of labor force	0.16	3.28	0.52
Non-land assets	0.74	6.4	4.74
Tractors in village	0.00	2.34	0.00
Village HYV rate	0.13	1.2	0.16

Appendix (Not for publication)

Table A1: Estimates of household split between 1999 and 2007 using REDS data

VARIABLES	(1) Household split
Head's age	0.036**
	(0.014)
Head's age squared	-0.000**
	(0.000)
land owned	0.203
	(0.310)
Mean schooling	-0.017
	(0.027)
Maximum schooling	-0.013
	(0.020)
variance in schooling	-0.002
	(0.007)
No of male children	0.106***
	(0.022)
No of female children	0.033
	(0.024)
Income growth, 1999-2007	-0.185
	(0.470)
Income growth x mean schooling	0.417**
	(0.179)
Income growth x max schooling	-0.389***
	(0.138)
Income growth x variance in schooling	0.050
	(0.053)
Total no of claimants	-0.010
	(0.021)
No of departed married daughter	-0.028
	(0.031)
No of departed son	0.153***
	(0.030)
Constant	-2.047***
	(0.366)
Observations	2944

Note: Variables used to predict household split are from REDS 1999 survey round. For detail please see Foster and Rosenzweig (2002). Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table A2: Correlates of rural wage

VARIABLES	(1) Rural wage
Output price	-0.007
	(0.036)
No of tractors	0.040*
	(0.020)
Urban wage	0.370**
	(0.140)
Panchayat welfare expenditure	0.001
	(0.005)
Fertilizer price	-0.038
	(0.040)
Share of HYV area	-0.029
	(0.040)
Asset's price index	-0.114*
	(0.056)
No of village shocks	0.031
	(0.024)
Constant	0.202**
	(0.088)
Observations	2,944
R-squared	0.104

Note: All variables used are at village level except Urban wage. Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1