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Analyzing Growth and Instability in Subsistence Agriculture of Odisha: Evidence from Major Crops

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Abstract

The paper has analyzed the performance of agriculture in terms of growth and instability of yield, area and production of major crops in Odisha. The growth analysis has shown a gloomy picture in the post-reform era, as instability has augmented during this period, rendering the agricultural sector of Odisha as unsustainable. The various causes of low growth rate have been identified. The study has discarded the hypothesis of direct relation between high growth and high instability. Weather variability and price risk as prime source of instability have been analyzed and the study has shown that mainly weather variability plays a pivotal role than price fluctuations in augmenting risk. The paper has suggested some policy implications to augment agricultural production in Odisha.

Key words: Agriculture, kink growth model, instability, weather index, price risk, Odisha

JEL Classification: C43, C51, Q18

Introduction

Agriculture is spinal cord of the state economy of Odisha. It provides employment opportunities to more than 70 per cent of the state population and more than 80 per cent of the population depends on it directly or indirectly (Economic Survey of Odisha, 2011-12). Though its share in state gross domestic product (SGDP) has come down to less than 20 per cent, its total influence through forward and backward linkages with other sectors is much larger. Realizing this aspect, concerted efforts were initiated in 1960s to modernize the sector by adopting modern technology which marked the onset of green revolution in Indian agriculture (Dantwala, 1991). In the early 1990s, the sector was liberalized hoping that confiscating the restrictions on export and import of agricultural commodities, imports of agricultural inputs would boost the sector. However, with the advent of modern technology and liberalization, there have been fluctuations in agricultural production rendering an intense debate on agricultural growth and instability in India since it has direct implications for food supply management and macroeconomic stability (Chand and Raju, 2009). While there is an obvious need for agricultural growth, the increased instability in production instills more uncertainty about sustainability of agricultural growth in India. Increased instability in agriculture augments the risks involved in farm production and adversely affects farmers' income and decisions to adopt modern technologies and make investments in farming. Instability in production affects price stability and the consumers, and it increases vulnerability of low-income households to market (Chand and Raju, 2009).

Instability in production and productivity of Indian agriculture in relation to green revolution has been intensely studied at aggregate level and there are contradictory views regarding the impact of green revolution on instability. Some studies (Hazell, 1982;

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Rao *et al*., 1988; Larson *et al*., 2004) have concluded that instability has increased in Indian agriculture during post-green revolution period due to adoption of modern technology. The contesting evidence has been lent by the studies like Mahendradev (1987) and Chand and Raju (2009) who have concluded that instability has declined during the post-green revolution period. However, a macro perspective overlooks many of the peculiarities at the regional level since the socio-economic and agronomic conditions vary from one region to another. Thus, there is a need to study instability at the disaggregated level so that the policy implications are more relevant. In the case of Odisha, a few studies (Das, 1978; Mahendradev, 1987; Tripathy, 1990; Chand and Raju, 2009) have concluded that there has been divergent instability in the agricultural sector in the post-green revolution period, but the sources of instability have not been paid due importance. Again, there is a dearth of research in the agricultural sector of Odisha in post-reform period. In this paper, growth and instability in Odisha agriculture have been analyzed with following specific objectives: (i) to analyze growth and magnitude of instability in area, yield and production of major crops of Odisha in pre-liberalized and liberalized periods, (ii) to test the controversy about the nexus between instability and growth rate of area, yield and production, and (iii) to explore the relationship between instability and weather variability along with price fluctuations.

Data and Methodology

The study has used time-series secondary data on area, yield, production, irrigated area (gross and net), fertilizer consumption, rainfall, temperature and farm harvest prices for major crops, viz., rice, wheat, bajra, maize, ragi, *kharif* foodgrains and *rabi* foodgrains at the aggregate level. The data for a period of forty-one years, from 1970 to 2010 were collected from various issues of *Odisha Agricultural Statistics* and Centre for Monitoring Indian Economy (CMIE), *Agricultural Data Book*. The data on rainfall and temperature were collected from the database of Indian Meteorological Department (IMD), Pune.

Growth Rate

The growth rate of yield, area and production of crops is calculated by using the method of kinked growth rate formula. It is an improved and alternative growth rate model when there are break-points in time series-data and different sub-periods. In the case of single break-point, the kink growth model can be written as Equation (1):

$$\ln Y_t = a + b_1 (D_1 t + D_2 k) + b_2 (D_2 t - D_2 k) + u_t \quad \ldots(1)$$

where, Y is the concerned variable (area, yield and production) for which the growth rate is being calculated; 'a' is the common intercept at the breakpoint between the two periods; D_1 is a dummy variable that takes the value 1 in the first sub-period and 0 in the second sub-period; D_2 is a dummy variable that takes the value 1 in the second sub-period and 0 in the first sub-period; and b_1 and b_2 are the growth rates during first and second sub-periods, respectively. So the elimination of discontinuity between sub-periods provides a superior basis for comparison of sub-period growth rates (Boyce, 1987).

To assess the impact of economic reforms of 1991 on Odisha's agriculture, the shift or break or structural change in the yield of crops was analyzed by extending the kinked growth rate model and comparing the growth rates of two sub-periods. If $b_2 > b_1$, then there would be an upward shift in yield during post-reform period and if $b_1 > b_2$, then this shift would be downward.

Measuring Instability

The instability of area, yield and production of selected crops was measured by using the Boyce method (1987) which was modified slightly to measure the instability accurately[1]. From Equation (1), the proportionate of residuals Z_t can be regressed on time in the same way that growth rate was calculated and the equation can be written as[2]:

$$Zt = a + b_1 (D_1 t + D_2 k) + b_2 (D_2 t - D_2 k) + u_t \quad \ldots (2)$$

The advantage of this method is that it gives the scope for a comparison of magnitude of instability when there are several sub-periods. This equation was used to measure instability.

[1] Details on other measures of instability can be found in studies like Ray (1983) and Chand and Raju (2008).

[2] The whole square of the difference between actual and predicted values (area, production and yield) expressed as proportionate of predicted values. In notations it is expressed as: $z_t = \left[\frac{(Y_t - \hat{Y}_t)}{\hat{Y}_t}\right]^2$.

Results and Discussion

Growth Rates of Area, Production and Yield of Major Crops

The growth rates of area, production and yield of major crops of Odisha for pre-liberalization and post-liberalization periods, analyzed by the kink exponential growth rate model, are given in Table 1. The results show that all crops, except rice experienced deceleration during post-liberalization period. Among those crops, bajra, jowar, wheat, ragi and small millet experienced a higher deceleration. Even the positive growth rate of rice area was very trivial. The reason behind such a dismal picture is that the farmers were experimenting with different crops as a coping strategy to weather anomalies, i.e., droughts and floods. So there was a wide diversification of crops. But, after liberalization in 1991 the government started encouraging the cultivation of high-value crops. Restrictions on export of common rice were lifted in 1992. In 1997, a special foodgrain production programme, namely, 'Integrated Programme for Rice Development' was initiated and more rice production was encouraged (Chand and Raju, 2008). This led to concentration of crops instead of crop diversification. Studies show that agriculture in Odisha is experiencing high concentration of crops towards rice (Lenka, 2010). Thus, there has been diversion of cultivable areas meant for other crops, towards rice. The competing demand for industrialization and urbanization after neoliberal policies of 1991 led to synchronization of cultivable areas further (Bhalla and Singh, 2009). The area under rice has somehow maintained a positive growth, though trivial because of only diversion of areas from other crops.

The analysis of growth rate of production has shown that some crops like wheat, ragi and millet experienced decline in the pre-liberalization period, which exacerbated in the post-liberalization period. Other crops like bajra, jowar, gram, arhar, experienced a deceleration in post-reform period compared to pre-reform period. The rice and maize are the two crops which maintained a positive growth trend in both the periods with maize experiencing acceleration, though not much. It shows that rice is the only crop that has been benefitted from the reforms. Somehow maize is also getting benefitted though its area is declining. The trade liberalization induced crop concentration instead of diversification as expected. The deceleration of production performance of other crops in post-reform period reveals that reforms have not been in favour of agricultural growth in Odisha.

Sources of Low Growth Rates

The patterns of inputs-use and some other factors, presented in Table 2, reveal that the area under cultivation, including net sown area and gross cropped area (GCA) has declined though GCA has improved after 2000. But if we compare the figures between 1980 and 2009, then the gross cropped area was 8746

Table 1. Discontinuous kinked exponential growth rates of area, production and yield of major crops of Odisha

Crop	Area			Production			Yield		
	1970-1990	1991-2010	1970-2010	1970-1990	1991-2010	1970-2010	1970-1990	1991-2010	1970-2010
Rice	-0.12	0.22	0.05	1.85	1.52	1.69	1.61	1.92	1.77
Maize	-0.31	-2.47	-1.39	0.53	0.91	0.72	0.84	3.38	2.11
Bajra	2.38	-6.28	-1.95	5.97	-9.44	-1.74	3.55	-3.15	0.20
Jowar	0.73	-7.02	-3.15	0.98	-8.38	-3.70	0.22	-1.36	-0.57
Wheat	-2.07	-15.27	-8.67	-2.05	-16.87	-9.46	-0.05	-1.59	-0.82
Gram	2.02	-1.73	0.15	3.36	-2.95	0.21	1.34	-1.22	0.06
Ragi	-1.44	-6.83	-4.14	-1.68	-8.69	-5.19	7.32	-3.24	2.04
Small millet	-5.32	-8.01	-6.67	-3.87	-9.69	-6.78	1.41	-1.74	-0.17
Arhar	5.83	-1.74	2.05	7.64	-1.46	3.09	1.78	0.16	0.97
Kharif foodgrains	0.19	-0.72	-0.27	1.86	0.51	1.19	1.67	1.27	1.47
Rabi fodgrains	-0.64	-6.4	-3.52	1.17	-2.73	-0.78	1.81	3.31	2.56

Table 2. Changing patterns of inputs-use and other factors in Odisha

Year	Net sown area ('000 ha)	Gross cropped area ('000 ha)	Gross irrigated area ('000 ha)	Net irrigated area ('000 ha)	Fertilizer-use (NPK) (kg/ha)	Power-use (million units)	Barren land ('000 ha)	Land for non-agricultural uses ('000 ha)
1980-81	6130	8746	1624	1181	9.68	59	265	…
1985-86	6323	9260	2054	1542	15.2	75	497	688
1990-91	6304	9642	2918	1925	20	305	499	746
1995-96	6212	9631	2510	2090	23	491	553	858
2000-01	5829	7878	2512	1335	41	186	843	999
2005-06	5691	8928	2691	1846	46	137	843	1015
2009-10	5574	9074	3308	2158	60	155	840	1298
2010-11	5407	8565	…	…	62.80	158	840	1300

Source: Compiled from various issues of *Agricultural Statistics of Odisha* and *Economic Survey*, Govt. of Odisha

thousand hectares in 1980 which after ups and downs in-between increased to 9070 thousand hectares in 2009-10, depicting an increase of 3.7 per cent after nearly three decades. In the case of net sown area, there is a declining trend and the percentage decline is 9 per cent. Thus, the decline in net sown area is about three-times more than the increase in gross cropped area, which renders negative returns of production. The ratio of gross irrigated area to gross cropped area presents a depressing picture. It was 18.6 per cent in 1980 and increased to 30.3 per cent in 1990. But, again it declined to 26.1 per cent in 1995 and finally increased to 36.5 per cent. However, when compared with other states of India it is found that the states like Bihar, Assam, West Bengal, Madhya Pradesh, Andhra Pradesh and Tamil Nadu have a higher proportion of cultivated area under assured irrigation (for details, see Bhalla and Singh, 2009).

Fertilizer-use, regarded as one of the yield-augmenting technologies, revealed that though its use increased after 2005 but remained abysmally low before this year and gloomy on interstate comparison. In 2008-09, a comparison of fertilizer-use showed that the state severely lagged behind the other major states like Punjab (215.7 kg/ha), Haryana (189 kg/ha), Andhra Pradesh (196.6 kg/ha), West Bengal (141 kg/ha), Tamil Nadu (185 kg/ha) and Karnataka (117 kg/ha). Even the hilly states of Himachal Pradesh, Jammu & Kashmir consume more fertilizer than Odisha. Chand *et al.* (2011) have also found deceleration in growth rates of fertilizer consumption in Odisha to be 5.10 per cent in 1985-95 and 2.84 per cent in 1996-2003.

The consumption of electric power, important for promoting irrigation, was 59 million units in 1980-81 which increased to 305 million units by 1990-91, an increase of 416 per cent. But after 1990-91, it declined to 186 million units in 2000-01 and further to 155 million units in 2009-10. On interstate comparison of power consumption, Odisha appears as a meagre power consuming state being third state from below, next to only Assam and Himachal Pradesh. This irregular and poor power supply to agriculture hampers its mechanization process severely and leads to a decline in agricultural production.

Increasing diversion of agricultural land to non-agricultural uses due to undue industrialization and urbanization and rising trend of barren land appear alarming. The non-agricultural use of land has increased by more than 50 per cent during 1985-86 to 2009-10. Similarly, the barren land has increased by about 217 per cent in the past three decades; it increased from 4 per cent of net sown area in 1980-81 to 16 per cent in 2010-11. Thus, on one side the GCA has increased at the rate of 3.7 per cent and on the other side, the use of land for non-agricultural purposes and laying barren has increased some multiple times, then there definitely will be synchronization of net sown area, leading to a decline in area under cultivation and ultimately in agricultural output.

Changes in Cropping Pattern

Crop diversification acts as a mechanism for incorporating risk aversion into a farmer's decision making process in which crop specialization/ concentration may lead to highly unstable income due to variance in yield, production, or price for the particular crop (World Bank, 1988). It declines the risk involved in the cultivation of one crop thereby ensures the sustainability of agricultural growth and marks a strong bearing on the welfare of the farmer (Johnson and Brester, 2001). It is also acknowledged that the farmers allocate area across different crops based on their relative profitability. The trade liberalization was expected to speed up the process of crop diversification from low-value crops to high-value cash crops in India. However, it was found that the pace of cropping pattern changes slowed down in post-reform period compared to pre-reform period (Bhalla and Singh, 2009).

A look at the cropping pattern changes in Odisha shows that there was efficient allocation of areas to other crops in pre-reforms era, though rice accounted for a bulk share of about 50 per cent. However, after reforms, the reverse has happened as there has been a complete concentration in the cropping pattern wherein rice accounts for more than 75 per cent of the GCA (Table 3). It has serious implications for agricultural growth, livelihood, sustainability and food security of the state. It is because rice is a crop that requires standing water on the field and is suitable for areas getting more than 300 mm of rainfall in the monsoon period. However, Odisha is a rainfed state where more than 65 per cent of its cultivated land is dependent on rainfall (Chand *et al*., 2010). Thus, growing rice on a large-scale in this state means involvement of risk on a large-scale since the fate of the crop is dependent on weather. Thus, crop concentration has exposed the farmers to a greater weather risk. The incidences of droughts and floods are common in Odisha; there was a severe drought in 2003-04 and again in 2010. Thus, low diversification of crops and changing cropping pattern towards rice are among the major sources of low growth of agriculture.

Irrigation Development in Odisha

The estimated water resource of Odisha is one of the highest in the country, of the order of 11 per cent of the country's total surface-water resources (Economic Survey, 2010-11). Out of the total 6.56 million ha of cultivable land of the state, 5.9 million ha can be brought under assured irrigation through different sources. Despite annual expansion in the created potential and capital investments on irrigation in Odisha, the area irrigated by the major, medium and minor irrigation systems has been either stagnating or declining (Selvarajan *et al.,* 2001). In many irrigation commands, effective irrigated area has declined due to deterioration in the distribution infrastructure. The annual investment on irrigation under different five-year plans has been fluctuating. However, after liberalization, the investment has been consistently high (Table 4).

In Odisha, the average annual outlay for irrigation sector was ₹ 619 crore for the triennium 2000-02. But, poor irrigation facilities, not matching with the crop water requirements, have resulted into low productivity of crops and income to the irrigators/farmers (Gosh

Table 3. Changes in cropping pattern of Odisha: 1980-81 to 2010-11

Crop group	1980-81	1985-86	1990-91	2000-01	2005-06	2009-10	2010-11
Rice	53.0	52.97	50.81	71.8	75.47	75.84	71.17
Cereals	65.6	61.48	57.2	75.0	78.32	78.69	74.77
Pulses	21.8	23.26	26.5	14.2	13.63	13.72	14.80
Foodgrains	87.4	84.74	83.7	89.2	91.95	92.41	89.58
Oilseeds	9.3	11.87	13.3	7.3	4.57	4.12	6.7
Fibres	1.3	1.36	1.0	1.0	1.55	1.51	1.62
Others	2.0	2.03	2.1	2.5	1.94	1.96	2.1
Total	100	100	100	100	100	100	100

Note: Cereals included rice and foodgrains included both cereals and pulses.
Sources: Compiled from various issues of *Economic Survey*, Govt. of Odisha

Table 4. Investment on irrigation during different five-year plans in Odisha

(in crore ₹)

Plan Periods	Investment on major and medium irrigation projects	Investment on minor (flow and lift) irrigation projects	Total investment
1st Plan (1951-56)	55.28	…	55.28
2nd Plan (1956-61)	20.00	1.65	21.65
3rd Plan (1961-66)	26.22	6.22	32.44
Annual Plans (1966-69)	20.44	7.95	28.39
4th Plan (1969-74)	20.89	18.88	39.77
5th Plan (1974-78)	70.63	31.00	101.63
Annual Plans (1978-80)	67.81	28.30	96.11
6th Plan (1980-85)	360.00	85.00	445.00
7th Plan (1985-90)	623.61	177.15	800.76
Annual Plan (1990-92)	404.74	103.50	508.24
8th Plan (1992-97)	2276.00	323.40	2599*
9th Plan (1997-02)	…	…	2383**
10th Plan (2002-07)	2334.0	427.54	2762***

Notes: * This amount is out of the total outlay of ₹ 3079.18 crore under irrigation and flood control sector.
**Provisional expenditure under irrigation and flood control sector.
***This amount is out of the total outlay of ₹ 4109.21 crore under irrigation and flood control sector.
Source: Compiled from various issues of *Economic Survey*, Govt. of Orissa

and Kumar, 2010). The maintenance of existing physical infrastructure is poor; canals, the dominating source of irrigation are not in good condition and 30-60 per cent of the canal command farmers don't get adequate and timely water supplies.

Output/unit of water in the Mahanadi Command of Odisha has been reported to be the lowest in the country (14 kg of ha-cm). By the year 2009-10, the utilization percentage of irrigation potential created was 68.45 only (*Odisha Agriculture Statistics*, 2010-11). Chand *et al.* (2011) have found that in Odisha, irrigation can be extended to more than two-thirds of the cropped area, whereas at present it is available to less than 27 per cent area. The elasticity of crop output with respect to irrigation has been found to be in the range of 0.31 to 1.004, which is quite reasonable. But, when irrigation suffers a setback, it affects the crops in many ways such as hampering the pace of diversification and instilling huge risks. Thus, irrigation is one of the major sources of stability in the growth process and sustainable development of agriculture.

Instability of Area Production and Yield

In framing policies for sustainable agricultural development, risk management is one of the major factors. The risks revealed by the instability of area, production and yield of major crops in pre-liberalization and post-liberalization periods were calculated by applying the alternative approach by modifying Boyce (1987) method. The results are shown in Table 5. The instability in crop area has depicted a declining trend in pre-reform period, except in maize. But, in the post-reform period, it has shown a rising trend for most of the crops. However, maize alone experienced a positive trend but not significant. Rice has not experienced any significant changes though in both periods there is a negative trend. In the case of wheat, the instability has risen very significantly in the post-reform period.

In production also, a similar trend has been observed. The rice production has not experienced any significant decline in instability in both the periods, while other crops, except gram production, have experienced a decline in instability in the post-reform period. On the other hand, bajra and wheat have experienced a huge increase in instability in production in the post-reform period. Though *kharif* foodgrains bear a negative sign in the post-reform period, it is not statistically significant. But, the instability of *rabi* crops has risen in the post-reform period.

Table 5. Percentage changes in instability of major crops in pre- and post-reform periods in Odisha

Crop	Area		Production		Yield	
	1970-1990	1991-2010	1970-1990	1991-2010	1970-1990	1991-2010
Rice	-0.001	-0.0003	0.001	-0.001	0.002	-0.001
Maize	0.048*	0.034	0.078*	0.015	0.003	-0.001
Bajra	-0.156*	0.210**	-22.87	75.11***	-0.002	0.024***
Jowar	-0.032*	0.048***	-0.064	0.212***	-0.001	-0.001
Wheat	-0.562	2.036***	-0.249	1.210***	0.027	0.051*
Gram	-0.117*	0.457***	0.066	-0.023	0.006	0.062***
Ragi	0.029	0.077***	0.066*	0.129***	-1.85***	9.373***
Small millet	-0.031	0.190***	0.001	0.143***	-0.009	0.075***
Arhar	0.006	0.021	0.005	0.077***	-0.031*	0.119***
Kharif foodgrains	0.001	0.001	0.001	-0.004	0.001	0.001
Rabi fodgrains	0.022***	-0.010*	-0.053	0.333***	-0.011	0.058***

Note: ***, ** and * indicate significance at 1per cent, 5 per cent and 10 per cent levels, respectively.

The yield carries both area and production effects. The analysis of yield revealed a similar picture in the sense that most of the crops experienced a rise in instability, with ragi having a significant increase. Thus, instability of area production and yield has increased for most of the crops in the post-reform period.

Linkage between Growth and Instability

There has been a controversy regarding the linkage between growth and instability in agricultural output. Hazell (1982) has argued that instability is a consequence of growth, i.e., there is a positive relationship between them. Contradicting this, Mahendradev (1987) has reported a negative relationship between them for the major states of India. Chattopadhyay (2001) has reported a positive as well as negative relationship between them. However, in this section an attempt has been made to test that hypothesis for Odisha agriculture. The cross-sectional regression estimates between changes in instability (INST) and growth rates (CGR) were estimated for area, production and yield for foodgrains in both the sub-periods. The estimates have shown mixed results in the sense that the OLS regression model between instability and growth rates of area in the pre-reform period is not significant. The results for area in pre- and post-reform periods were obtained from Equations (3) and (4), respectively:

$$\text{INST (area)} = \underset{(-1.33)}{-0.073} + \underset{(0.46)}{0.0094}\ \text{CGR} \quad \text{Adj } R^2=0.02,\ N=11 \qquad \ldots (3)$$

$$\text{INST (area)} = \underset{(-1.19)}{-0.23} - \underset{(-3.38)}{0.101}\ \text{CGR} \quad \text{Adj } R^2=0.51,\ N=11 \qquad \ldots (4)$$

The results for production in pre- and post-reform periods were obtained by Equations (5) and (6), respectively.

$$\text{INST (prod)} = \underset{(-0.37)}{-0.801} - \underset{(-1.48)}{0.90}\ \text{CGR} \quad \text{Adj } R^2=0.19,\ N=11 \qquad \ldots (5)$$

$$\text{INST (prod)} = \underset{(0.19)}{1.87} - \underset{(-0.78)}{0.98}\ \text{CGR} \quad \text{Adj } R^2=0.06,\ N=11 \qquad \ldots (6)$$

The results for yield in pre- and post-reform periods were obtained by Equations (7) and (8), respectively.

$$\text{INST (yield)} = \underset{(2.69)}{0.312} - \underset{(-5.82)}{0.24}\ \text{CGR} \quad \text{Adj } R^2=0.79,\ N=11 \qquad \ldots (7)$$

$$\text{INST (yield)} = \underset{(0.96)}{0.784} - \underset{(-1.41)}{0.504}\ \text{CGR} \quad \text{Adj } R^2=0.18,\ N=11 \qquad \ldots (8)$$

The figures in brackets in Equations (3) to (8) are t-statistic values. All the cross-sectional regression equations, except the first one on area in pre-reform period, have demonstrated a negative association, with some significant and some not. Thus, it indicates that there exists a negative relationship between trends in instability and growth rates in the sense that when instability declines, growth rate increases and vice versa. The comparison of changes in growth rates and instability between two periods also supports the result. For rice, the instability in area has declined in the post-reform period, while growth rate has increased. But, for other crops, the instability has increased in the post-reform period and growth rates have declined. In the case of production, rice and gram are the exceptions in the sense that both instability and growth rates move in the same direction whereas it is reverse in the case of other crops. Similarly, in the case of yield, except for jowar, there is a reverse relation between the two. Thus, this study supports the conclusion of Mahendradev (1987) and discards the hypothesis of high growth causing high instability, though there are some exceptions.

Weather Variability, Price Risk and Instability in Production and Yield

Agricultural production is a risky activity, particularly in the rainfed areas where agro-climatic conditions largely dictate the decisions of farmers. Risks may arise from many sources, but they emerge primarily from the variability inherent in natural, climatic and biological systems. From plantation to harvesting, the crop is exposed to precipitation, temperature, sunshine, wind velocity, etc. which in turn, affect it leading to instability in yield quantitatively as well as qualitatively. The fluctuations in weather conditions also lead to the fluctuations in inputs-use such as fertilizers, HYV seeds, irrigations, etc. In a good monsoon year with normal temperature, soil-moisture is adequate and groundwater level is favourable leading to more use of fertilizers. So the crop yields are pushed-up significantly. But, in a year of deficit rainfall, crop yields go down steeply because of a significant reduction in the use of inputs, thus widening the year-to-year fluctuations in yields. As a consequence, there will be a rise in the sensitivity or elasticity of output with respect to variations in weather condition (Rao *et al*., 1988). This prolonged risk on yield instability spawned from weather needs to be studied carefully. However the previous studies (Ray, 1983; Rao *et al*., 1988; Mahendradev, 1987) have concentrated only on rainfall and its impact on crop yield. Some studies have taken temperature along with rainfall or a composite index of both and have measured their impact on crop yield (Kumar *et al*., 2011; Paltasingh *et al*., 2012). But the variability in yield as a result of fluctuations in weather conditions, mainly rainfall and temperature, has seldom been studied.

In this section, we have analyzed the influence of weather variability (W_v) and price risk or price variability (PR) on yield and production variability (Z_t). The method adopted, including data sources and measurement of different variables, has been described in Appendix I.

The influence of weather risk and price risk on production instability of selected crops has been presented in Table 6. The intercept term was positive and highly significant in most of the cases, indicating that some other regional and institutional factors augment risks. In the case of rice, weather variability at all the three phonological stages affected the production and yield. The price risk was negative and significant showing the effectiveness of support price. In fact, the farm harvest price and the procurement price

Table 6. Impact of weather variability, price risk on production instability for major crops of Odisha

Variable	Rice	Maize	Wheat	Bajra	Gram
Constant	0.007***	0.0139***	0.12***	4.03*	0.015***
W_V at sowing period	0.021*	-0.027	-0.47	12.61*	-0.6
W_V at growing period	0.012**	0.021*	0.068*	16.18	0.047**
W_V at harvesting period	0.006	0.009	-0.07	1.25	0.27***
Price risk (PR)	-0.0005	0.018***	-0.007	0.029	…
Adj R^2	0.59	0.53	0.74	0.17	0.58
DW	1.85	1.72	1.65	1.43	1.67
F-statistic	7.25	6.33	4.87	1.86	5.58

Note: ***, ** and * indicate significance at 1per cent, 5 per cent and 10 per cent levels, respectively.

Table 7. Impact of weather variability, price risk on yield instability for major crops of Odisha

Variable	Rice	Maize	Wheat	Gram
Constant	0.014***	0.007***	0.051*	0.0076***
W_V at sowing period	0.02*	0.002*	-0.019***	0.002
W_V at growing period	0.016**	-0.0012	0.09**	0.014
W_V at harvesting period	0.0005	0.0095	-0.062	0.003
Price risk (PR)	-0.002*	0.0001***	0.001**	…
Adj R^2	0.57	0.42	0.87	0.59
DW	1.86	1.55	1.74	1.58
F-statistic	7.85	3.22	3.01	3.85

Note: ***, ** and * indicate significance at 1per cent, 5 per cent and 10 per cent levels, respectively.

for rice in Odisha did not characterize a fluctuation, rather they showed a rising trend over the period. In the case of maize, the weather variability at sowing period affected the production. Though price risk reduced the production variability, the influence was too small. The results for bajra production were not impressive as indicated by the adjusted R square and DW statistics. The weather variability at the sowing and the growing periods influenced the gram production. Wheat production was affected by weather anomalies at the growing period.

The influence of weather variability and price variability on yield instability of selected crops has been shown in Table 7. The story in yield instability is more or less same as that of production instability. In the case of rice, the weather variability influenced the yield instability at the sowing and growing periods. The price variability reduced the yield instability. In the case of maize, weather variability at the growing stage was negative but insignificant in its influence statistically as well as quantitatively. In the case of wheat, weather variability at the growing period and price risk augmented yield risk, except the weather anomaly at the sowing period. In the case of gram, none of the variables was significant but retained their theoretical sign. Bajra and other crops were excluded because of the irrelevance of results. Apart from these two factors, there are numerous other factors that augment instability in production and yield. However, Tables 6 and 7 have made it clear that weather variability is an important determinant of production and yield instability than price variation. The reason is that the farming in Odisha is mostly rainfed and the farmers are not driven by the market to a greater extent (Paltasingh and Goyari, 2013).

Conclusions and Policy Implications

The analysis of growth and instability of agriculture in Odisha as revealed by major crops has shown a distressing picture in two ways. First, incidences of green revolution and subsequently of liberalization have not provided any improvement in agricultural sector. Second, the irrigation development has been very slow and consequently, much of the cultivated land is still rainfed in Odisha. This hinders the growth aspect of agriculture on one hand and augments risk on the other hand. The sources of low growth, particularly in the liberalized era have been attributed to poor irrigation intensity, decline in net sown area as well as gross irrigated area and meagre use of fertilizers and other inputs. There has been an alarming decline in the net sown area and rising trend of shifting land for non-agricultural purposes.

The study has shown an increase in instability in the post-reform period. The analysis of the sources of instability has revealed that weather variability rather than price fluctuations plays a pivotal role along with other institutional factors. The cropping pattern has been found highly skewed towards rice and crop diversification is very low making it subsistence agriculture in the sense that if there is a natural calamity the entire crop is lost. The study has suggested that public investments on irrigation, water management, droughts and flood control should be enhanced. The relationship between growth and instability has shown that there is no basis to believe that high growth causes high instability. Therefore, the growth rate of production can be augmented with minimizing instability. Yield stabilizing measures should be prioritized. Development of market infrastructure with adequate support pricing, setting-up cold storages and introduction of farmer-friendly weather insurance, better contact with development authorities and extension services can minimize the income risk of the farmers in the state.

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Appendix I

Measure of Weather Variability and Price Risk

For exploring the relation between variability in yield and production with weather variability (W_v) and price risk (PR), we had regressed the yield or production variability (Z_t) on the weather variability computed at three different periods, i.e., at sowing period, growing period and harvesting period (W_v^s, W_v^g and W_v^h) and price risk. The variability in yield and production were calculated as described in the paper. A composite weather index, instead of rainfall alone was used. The Angstrom aridity index was used because it performs better in explaining the yield variability (Paltasingh *et al.*, 2012). This index was constructed by using monthly figures of rainfall and temperature and was defined as:

$$W_i = {}^{\mathrm{R_i}}/_{1.07^{\mathrm{T_i}}}; \quad \mathrm{i} = 1, 2 \ldots \mathrm{n}$$

Both R_i and T_i indicate monthly rainfall and temperature, respectively of the i^{th} year at three phonological periods. We had taken the monthly average of daily maximum temperature because of the fact that India is a hot country and maximum temperature rather than mean or minimum temperature affects the crop yield badly. A simple measure of weather variability (W_v) was used. This measure is close to the theoretical measure of riskiness (price or any other variables) and it was expressed as the whole square of deviations of actual values from the normal value and expressed as the proportionate of normal value. It was written as:

$$W_{vi} = \left[\frac{W_i - \bar{W}}{\bar{W}}\right]^2$$

The $\bar{W}$ was the normal weather index computed from the normal values of rainfall and temperature.

Apart from weather, the volatile nature of price poses a great deal of risk to farmers. The intra- and inter-year variation of farm harvest price is very high and it is quite pronounced in regions where support pricing system is not that much effective. After liberalization, agriculture is getting highly commercialized and price fluctuation has become a significant source of market risk. The role of price risk (PR) in augmenting the instability is studied by adopting a measure of price risk used by Hurt and Gracia (1982). It is based on the squared deviation of the expected price and actual price and expressed as:

$$PR_t = [E(P_t) - (P_t)]^2$$

In our study, the expected price was determined within Goodwin's extrapolative framework with static expectation. The adaptive expectation framework for expected price was expressed in the following manner. $P_t^* - P_{t-1}^* = \lambda(P_{t-1} - P_{t-1}^*);\ 0 \leq \lambda \leq 1$. The expected price was expressed as $P_t^* = \lambda P_{t-1} + (1-\lambda)P_{t-1}^*$, where P* was expected price in current period and λ was adjustment coefficient. Taking static expectation, λ becomes one and the expected price for current period becomes equal to previous year price. This is also called the naïve expectation. For details about various measures of price risk, see Brennan (1982).