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# Yield and Acreage Response in Agriculture of Odisha : Some Policy Implications

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*In this paper the yield and acreage response of farmers in agriculture of Odisha has been analyzed. A weather index, instead of rainfall has been included to get a better representation of sensitivity of weather in the response analysis. The empirical evidence suggests that there is price inelasticity of supply in the case of rice but reverse in the case of maize. However, the elasticity of weather and irrigation are found to be significant. Therefore, the paper concludes that importance of irrigation needs to be prioritized in agricultural policies of government. The declining trend of public investment in agriculture should be made reversed and the irrigation potential through public investment needs to be emphasized so as to bring more cultivable land under assured irrigation.*

Keywords : Agriculture, Price Elasticity, Distributed Lag Model, Weather Index.

## Introduction

Whether and to what extent the economic incentives enhance the farmers to change their farming decision and practices is vital for agricultural planning. The elasticity of supply response analysis holds the key in providing the essential information to adopt an effective policy measure for bridging the gap between demand for and supply of food grains. Agricultural supply response has remained a central issue in agricultural development especially in developing economies like India where more than 70 per cent of population are agriculture dependent. The agriculture in developing countries faces a lot of rigidities like low public and private investment, weak support services, institutional rigidities in the form of government regulation and policy instability. These rigidities couple with large macroeconomic imbalances and cause huge economic misfortunes. For example, the high food inflation rate in India is pretty much supply driven. So here the study of farmers' supply response assumes a great importance in framing policy actions. If the response is very little then it endorses the fact that price instrument can no longer act effectively to bring about structural changes and development in agriculture (Palanivel, 1995; p. 251). At the same time if the other shifters in response

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function dominate the price variable then the policy framework changes accordingly. The large bodies of literature (Krishna, 1963; Narayanan & Parikh, 1981; Lahiri& Roy, 1985; Kumar &Rosegrant, 1997; Gulati & Kelley, 1999; Deb 2003; Kanwar, 2004; Mythili, 2008; Tripathi, 2008) on supply response in India show no agreement regarding the supply elasticity. Some studies found the price elasticity is very high and some contradict it. However, most of those studies are undertaken at aggregate level based on all India level data. So they suffer from many limitations. First, most of these studies treat the farmers alike in the sense that they all operate in same condition. But farmers in agriculturally developed states like Punjab and Haryana are well equipped and well-facilitated different schemes. Therefore, they are supposed to respond actively to the price movement than farmers in underdeveloped regions. Again the farmers operating in rainfed agriculture are exposed to more risk and they respond more to weather condition than price or market condition. Another loophole is that rainfall or rainfall index makes a proxy for weather in a linear fashion along with prices and other shifters in the past Indian studies. But it is fairly recognized that both rainfall and temperature together affect the crop yields and also acreage devoted to cultivation. Farmers make allocation of their land on the basis of soil moisture level which is partly determined by rainfall of last season and current temperature (Yu et al., 2012). Therefore in this study the aridity index, a composite index made of both rainfall and temperature as suggested by Oury (1965) is used to measure the farmer's response to weather[1].

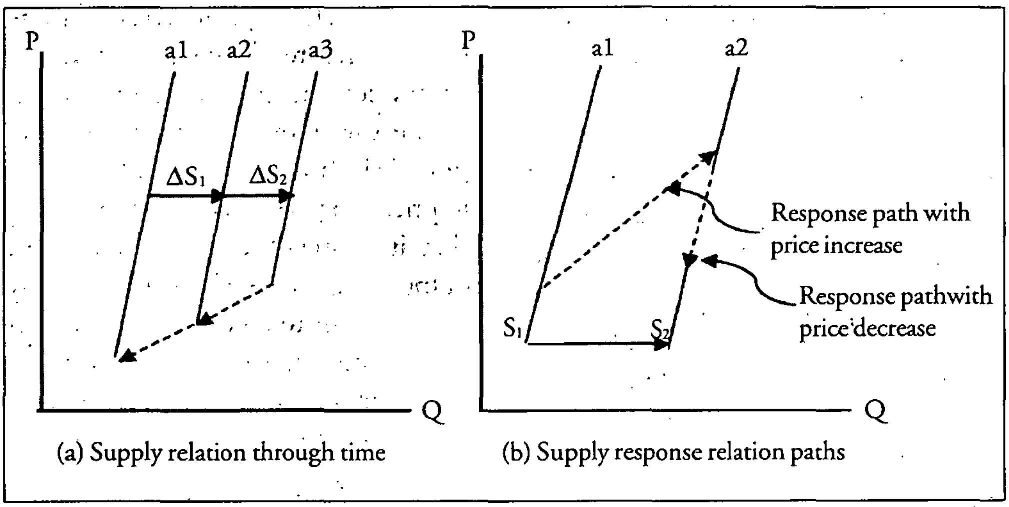
In this paper we attempt to answer the query that whether the farmers respond more to weather condition or pricing situation in rainfed agriculture of Odisha by estimating the yield and acreage response in the case of rice and maize. The reason for studying farmers' supply response behavior in the case of rice and maize is that the agrarian economy of the state is highly rice based though considered as rainfed agriculture[2]. Rice is the staple food and major crop grown in all the three seasons in Odisha. Next to rice, maize is the major crop grown here. However, the specific objectives of the paper are : one, to estimate the supply response function for two crops and analyze both short-run and long-run elasticities of price and weather for effective policy implications and second, to justify the use one aridity index to measure the elasticity of weather response of crops. So that the complete information regarding the weather influence on crops can be obtained. The paper is organized as follows: after a brief introduction the second section discusses the theoretical background of the study. The third section deals with the analytical developments and the fourth section talks about the data sources and the variables construction. The fifth section explains the empirical results of the model and finally the paper concludes with some policy implications.

## Theoretical Framework

Agricultural supply of product is more diverse than the counterpart demand function as the former is determined by many factors consisting of both economic and noneconomic such as the climatic condition, technological progress and government policies. Nerlove (1958) who laid the foundation supply analysis, defined supply curve in the context of competitive structure where all the sellers are price takers. Heady et al. (1958) proposed that there is a clear-cut difference between supply function and supply response though both are very often used synonymously. Supply function is reversible in the sense that the movement on the supply curve is due to price change, but supply response function is more general and irreversible. In other words, it is the shift of the supply curve or the structural change induced by price change along with other determinants. The response concept is based on hypothesis that when price factor changes, there are likely to be correlated changes in the form of environmental factor or technological factor relationship. Therefore, the change or shift in supply curve is spawned from changes in the values of variables along with price (Much et al. 2011). The change in price is expected to have two effects : first, it enforces the farmers to increase output along the supply curve. Secondly, it leads them to land on a new supply curve. Thus, supply response relation is shift of supply curve from changes in more than one parameter.

The Figure-1a and Figure-1b depicts supply function and response relation. Figure-1a shows the supply of a commodity that moves up and down on a given supply curve $a_1$, $a_2$ or $a_3$ in response to price change and also the shift of supply ($\Delta S_1$ and $\Delta S_2$). This occurs through time induced by investment or adoption of new technology, changes in weather condition etc. That shift is called supply response that depends on a number of variables along with price. Figure-1b further exhibits that when price increases the producer expands production along the diagonal line $S_1$ and $S_2$ which is termed as supply response path with price increase. On the other hand, the fall in price leads to a decline in output along the new supply curve $S_2$, which is called response path with price decline. Thus, supply response analysis encompasses more variables (say climatic condition,

**Figure-1 : Supply Function and Supply Response Relation**




*Source : Tomek & Robinson (1991) and Much et al. (2011)*

technological progress, government policies and so on) in the supply relationship along with price of product.

## Analytical Development

The study makes use of the Nerlovian reduced form approach[3]. Nerlovian model is built to examine farmer's output reaction based on price expectation and partial adjustment (Nerlove, 1958). It enables us to estimate both short-run and long-run elasticity's and it is also flexible enough to incorporate non-price factors. It can be computed in terms of yield, area or output response. The model is expressed as the desired yield of a crop in period 't' as a function of expected relative price P and exogenous shifters Z.

$$Y_t^* = \alpha_1 + \alpha_2 P_t^* + \alpha_3 Z_t + u_t \ldots(1)$$

Where $Y_t^*$ is the desired cultivated area in period t; $P_t^*$ is expected relative price of the crop and of other competing crops; $Z_t$ is a set of other exogenous variables including the physical and institutional factors. $u_t$ takes into accounts those unobserved random factors affecting the area under cultivation. $\alpha_s$ are long-run coefficients to be estimated. Specifically, $\alpha_2$ is long-run coefficient of supply response.

### *Partial Adjustment and Adaptive Expectation*

Response of farmers is constrained by many factors like small holding, price risk, credit constraint, lack of availability of inputs and so on. Again the volatile nature of monsoon appends to the magnitude of risk attached with cultivation. Thus, full adjustment in desired position within a short span of time is subject to those constraints. In order to incorporate that possibility in the cultivation process, it is assumed in Nerlovian tradition that the change in yield between two periods occurs in proportion to the difference between the expected output for current period and actual output in previous period.

$$Y_t = Y_{t-1} = \delta\left(Y_t^* - Y_{t-1}\right) + \varepsilon_t;\ 0 \le \delta \le 1 \quad \text{........(2)}$$

$$Y_t = \delta Y_t^* + (1-\delta)Y_{t-1} + \varepsilon_t \quad \text{........(3)}$$

The price that farmers expect to prevail at harvesting time cannot be observed. Therefore, one has to form expectation based on actual and past prices. In Nerlovian tradition, adaptive expectation implies that the farmers revise their expectations by some proportion of the extent by which his expectation in the last period differed from actual (Lahiri & Roy, 1985).

$$P_t^* - P_t^* = \lambda\left(P_{t-1} - P_{t-1}^*\right) + \varepsilon_t\ \ 0 \le \lambda \le 1 \quad \text{........(4)}$$

$$P_t^* = \lambda P_{t-1} + (1-\lambda)P_{t-1}^* + \varepsilon_t \text{........(5)}$$

Where $P_t^*$ expected relative price at t, $P^*_{t-1}$ expected relative price at t-1 and $P_{t-1}$ is actual price in previous period. $\lambda$ is an adjustment coefficient. If $\lambda$ is one then it becomes static expectation where expected price of current year equals to preceding year price.

Now with little algebraic manipulation to eliminate the unobservable $Y_t^*$ and $P_t^*$ from the system we put equation (1) and (5) into (3) and the final reduced form equation comes out as follows :

$$Y_t = \beta_1 + \beta_2 P_{t-1} + \beta_3 Y_{t-1} + \beta_4 Y_{t-2} + \beta_5 Z_t + e_t \text{.......(6)}$$

Where $\beta_1 = \alpha_1\delta\lambda$; $\beta_2 = \alpha_2\delta\lambda$; $\beta_3 = (1-\delta)(1-\lambda)$; $\beta_4 = -(1-\delta)(1-\lambda)$; $\beta_5 = \alpha_3\delta$

and $e_t = \varepsilon_t - (1-\lambda)\varepsilon_{t-1} + \delta u_t - \delta(1-\lambda)u_{t-1} + \alpha_2\delta\varepsilon_t$

This estimable reduced form equation is called distributed lag model with lag dependent variable as independent variable. The $\beta$ coefficient except that of lagged dependent variable shows short-run elasticities if taken in logarithm form in equation and long-run elasticities are obtained by dividing the short-run elasticities by an adjustment coefficient i.e., one minus coefficient of lagged dependent variable, i.e., $(1-\beta_3)$

## Data and Variables

The study undertakes the investigation of supply response in case of yield and acreage of rice. The yield and acreage functions are defined below as follows :

$$Y = f\left(P_1/q, GIR, W_g\right) \text{.....(7)}$$

$$A = g\left(P_1/P_2, F, W_s\right) \quad .....(8)$$

Where Y and A are yield and acreage of rice and maize (kg/ha); $P_1$, $P_2$ and q are prices of respective crop and competing crop and fertilizer. GIR and F are gross irrigated area (000'ha), and total fertilizer consumption (000' ton). $W_g$, $W_s$ are growing period and sowing period weather index. All the variables are constructed from secondary data for the time period of 1980-2011. The data on yield, acreage, irrigated area and fertilizer consumption are collected from various issues of the 'Odisha Agricultural Statistics' published by Directorate of Agriculture and Food Production, Government of Odisha and Economic Survey of Odisha, published by Directorate of Economics and Statistics, Government of Odisha. The Centre for Monitoring Indian Economy (CMIE) data base also serves as a useful source. The procurement prices published by Commission for Agricultural Costs and Prices (CACP), Government of India are taken as price variables. The climatic data like rainfall and temperature are collected from India Meteorological Department (IMD), Pune and also from the website http://indiawater portal.org/metdata, developed by School of Environmental Sciences, University of East Anglia, U.K. To account for weather influence in supply response analysis we use the Angstrom aridity index[4]. This index is constructed by using monthly figures of rainfall and temperature and it is defined as :

$$W_i = P_i / 1.07^{T_i} \; ; \; i = 1, 2, \ldots n \quad ......(9)$$

Both $P_i$ and $T_i$ indicate growing period or sowing period precipitation/rainfall and temperature of $i^{th}$ year. Out of total cultivated area farmers have to decide on the proportion to be allocated to rice. The decision on acreage is determined in part by anticipated relative price $\left(P_1/P_2\right)^*$ since the output prices and input prices are uncertain at the time of sowing. Once the acreage decision is taken, yield depends on relative price of output, i.e., relative to the input price $\left(P_1/q\right)^*$ which is uncertain. Yield is also gets influenced by the portion of irrigated area under rice. Fertilizer consumption and irrigated area are incorporated as the proxy for technological transformation. Both fertilizer and irrigation are not included in one equation because of possible colinearity between them.

## Results and Discussion

The estimated results for yield response function of rice and maize are presented in Table-1. The yield is expressed as the lagged relative price, irrigation, weather index and lagged yield. The OLS estimation technique is employed to estimate the equations. Both the equations are well fitted since the values of adjusted R-squared, DW statistics and F-statistics are well above the minimum requirements. In the case of rice, the price variable is insignificant but retains the theoretical sign. However, the short-run elasticity of relative price in the case of maize is highly significant and greater in magnitude. It implies that farmers growing maize are more sensitive to price policy. It happens because the farmers of Odisha have this option of growing maize when there is loss of crop in the case of rice, since maize is the next alternative. Thus farmers find it more convenient to grow maize because of several reasons like the procurement price is comparatively close to that of rice and besides being a relatively drought resistant crop, has less demands for modern inputs. Thus, the output decision of farmers growing maize is very much driven in terms of pricing policy. But in the case of rice, the price elasticity is very small and insignificant showing that farmers are not responsive to price.

Coming to other shifters, it is found that the variables like irrigated area and weather are statistically significant and

**Table-1 : Yield Response of Rice and Maize of Odisha**

| Rice Yield | | | Maize Yield | | |
|---|---|---|---|---|---|
| Variables | Coeff. | t-Stat. | Variables | Coeff. | t-Stat. |
| Const. | −1.44 | -0.829 | Const. | 4.971 | 3.36*** |
| Log ($P_1$/q) | 0.078 | 0.359 | Log ($P_1$/q) | 0.502 | 2.80*** |
| Log (GIR) | 0.782 | 1.71* | Log (GIR) | 0.031 | 0.16 |
| Log (Wg) | 0.484 | 2.25*** | Log (Wg) | −0.159 | −1.98** |
| Log ($Y_{t-1}$) | 0.253 | 1.11 | Log ($Y_{t-1}$) | 0.072 | 0.41 |
| MA(1) | −0.997 | −9.16*** | MA(1) | 0.54 | 2.87*** |
| Adj $R^2$ | 0.57 | | Adj $R^2$ | 0.63 | |
| DW | 1.63 | | DW | 2.09 | |
| F- stat | 7.31 | | F-stat | 9.34 | |
| DF | 26 | | DF | 26 | |

Note : ***, ** and * indicate level of significance at 1%, 5% and 10%.

$P_1$ in each of cases indicates the procurement price of respective crop in yield equation.

MA (1) is moving average process one.

bigger than that of price coefficient. In the case of rice, the short-run elasticity of weather and irrigated area are 0.48 and 0.78 respectively. It shows that one percent change in yield could be due to 0.48 per cent change in weather and also 0.78 per cent change in irrigated area. This also reveals that farmers are more sensitive to weather condition and irrigation potential in Odisha. Rice is a kind of crop that requires more water during its phonological stages of growth. But in Odisha more than 60 per cent of cultivated area is rainfed where weather is sole determinant of crop yield. A good monsoon leads to good crop year otherwise a drought year. The short-run elasticity of irrigated area is highly significant and bigger indicating the potential increase in crop output could be achieved if the agricultural policy is shifted to more focused irrigation policy to bring more cultivated area under irrigation. The elasticity of both variables provides one policy implications that farmers should be insured against weather vagaries since it is uncertain and growing evidence suggests that climate change impact is going to be exacerbated and agriculture in developing countries, specially rice production in India is predicted to be severely affected (Lal, 2007). The result also supports earlier studies at aggregate level like Palanivel (1995), Rao (2004) and Kanwar (2004) who concluded the inelasticity price responsiveness of the farmers whereas the non-price factors were more significant in influencing the farmers output decision. In the case of maize yield, the short-run elasticity of weather is negative and significant while the elasticity of irrigated area retains its theoretical expected sign but statistically insignificant. The coefficient of lagged output is not significant in case of both crops.

The acreage behavior of farmers is estimated and presented in Table-2. The results for maize are slightly better than rice from adjusted R-squared and values while other criteria are fulfilled adequately. The results for rice are more or less similar to that of yield equation. The price coefficient is insignificant but positive. The short-run elasticity of weather and fertilizer are significant. The magnitude of weather coefficient is 0.324 which is higher than that of price and fertilizer indicating that weather plays a pivotal role in allocating area under cultivation. However, in the case of maize, the short-run elasticity of price is highly significant and quite big i.e. 2.08. The elasticity of weather variable is not significant. But fertilizer comes as a helpful parameter.

Table-3 shows the short-run and long-run elasticities of yield and acreage response to different variables. It is observed that irrigation and weather are two

## Table-2 : Acreage Equation of Rice and Maize of Odisha

| Rice Acreage | | | Maize Acreage | | |
|---|---|---|---|---|---|
| Variables | Coeff. | t-Stat. | Variables | Coeff. | t-Stat. |
| Const. | 6.75 | 4.14*** | Const. | –3.901 | –2.87*** |
| Log (P1/P2) | 0.039 | 0.65 | Log ( P1/P2) | 2.086 | 2.36*** |
| Log (Ws) | 0.324 | 1.73** | Log (Ws) | –0.099 | –0.59 |
| Log (F) | 0.027 | 2.58*** | Log (F) | 0.271 | 2.17** |
| Log ($A_{t-1}$) | 0.169 | 0.85 | Log ($A_{t-1}$) | 0.525 | 3.16*** |
| Adj $R^2$ | 0.66 | | Adj $R^2$ | 0.77 | |
| DW | 2.12 | | DW | 2.02 | |
| F-stat | 5.59 | | F-stat | 20.68 | |
| DF | 26 | | DF | 26 | |

Note: ***, ** and * indicate level of significance at 1%, 5% and 10%. P1 is own procurement price and $P_2$ is price of competitive crop.

## Table-3 : Elasticities of Yield and Acreage Response of Rice and Maize

| Rice Yield | | | Maize Yield | | |
|---|---|---|---|---|---|
| Variables | Short-run | Long-run | Variables | Short-run | Long-run |
| PRICE | 0.078 | 0.104 | PRICE | 0.502 | 0.541 |
| GIR | 0.782 | 1.047 | GIR | -0.031 | -0.033 |
| Wg | 0.484 | 0.648 | Wg | -0.159 | -0.171 |
| Rice Acreage | | | Maize Acreage | | |
| Variables | Short-run | Long-run | Variables | Short-run | Long-run |
| PRICE | 0.039 | 0.047 | PRICE | 2.086 | 4.392 |
| Ws | 0.324 | 0.390 | Ws | -0.099 | -0.208 |
| FRT | 0.027 | 0.033 | FRT | 0.271 | 0.571 |

important drivers of yield in thecase of rice in both short-run and long-run, while price play a major role in the case of maize. There is price inelasticity supply in case of rice. Similarly, in case of acreage response it has been found that the acreage behavior of rice is not influenced greatly by any variables but comparatively. But the acreage behavior of maize is very much driven by price since both the short-run and long-run price elasticities are very high along with the risk associated relative to price variation.

## Conclusion and Policy Implications

The empirical analysis in this study indicates that there has been price inelasticity in the case of rice and reverse in the case of maize. The non-price factors like irrigation and weather are important drivers of both yield and acreage in thecase of rice. Thus, our study brings out the fact that in rainfed agriculture of Odisha where rice, the main crop grown is very much influenced by irrigation and weather than the relative price. Therefore, in this context the importance of irrigation should be pressed in agricultural policies of government. The proportionately declining trend of public investment in agriculture should be made reversed and the irrigation potential through public investment needs to be emphasized so as to bring more cultivable land under assured irrigation. The weather is one of the pivotal factors that influence agricultural practices, decision-making of the farmers and ultimately the agricultural output. The small and marginal farmers depending upon good monsoon sometimes bear the complete crop loss if there are some fluctuations. Because they are unable to mobilize the adequate resources to finance the lift irrigation or any other options to save the crop. Therefore, the irrigation is one panacea that could eradicate many problems. The crop insurance against weather should be pressed. However, the price mechanism also holds importance since the price elasticity of maize is very high and also statistically significant. The adoption of HYV seeds by farmers should be encouraged by a large-scale, because HYV seeds are photo-insensitive and can be resilient to the fluctuations of temperature. The modernization of agriculture also an issue to be looked at but careful assessment should be done since modern technologies like HYV seeds, fertilizer and so on are risk rendering in rainfed agriculture than risk reducing. However, with assured irrigation modernization comes easy which should be the agenda of agricultural development of state agrarian economy. The minimum support price programme that reduces the variations in price also ensures more producers' welfare. But it should be adequate enough to cover the cost of cultivation along with normal profit. Thus, in this context the government should continue to use both input subsidy and price support to achieve desired agricultural production.

## Notes

1. The aridity index is better proxy for weather because it differentiates moisture condition of soil from one location to another at a particular point of time and reflects influence of weather on crops over the periods when taken historically. Most importantly, it also allows the law of diminishing returns in production process (Oury, 1965).

2. The agriculture of a region is defined as rainfed if more than 60 per cent of its cultivated area is dependent on rainfall (Chand et al, 2010). So in the case of Orissa, 70 per cent of cultivated land is rain dependent.

3. Indirect structural form approach is not applicable in case of India because it requires detailed information regarding input and output prices. But Indian agricultural market is not that much developed and does not function in profit-maximizing framework. Sadoulet and de Janvry (1995) reviewed all the methodologies used for supply analysis.

4. Out of many aridity indexes suggested by Oury (1965) Angstrom index is generally widely used for economic analysis (Zhang & Carter, 1997). It has been also proved that Angstrom index performs better than others (Paltasingh et al. 2012)

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