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Did Crop Insurance Programmes Change the Systematic Yield Risk?

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I

INTRODUCTION

Modeling crop yield, revenue, or loss cost ratio distributions of a farm, tehsil, district, region, or state involves estimation and identification of systematic and random component(s) of crop yields. What is systematic component of crop yield distribution? The systematic component is a known source of variation and commonly identified with high-yielding, genetically modified, disease-insect resistant varieties or other technological innovations, and changes in crop insurance programmes. The systematic component of crop yields is modeled as linear, quadratic or cubic time trend variables.[1] What is random component of crop yield? The deviation of crop yields from the estimated systematic component is random hence the random component of crop yields. Here, the focus is on the systematic component of crop yields, specifically the average systematic component (ASC) of yield, spatial systematic risk (SSR), i.e., variation of crop yields across districts within a state in a year and temporal systematic risk (TSR), i.e., variation of crop yield over time for each district within a state. Identification of ASC, SSR and TSR is important, especially when dealing with implications of crop insurance policies and its changes. For example, are technology innovations and/or crop insurance programmes that are catering to major crop growing states in India driving differential changes in ASC, SSR and TSR component of yields across states?

Agriculture policies including crop insurance programmes are not supposed to alter acreage allocations, production or distributions. However, given the core objective of the crop insurance programme, it is anticipated to reduce production variability of the producers during times of low yield due to natural disasters. With the turn of the century and specifically since the dawn of Independence in 1947, crop insurance is increasingly viewed as an important risk management tool and the first government-supported crop insurance programme was introduced in 1972. This led to the introduction of three more major crop insurance programmes since 1972. Given this history of crop insurance programmes in India, the study attempts to estimate and examine the changes in the ASC, SSR and TSR of rice and wheat yields with the

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introduction of new crop insurance programmes in 1972, 1979 and 1999. Second, did the changes in the ASC, SSR and TSR of rice and wheat yields suggest bias toward major crop growing states and also over time?

Past studies in modeling crop yield distributions to estimate systematic component have used time-series (TS) statistical procedures that accounts for temporal variation. However, TS statistical procedure is convoluted by spatial yield correlation or spatial random variation of yields due to periodic area-wide events and changes in technology. Recently Shaik (2007 and 2010) examined the importance of accounting for spatial variation using one- and two-way panel random effects (PRE) statistical procedures on normality of crop yields. The application to Indian district level data from 1956-2002 for 15 crops and 14 states indicated accounting for spatial variation seems to change the distribution of crop yield residuals between normal and non-normal in 20 per cent, 14 per cent and 17 per cent of districts based on skewness, kurtosis and omnibus tests, respectively. Still both the TS and PRE statistical procedures encounter the limitation of accounting for the spatial correlation or spatial random variation without taking into account the hierarchical structure of districts nested in a state and country.

This spatial correlation or spatial random variation observed across districts within a state or across states within a country is nested or hierarchically structured. Hence, to accurately estimate ASC, SSR and TSR components of crop yields, the nested hierarchically structure that accounts for similar observable/unobservable factors within each nest needs to be used. Statistical procedure like hierarchical linear models (HLM) allows examination of the importance of accounting for the nested structure of the data as well as spatial random variation on the systematic risk of crop yields.

In this paper, changes in the ASC, SSR and TSR of rice and wheat yields is examined using district level data from 16 rice and wheat growing states in India. Section II provides a brief description of the evolution of crop insurance programmes in India and the respectively time periods. HLM statistical procedure to estimate the systematic component is presented in the third section. Section IV gives a brief description of the data. Section V deals with an empirical application to rice and wheat growing district data from India over the period 1956-2006. Finally, the study concludes with future research issues.

II

EVOLUTION OF INSURANCE PROGRAMMES IN INDIA

According to Rejda (1995), for any insurance (including crop insurance) programme to be viable the following ideal conditions or principles of insurance (see Figure 1) should be ensured:

(1) Large number of roughly homogeneous, independently insured units.

(2) Economically feasible premium.
(3) Determinable and measurable loss.
(4) Accidental and unintentional losses.
(5) Calculable chance of loss.

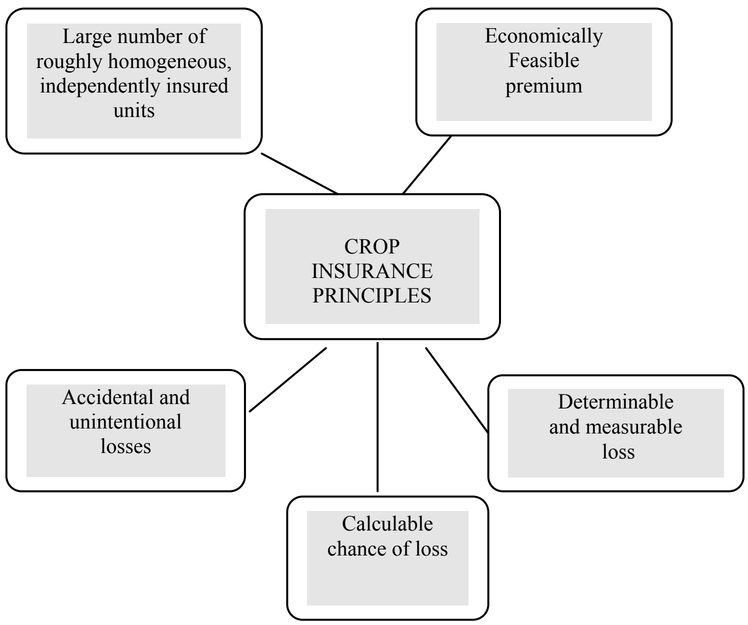

Figure 1. Principles of Crop Insurance

Due to the covariate risk (violates the law of large numbers) faced by agriculture around the world and not only in India, it is hard for any crop insurance programme to comply with the principles or conditions of insurance. An additional issue faced by Indian agriculture is the lack of publically available historical farm or unit level production, acreage and loss data to estimate the economically feasible premium rate that matches the risks faced by the farmer on his farm and premium provided by the government. Further, based on the aggregate indemnity, premium, subsidy and liability of an insurance programme there is lack of actuarially sound premium rates to reflect the asymmetric issues like adverse selection and moral hazard, farm size, production systems, i.e., commodities grown and production practices.[2] Special attention should be paid to the adverse selection issues especially in India as farmers with consistent losses every year end up remaining in the pool by pushing out less risky farmers. The crop insurance policies are also plagued by moral hazard issues, but will not be addressed. All these issues can be addressed with publically available crop insurance data.[3]

Even though faced with issues related to principles of insurance, policy makers in India pursued the potential for crop insurance programmes since the time of

Independence in 1947. Interest in mitigating risks faced by agricultural producers led to the introduction of the crop insurance scheme (CIS) programme based on the "individual approach" in 1972 by General Insurance Corporation of India (GIC). The programme started specifically to provide insurance for H-4 cotton in Gujarat and extended to paddy and groundnut crops. Crop insurance based on the "individual approach" ended in 1978. Between 1972 and 1978, the CIS programme covered 3,110 farmers, collected insurance premium of Rs.0.454 million and farmers received indemnity to the amount of Rs.3.788 million. This programme was phased out due the inability of the programme to meet the principles of crop insurance and additional characteristics of Indian agriculture.

A Pilot Crop Insurance Scheme (PCIS) was introduced by GIC in 1979 based on the recommendations of the report by Prof. V. M. Dandekar (for details see Dandekar, 1976 and 1985). Unlike the individual approach, the PCIS was based on the "homogeneous area" approach. The PCIS programme covered food crops including cereals and millets, oilseeds, cotton, potato and gram spread across 13 states. This PCIS programme was restricted to loanee farmers only and on a voluntary basis up to 100 per cent (later increased to 150 per cent) of the crop loan. The PCIS programme risk was shared between GIC and state government in the ratio of 2:1. A 50 per cent premium subsidy provided to small/marginal farmers was equally shared by state and central government. The PCIS programme based on the "area approach" ended in 1984. Between 1979 and 1984, the PCIS programme covered 0.627 million farmers, collected insurance premium of Rs.19.695 million and farmers received indemnity to the amount of Rs.15.705 million.

The Comprehensive Crop Insurance Scheme (CCIS) was introduced in 1985 and it is an expansion of PCIS. Similar to PCIS, the CCIS was based on the "homogeneous area" approach. The CCIS programme covered food crops including cereals and millets, oilseeds and pulses spread across 15 States and 2 Union Territories (5 states opted out after few years). This CCIS programme was restricted to loanee farmers only and on a voluntary basis up to 100 per cent of the crop loan or a maximum of Rs.10,000 per farmer. The CCIS programme premium and indemnities was shared between central and state government in the ratio of 2:1. A 50 per cent premium subsidy was provided to small/marginal farmers by the state and central government on 50:50 basis. The CCIS programme ended in 1999. Between 1985 and 1999, the CCIS programme covered 7.63 million farmers, collected insurance premium of Rs.40.36 million and farmers received indemnity to the amount of Rs.231.9 million.

During the *rabi* season of 1999, the National Agricultural Insurance Scheme (NAIS) was introduced. Agricultural Insurance Company of India Ltd. (AIC) was formed in 2002 and by early 2003 was in-charge of NAIS programme in India. The NCIS is based on both ‘area approach’ for widespread calamities, and ‘individual approach’ for localised calamities such as hailstorm, landslide, cyclone and floods. The NCIS programme covers all food grains, oilseeds and annual horticultural/commercial crops for which past yield data are available for an adequate number of years and available for all states and union territories. The unit of insurance varies and is defined by the state government. It could be village panchayat, mandal, hobli, circle, phirka, block, or taluka. The sum insured under NCIS programme covers the amount of loan for loanee farmers, and can also be extended to cover 150 per cent of the average yield for loanee and non-loanee farmers. The NCIS program indemnities beyond 100 per cent of premium collected will be between central and state government on 50:50 basis. For annual horticultural/ commercial crops, indemnities beyond 150 per cent of premium in the first 3 or 5 years will be shared by central and state government on 50:50 basis. Until 2006-07, the NCIS programme covered 790.8 million farmers and collected insurance premium of Rs.29.44 billion. The farmers received indemnity to the amount of Rs.98.57 billion. These five crop insurance program periods form the basis for comparison of systematic component of yield distribution using HLM. Next, the HLM statistical procedure to model yield distributions for the different phases of crop insurance programmes period is presented.

III

MODELING TO ESTIMATE SYSTEMATIC TEMPORAL AND SPATIAL YIELD RISK

The section provides an overview of the HLM statistical procedure for modeling crop yields to estimate average systematic component, spatial and temporal systematic yield risk. Suppose $y_{ik,t}$ represents a 1 × T vector of crop yields produced in district, i = 1, ..., I, which is located in state, k = 1, ...,*K* with t = 1, ..., T data points, and $x^{m}_{ik,t}$ represents a M × T matrix of exogenous linear, quadratic and cubic time trend variables, m = 1, ...,M; α is the intercept, β^m is the associated parameters of linear, quadratic and cubic time trend variables to be estimated; and $\varepsilon_{ik,t}$ pure random error. The parameter coefficients in equation (1) are estimated.

3.1 *Hierarchical Linear Model Statistical Procedure*

The HLM statistical procedure allows to model and account the nested or hierarchical structure of the crop yield data. The two-way hierarchical linear model (HLM2) statistical procedure requires the randomisation of district, i = 1, ..., I nested within each state, k = 1, ...,*K* and as:

$$y_{ik,t} = \alpha + \beta^m x^m_{ik,t} + z_{i(k)} + z_k + \varepsilon_{ik,t} \qquad \text{….(1)}$$

where $z_{i(k)}$ represents district random error nested within state, k, z_k represents state random error and $\alpha_{ik,t}$ represents the remaining pure random error, and α is the intercept, β is the parameter of time trend variables representing the degree of polynomial.

Equation (1) allows the decomposition of crop yields into systematic and random components and re-written as

$$\begin{aligned} y_{ik,t} &= \alpha + \beta^{\gamma} x^{\gamma}_{ik,t} + z_{i(k)} + z_k + \varepsilon_{ik,t} \\ &= \text{systematic} \qquad\qquad + \text{random} \end{aligned} \qquad \text{….(2)}$$

where $\hat{y}_{ik,t} = (\alpha + \beta^{\gamma} x^{\gamma}_{ik,t} + z_{i(k)} + z_k)$ is the systematic component or predicted yields and the deviation away from the systematic component is the random component, $\varepsilon ik,t = y_{ik,t} - \hat{y}_{ik,t}$.

Next the ASC, SSR and TSR are computed based on the systematic component or predicted yields estimated from equation (2) for five crop insurance programme periods (CIPP) by state. The five crop insurance programme periods are

CIPP1: Pre-crop insurance period from 1956 to 1971.
CIPP2: Crop insurance scheme (CIS) from 1972 to 1978.
CIPP3: Pilot crop insurance scheme (PCIS) from 1979 to 1984.
CIPP4: Comprehensive Crop Insurance Scheme (CCIS) from 1985 to 1999.
CIPP5: National Agriculture Insurance Scheme (NAIS) from 1999 to 2006.

The average systematic component for each state, ASC_k is defined as the average of the systematic yield component across all the districts in each state computed for each of the five crop insurance program periods over the period 1956-2006. This is represented as

$$ASC_k = \frac{\sum_{i=i}^{I} \sum_{t=1}^{T} \hat{y}_{ik,t}}{I * T} \qquad \text{….(3)}$$

The SSR and TSR is defined as the coefficient of variation of temporally invariant spatial yield risk and spatially invariant temporal yield risk, respectively, of the systematic component, $\hat{Y}_{ik,t}$ computed for each state, k = 1, ...,K. The coefficient of variation of systematic spatial risk for each state, SSR_k, defined as the ratio of the standard deviation over mean of temporally invariant spatial yield risk is presented as

$$SSR_k = \frac{\sigma_{\overline{\hat{y}ik}}}{\mu_{\overline{\hat{y}ik}}} = \frac{\sum_{i=1}^{I} (yik,t - \hat{y}ik,t)/I - 1}{\sum_{i=1}^{I} \hat{y}ik,t/I} \qquad \text{….(4)}$$

Similarly, the coefficient of variation of systematic temporal risk for each state, TSR_k, defined as the ratio of the standard deviation over mean of spatially invariant temporal yield risk is presented as

$$STR_k = \frac{\sigma_{\overline{\hat{y}t}}}{\mu_{\overline{\hat{y}t}}} = \frac{\sum_{t=1}^{T} (yk,t - \hat{y}k,t)/T - 1}{\sum_{t=1}^{T} \hat{y}k,t/T} \qquad \text{….(5)}$$

The average, temporal and spatial systematic risk is computed for the five CIPP's.

IV

INDIAN DISTRICT DATA

The district is the smallest administrative unit in India for which data on crops are available. This study covers a total of 265 districts across rice and wheat and 16 states in India for the period 1956-2006. This is a unique data set as it provides historical district level yield that has never been used in the estimation. District level data is available from four publications - *Area and Production of Principal Crops in India; Agricultural Situation in India; Statistical Abstracts of India*; and *Crop and Season Reports* by individual States.

V

INDIAN STATE LEVEL ANALYSIS OF SYSTEMATIC YIELD RISKS

To evaluate the changes in the average systematic component, spatial systematic risk and temporal systematic risk components, the following steps were involved.

(1) Estimated and decomposed crop yields into systematic and random components (Equation 2).
(2) Systematic component is used to compute average systematic component or ASC (Equation 3); spatial systematic risk or SSR (Equation 4); and temporal systematic risk or TSR (Equation 5).
(3) The ASC, SSR and TSR measures are estimated for the five-crop insurance programme periods (CIPP) by state, see Figure 2.

The HLM statistical procedure is used to estimate the systematic component of rice and wheat yields (Equation 2) used in the computation of ASC, SSR and TSR measures. The averages and coefficient of variation by five crop insurance programme periods (CIPP) for 16 rice and wheat growing states are presented in Tables 1 to 4. The results indicated the average systematic yield component increased from thepre-crop insurance period, 1956-1971 to the current NAIS programme period, 1999-2006 for rice and wheat in all the states. The only exception was Uttaranchal for rice and wheat crops, with lower average systematic yield component during the PCIS programme period, 1979 to 1984.

TABLE 1. STATE-WISE AVERAGE AND CV OF SYSTEMATIC YIELD RISK BY CROP INSURANCE PROGRAMMES

		Rice					Wheat				
State (1)	Time period (2)	Districts (3)	Years (4)	Average (5)	SSR (6)	TSR (7)	Districts (8)	Years (9)	Average (10)	SSR (11)	TSR (12)
Andhra Pradesh	CIPP1	20	16	1.448	20.241	4.839	12	16	0.088	235.232	228.091
	CIPP2	20	7	1.671	17.137	3.733	12	7	0.499	41.351	20.903
	CIPP3	20	6	1.87	15.32	3.152	11	6	0.74	19.76	11.903
	CIPP4	20	14	2.154	13.297	4.809	11	14	1.06	12.585	10.139
	CIPP5	20	8	2.331	12.295	0.594	11	7	1.308	10.63	2.163
Bihar	CIPP1	9	16	0.57	28.848	9.737	9	16	0.716	17.273	18.999
	CIPP2	9	7	0.797	20.642	7.831	9	7	1.132	10.924	8.315
	CIPP3	9	6	0.995	16.528	5.923	9	6	1.417	8.725	5.728
	CIPP4	9	10	1.233	13.341	6.695	9	10	1.731	7.145	6.043
	CIPP5	9	7	1.456	11.297	0.784	9	7	1.987	6.222	0.482
Chhattisgarh	CIPP1	6	16	0.502	18.185	11.057	6	16	0.211	74.193	64.433
	CIPP2	6	7	0.729	12.529	8.563	6	7	0.627	24.973	15,008
	CIPP3	6	6	0.927	9.849	6.358	6	6	0.912	17.165	8.897
	CIPP4	6	14	1.211	7.535	8.552	6	14	1.283	12.207	10.017
	CIPP5	6	6	1.387	6.582	0.8888	6	5	1.488	10.529	0.355
Gujarat	CIPP1	17	16	0.741	35.262	7.487	18	16	1,136	31.108	12.007
	CIPP2	17	7	0.97	27.062	6.84	18	7	1.543	23.138	6.105
	CIPP3	17	6	1.166	22.416	5.053	18	6	1.83	19.5	4.425
	CIPP4	17	13	1.428	17.959	6.508	18	13	2.196	16.262	5.874
	CIPP5	13	6	1.59	18.217	0.92	18	6	2.401	14.869	0.402

TABLE 2. STATE-WISE AVERAGE AND CV OF SYSTEMATIC YIELD RISK BY CROP INSURANCE PROGRAMMES

		Rice					Wheat				
State (1)	Time period (2)	Districts (3)	Years (4)	Average (5)	SSR (6)	TSR (7)	Districts (8)	Years (9)	Average (10)	SSR (11)	TSR (12)
Haryana	CIPP1	6	16	1.572	15.267	3.069	7	16	1.871	12.639	8.585
	CIPP2	6	7	1.788	13.585	3.489	7	7	2.259	9.146	4.167
	CIPP3	6	6	1.987	12.229	2.966	7	6	2.544	8.121	3.191
	CIPP4	6	11	2.24	10.845	4.203	7	11	2.877	7.182	4.098
	CIPP5	6	6	2.446	9.93	0.503	7	6	3.116	6.63	0.299
Jharkhand	CIPP1	5	16	0.57	28.302	9.739	5	16	0.562	20.059	24.211
	CIPP2	5	7	0.797	20.25	7.832	5	7	0.978	11.524	9.626
	CIPP3	5	6	0.995	16.214	5.923	5	6	1.264	8.991	6.6
	CIPP4	5	10	1.213	10.824	5.26	5	10	1.552	5.809	5.964
	CIPP5										
Karnataka	CIPP1	19	16	1.461	30.492	3.8	14	16	0.276	135.559	194.977
	CIPP2	19	7	1.687	26.397	3.697	14	7	0.638	47.239	15.025
	CIPP3	19	6	1.886	23.622	3.125	14	6	0.919	32.739	8.877
	CIPP4	19	13	2.159	20.628	4.588	14	13	1.271	22.945	8.366
	CIPP5	19	7	2.346	18.983	0.486	11	7	1.397	17.91	1.834
Madhya Pradesh	CIPP1	37	16	0.305	89.9	16.984	37	16	0.518	60.64	26.311
	CIPP2	37	7	0.53	52.035	11.763	37	7	0.93	33.738	10.121
	CIPP3	37	6	0.729	37.876	8.087	37	6	1.215	25.819	6.68
	CIPP4	37	14	1.008	27.651	10.558	37	14	1.586	19.786	8.102
	CIPP5	37	6	1.189	23.218	1.036	37	6	1.787	17.558	0.521

TABLE 3. STATE-WISE AVERAGE AND CV OF SYSTEMATIC YIELD RISK BY CROP INSURANCE PROGRAMMES

		Rice					Wheat				
State (1)	Time period (2)	Districts (3)	Years (4)	Average (5)	SSR (6)	TSR (7)	Districts (8)	Years (9)	Average (10)	SSR (11)	TSR (12)
Maharashra	CIPP1	26	16	0.669	61.891	9.983	23	16	0.236	68.605	57.553
	CIPP2	26	7	0.893	45.969	6.987	23	7	0.651	24.877	14.403
	CIPP3	26	6	1.091	37.617	5.4	22	6	0.938	17.669	8.656
	CIPP4	26	14	1.373	29.815	7.733	23	14	1.304	12.538	9.842
	CIPP5	24	6	1.543	26.391	1.083	23	7	1.507	10.765	0.575
Orissa	CIPP1	13	16	0.629	19.022	8.826	13	16	0.728	20.1	18.91
	CIPP2	13	7	0.855	13.983	7.293	13	7	1.141	12.699	8.248
	CIPP3	13	6	1.054	11.352	5.592	13	6	1.427	10.16	5.691
	CIPP4	13	11	1.32	9.06	8.155	13	11	1.775	8.167	7.528
	CIPP5	13	7	1.515	7.895	0.782	13	7	1.998	7.244	0.649
Punjab	CIPP1	11	16	2.112	12.035	2.829	11	16	2.184	13.108	5.76
	CIPP2	11	7	2.333	10.735	2.674	11	7	2.586	11.399	3.639
	CIPP3	11	6	2.531	9.894	2.328	11	6	2.872	10.267	2.827
	CIPP4	11	14	2.816	8.894	3.679	11	14	3.242	9.094	3.963
	CIPP5	11	7	2.993	8.369	0.396	11	7	3.443	8.563	0.248
Rajasthan	CIPP1	16	16	0.611	51.259	9.417	26	16	1	24.223	13.503
	CIPP2	17	7	0.838	35.952	7.207	26	7	1.424	16.851	6.58
	CIPP3	17	6	1.026	29.437	5.711	26	6	1.708	14.059	4.753
	CIPP4	17	12	1.288	23.379	7.533	26	12	2.055	11.685	5.981
	CIPP5	17	7	1.481	20.379	0.867	26	7	2.278	10.541	0.421

TABLE 4. STATE-WISE AVERAGE AND CV OF SYSTEMATIC YIELD RISK BY CROP INSURANCE PROGRAMMES

		Rice					Wheat				
State (1)	Time period (2)	Districts (3)	Years (4)	Average (5)	SSR (6)	TSR (7)	Districts (8)	Years (9)	Average (10)	SSR (11)	TSR (12)
Tamil Nadu	CIPP1	11	16	1.901	23.099	2.919					
	CIPP2	11	7	2.128	20.639	2.932					
	CIPP3	11	6	2.326	18.88	2.533					
	CIPP4	11	13	2.6	16.893	3.81					
	CIPP5	11	7	2.788	15.755	0.425					
Uttar Pradesh	CIPP1	46	16	0.817	28.655	6.792	46	16	1.082	26.09	12.566
	CIPP2	46	7	1.044	22.434	5.977	46	7	1.499	18.846	6.282
	CIPP3	46	6	1.242	18.853	4.744	46	6	1.784	15.832	4.551
	CIPP4	46	12	1.504	15.567	6.25	46	14	2.154	13.109	5.964
	CIPP5	46	5	1.7	13.777	0.719	46	5	2.355	11.989	0.307
Uttaranchal	CIPP1	2	16	1.254	35.098	4.427	2	16	0.889	41.527	15.305
	CIPP2	2	7	1.48	29.725	4.215	2	7	1.305	28.285	7.214
	CIPP3	7	6	1.212	31.481	4.862	7	6	1.088	35.112	7.46
	CIPP4	7	12	1.474	25.882	6.378	7	14	1.459	26.193	8.808
	CIPP5										
West Bengal	CIPP1	15	16	1.101	23.008	5.043	15	16	0.884	15.19	15.354
	CIPP2	15	7	1.327	19.08	4.7	15	7	1.299	10.346	7.245
	CIPP3	15	6	1.526	16.601	3.863	15	6	1.584	8.483	5.123
	CIPP4	15	34	1.799	14.076	5.506	15	13	1.942	6.922	6.363
	CIPP5	15	7	1.987	12.746	0.596	15	7	2.156	6.234	0.395

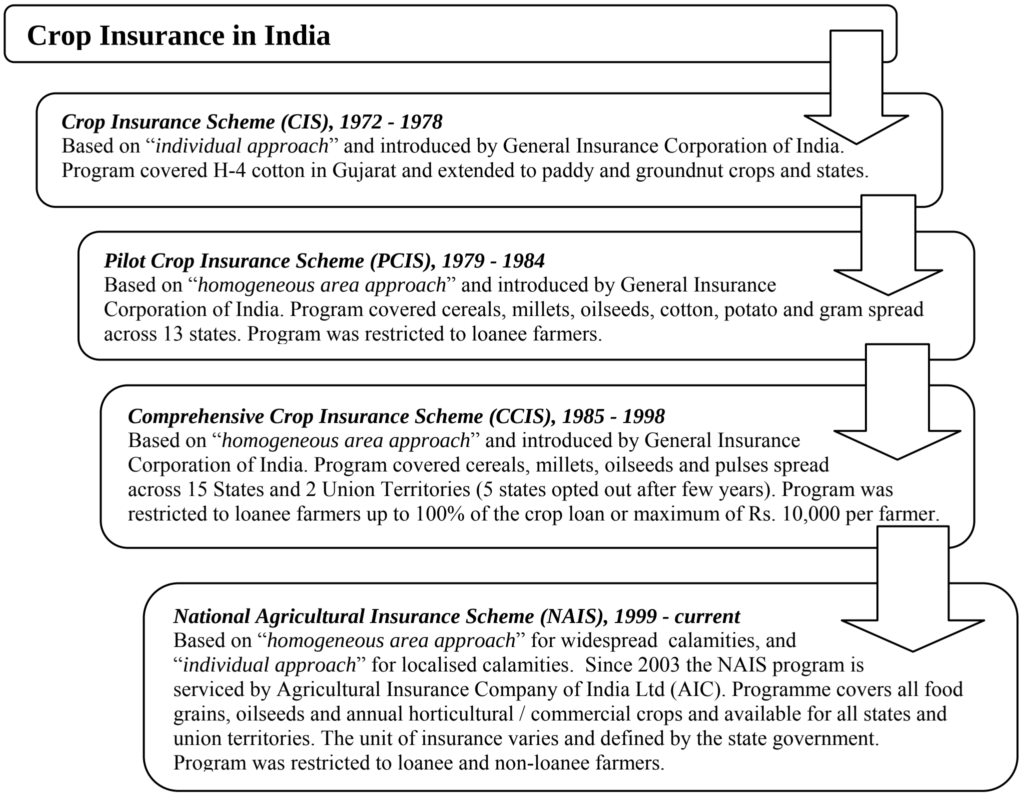

Figure 2. Evolution of Crop Insurance Programmes in India

5.1 *Rice*

The average systematic component of crop yields for Andhra Pradesh, Haryana, Karnataka, Punjab, Tamil Nadu and West Bengal were higher than all India average for all the five CIPP's. This suggests, the farmers in the above six states have realised higher crop yields per acre during each of the five-crop insurance programme periods by utilising the available technology. However, crop yields could be increasing at an increasing or decreasing rate, decreasing at a decreasing rate or must have reached a plateau. Further, at this stage there is no way of differentiating the increase or decrease to difference in farm size groups within each district due to the lack of historical data.

The average systematic component is lower in Bihar, Chhattisgarh, Gujarat, Jharkhand, Madhya Pradesh, Maharashtra, Orissa, Rajasthan and Uttar Pradesh compared to all India average. It is possible that farmers in these states have declining yield per acre due to the lack of irrigated water and are faced with inclement weather. Second, it could also mean there is lack of emphasis by the government to push additional new crop insurance policies specifically catering to the needs and prevailing conditions of the farmers in these states. With the five year plans and the associated policies in the plans including crop insurance programmes, the strategy of the Indian government was, is and will be to address the needs of major producing states and larger producing farmers. The only exception was Uttaranchal, with the average systematic yield component higher than all India average during the pre-crop insurance and CIS program period. What does it mean if the average systematic yield is increasing? This suggests the technological innovations during each of the crop insurance programme periods have increased the average yield per acre across all the districts in each state.

Next, the results of the systematic component of yield risk decomposed into SSR and TSR is discussed. In all the 16 states, the SSR of rice yield decreased starting from pre-crop insurance period to the present NAIS programme period. This is an indication that the differences in the systematic variation or risk of rice yields between districts within each state is declining as reflected by SSR. A comparison across states reveals that Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan, and Uttaranchal had higher SSR of rice yield compared to all India. This indicates an increased risk in rice crop yields across districts in each of the above 6 states. This could be due to low and high yield producing districts along with the presence of small, medium and large farmers in each state or farmers are facing increased risk due to natural disasters. For the remaining states, the SSR of rice yield was lower than for all India. The only exception was Tamil Nadu, with higher average SSR than the all India average during the pre-crop insurance, CIS and PCIS periods, while realised lower average SSR than all India average during the CCIS and NAIS periods.

Similarly, TSR of rice yield declined from the pre-crop insurance period to the CPIS programme period in all the 16 states with an exception. During the CCIS programme period, the TSR of rice yield actually increased compared to the earlier programme period. However, the TSR was less than 1 per cent during the present NAIS programme period. The TSR of rice yields in Andhra Pradesh, Haryana, Karnataka, Punjab, Tamil Nadu, Uttar Pradesh and West Bengal had lower TSR of rice yield compared to all India. This is an indication that the average variation over time is declining due to the technology becoming more homogenous as well as adoption of technological innovations, lowering the risks faced by the farmers in these states. The remaining states had higher or mixed results over the different crop insurance programme periods.

5.2 *Wheat*

Next for the wheat crop, the average systematic yield component was higher in Gujarat, Haryana, Punjab, Rajasthan, Uttar Pradesh and West Bengal compared to all India average. Once again this suggests the emphasis of the Indian government towards the needs of major producing states and associated larger producing farmers.

It was lower in the remaining states with the exception of Uttaranchal where the average systematic yield component was lower than the all India average during the PCIS, CCIS and NAIS programme periods. During the pre-crop insurance and CIS periods, the average systematic component of yield was higher than all India average.

In all the 15 states, the SSR of wheat yield indicated a declining trend starting from pre-crop insurance period to the present NAIS programme period. This is an indication that the difference in the systematic yield risk of wheat yield between districts within each state is declining. A comparison across states reveals Karnataka and Madhya Pradesh had higher SSR of wheat yield compared to all India. This indicates the variation in wheat crop yields across districts in these states is high. Bihar, Haryana, Jharkhand, Orissa, Punjab, Rajasthan and West Bengal, the SSR of wheat yield was lower than all India. In the remaining states of Andhra Pradesh and Chhattisgarh the SSR of wheat yields was higher than all India average during the pre-crop insurance, CIS and PCIS programme period, while it was lower during the CCIS and NAIS periods. In Gujarat, the SSR of wheat yields was higher than the all India average during all the periods with the exception of pre-crop insurance programme period. In Maharashtra, the SSR of wheat yields was lower than all India average during the CCIS programme period. In Uttaranchal, the SSR of wheat yields was higher than all India average during the CIS, PCIS, and CCIS programme periods and lower in the remaining two periods.

Similarly, the TSR of wheat yield declined from the pre-crop insurance period to the CPIS programme period in all the 15 states with an exception during the CCIS programme period. The TSR of wheat yield actually increased compared to the earlier programme period. The TSR of wheat yield was less than 1 per cent during the present NAIS programme period. With respect to the TSR of wheat yields, it was lower in Andhra Pradesh, Haryana, Karnataka, Punjab, Tamil Nadu, Uttar Pradesh and West Bengal compared to all India.

Overall, the average systematic component of rice and wheat yield has increased for all the states. This suggests that crop yields per acre are at least increasing with technological changes over time. However, the spatial systematic component of rice and wheat yields per acre is declining across districts in most of the states with few exceptions. Similarly the temporal systematic component of rice and wheat yields per acre is declining over time in most of the districts of each state with few exceptions.

VI

SUMMARY AND CONCLUSIONS

The study research examines the changes in the average systematic component of crop yields, spatial and temporal systematic component of yield variation or risk for rice and wheat. The ASC, SSR and STR changes are estimated by five-crop insurance programme periods using district level data from 16 major rice and wheat growing states in India for the period, 1956-2006. Second, the HLM statistical procedure is used in the estimation of the systematic component of crop yields as it accounts for hierarchical or nest structure of the spatial random variation across districts within state and across states within India.

To summarise, first the average systematic component has increased with each crop insurance programme period over time for rice and wheat yield during the period, 1956-2006. The lowest was during the pre-crop insurance programme period and highest during the NAIS programme period. Second the spatial systematic risk was highest during the pre-crop insurance programme period followed by the CIS, PCIS, CCIS and NAIS programme periods for both rice and wheat crop yields. In contrast, the temporal systematic risk was the highest during the pre-crop insurance programme period followed by CIS and PCIS. During the CCIS, the temporal systematic risk was higher than PCIS. However, the temporal systematic risk was the lowest during the NAIS program period for both rice and wheat crop yields. A comparison across states revealed that the spatial and temporal risk was higher for lower acreage states (fringe production regions) compared to higher acreage states (core production regions).

Future research needs to examine the importance of changes in the climate variables on systematic and random yield risk. Second, there needs to be a comparison of the changes in systematic and random yield risk due to changes in liability, premium and indemnity payments.

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NOTES

1. It is easy to estimate using nonlinear or spline trends using semi- or non-parametric techniques. However, it is simple, straight forward and logical to estimate linear (increasing), quadratic (increasing and then decreasing or decreasing and then increasing or cubic (did the yield reach a plateau or flat top), unless there is very strong a priori indication of truly a nonlinear or spline trend.

2. The last decade saw a push of weather index insurance policy by domestic policies with the support of the World Bank and private companies to address losses in crop yield due to short term variation or risk. In reality, insurance policies that provide protection due to externalities associated with extreme events like monsoons and drought. This can be identified with measures of kurtosis and skewness of crop yields distributions. Second, there is hardly consistent and significant correlation between climate variables (temperature and precipitation) and yield variation (Shaik, 2012 - unpublished manuscript).

3. The author had contacted Agricultural Insurance Company of India Ltd. to request historical data without much luck. However, this information is provided to World Bank and private companies that are pushing for weather index insurance without good evidence of correlation between climate variables and yield distributions.

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