# Crop diversification and risk: an empirical analysis of Indian states

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# Crop Diversification and Risk: An Empirical Analysis of Indian States

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**Abstract**

The current study explores relationship between the crop diversification and risk in India. Herfindahl Index has been used to analyse the level of crop diversification across the major states over the period of study. An effort has been made to compute yield risk and price risk of each state using the Markowitz's Mean-variance theory and map it with the crop diversification for the corresponding states. Result shows that, while the relationship is positive in the case of crop-diversification and yield risk, we cannot conclude the relationship between crop diversification and price risk.

## 1 Introduction

It is argued that Indian agriculture is diversifying towards high value commodity during the last two decades, and the pace has accelerated during the decade of 1990s (Birthal et al, 2007). But it is worth noting that the contribution of agriculture to Gross Domestic Product (GDP) has fallen from 40% in 1980-81 to 17.8% in 2007-08 and 17.1% in 2008-09. It is also claimed that Indian agriculture has shifted towards specialized cropping pattern increasingly over the last three decades and non-viability of small and marginal holdings have become a major issue (Sen & Raju, 2006). However, 72% of India's population lives in rural areas, and three-fourths of the rural populations depend on agriculture and allied activities for their livelihoods. Furthermore, the agricultural sector is the main source of employment in India, comprising 52.1% of the country's labor force in 2008-09 (Economic Survey, 2008-09).

Under these circumstances, it is interesting to analyze the issue of crop diversification, which is supposed to be the most rational response, given the various risks associated with cultivation. It is important to assess if it has emerged as an apt strategy to counter the emerging challenges associated with cropping practice. This research is an effort made towards answering such questions.

## 2 Literature Review and motivation

Diversification is an integral part of the process of structural transformation of an economy. Diversification in agriculture can mean any of the three situations: (i)A shift from farm to non-farm activities, (ii) A shift from less profitable crop (or enterprise) to more profitable crop (or enterprise), (iii) Using resources in diverse but complementary activities (Vyas, 1996). The first type of diversification is essentially the diversification of the rural economy per se. The second type can be viewed as a farmer's response to relative price signals to adjust to the market conditions. The third type hints towards efficient allocation of resources. The current study is concerned mainly with third type of diversification, where our emphasis is at minimization of risk emanated from the process of cropping. However our study does not look at agricultural diversification as a whole, rather concerned only to the diversification of crop sector, which dominates the agricultural sector.

The broad rationale for crop diversification emanates from the opportunities it offers to reduce production and price risks, increasing yields, natural resource sustainability, maintaining ecological balance, increasing flexibility and sustain productivity and growth. It also creates opportunities for more employment and higher incomes through more efficient use of resources and exploitation of comparative advantage (World Bank, 1990). On a whole, crop diversification is a process, which on one hand helps the grower to improve per capita income and diffuse risk, and on the other hand provides more diversified food items to the consumers. It minimizes the risk associated with production of single crop and helps the farmer to liberate from the poverty trap (Deshpande, et al 2007).

Hence crop diversification can be treated as a risk mitigating strategy under unpredictable circumstances. However, one has to keep in mind that the relative level of diversification across regions within a country will depend upon agro-climatic conditions, resource endowments and infrastructure (Rao et al, 2004).

Crop diversification has been widely studied by scholars in India from different perspectives; however one aspect which seems to be less examined is the assessment of real risk hedge achieved by Indian farmers through adopting the strategy. But diversification which merely increases the return without minimizing risk is 'blind diversification' (Luenburger, 1998).

Motivation of this research is to capture risk associated with the emerging pattern of crop diversification in India. The approach taken to analyse crop diversification in our study is from the standpoint of uncertainty and risk involved when cropping decisions are made. Hence, accounting for the existence of uncertainty and the attitude towards risk, will help in a better comprehension of the cropping decision. This study draws inspiration from several foreign studies which has explored the issue of crop diversification using the 'mean- variance portfolio approach of diversification' developed by Harry M. Markowitz (1952) and extended by Linter (1965) and Sharpe (1970).

The essence of the theory lies in the fact that, as a general rule, the variance of the return of a portfolio can be reduced by including additional assets. 'Portfolio' is defined simply as a combination of items: securities, assets, or other objects of interest. Portfolio theory is used to derive efficient outcomes, through identification of a set of actions, or choices, that minimize variance for a given level of expected returns, or maximize expected returns, given a level of variance. Decision makers can then use the efficient outcomes to find expected utility-maximizing solutions to a broad class of problems in investment, finance, and resource allocation (Robison and Brake, 1979). Simply stated, portfolio theory although developed in context of financial assets, but the concept can be borrowed in a wide variety of settings and choice made under uncertainty and associated with risk, even in case of crop selection.

The application of portfolio theory for conceptualizing crop selection decision is well demonstrated by Barkley and Peterson (2008), while working on selection of wheat variety for Kansas. Other studies which have demonstrated the use of these theories for crop selection are:

Study by Toledo T. and Engler P. (2008) analyzing the risk preferences of small producers of raspberries and the production function associated with their production system in the Bio-Bio region of Chile, is also based on this theory; Gemech et al (2009), for analyzing the extent of benefit for producers of coffee to manage the price risk by hedging in the market, leading to efficient allocation of resources in the production of coffee; and by Akca and Sayili (2005), for to analyzing yield, price and income variability of wheat production in Turkey.

## 3 Theoretical Framework

By accounting for the existence of uncertainty and the attitudes towards uncertainty, all agricultural decisions can be better understood. Since uncertainty incurs risk implicitly, so to assess uncertainty we need to have a measure of risk. When measuring risk, it is important to assess the variability of an uncertain event in relation to its expected value. Coefficient of variation, which is the ratio of the standard deviation to mean, gives a convenient unit free measure of the relationship between the variability of the returns and the expected return. Calculation of coefficient of variation for different crops, tells the farmer something about relative amount of uncertainty associated with each crop.

The relationship between two uncertain events is also an important concept. When a farmer grows a single variety of crop or a combination of different varieties, he does not know for sure what will be the yield or the price of these crops, when eventually they are marketed. But if they know how these prices and yields of these crops fluctuate in relation to one another, it can help their decision making about which crops to grow. Correlation is a measure of association between two events. It ranges in value from -1 to +1. A negative (positive) value implies that fluctuations of the two uncertain variables tend to be in the opposite (same) direction. A zero correlation implies no systematic relationship exists between the fluctuations of two uncertain variables. Thus, if the price or yield of two crops moves in same direction their correlation is positive, if in opposite direction, correlation is negative. However if the price or yield of those two crops are independent, then their correlation should be zero (Penson et el, 1986).

Now using Markowitz's model, we formulate the theoretical foundation of risk and diversification in context of cropping as follows. Suppose a farmer has n crops and $\alpha_i$, the share of each crop 'i' in the farm. Now, we define $\mu_i$ as the mean price of crop i, then the total return for the farmer will be weighted average of price, equal to,

$$\mu = \sum_{i=1}^{n} \alpha_i \mu_i \tag{1}$$

Taking price and yield volatility of the crop as a major concern for risk, we can compute the variance of the farm revenue, which will give us a measure of farm risk ($\sigma$ ) under diversification, as

$$\sigma = \sqrt{\sum_{i=1}^{n} \sum_{j=1}^{n} \alpha_i \alpha_j C_{ij}} \tag{2}$$

Where, $C_{ij}$ is the covariance between the price movements of crop i and j. Now let us consider a simplistic case of only 2 crops. Then,

$$\mu = \alpha_1 \mu_1 + \alpha_2 \mu_2 \tag{3}$$

and

$$\sigma = \sqrt{\alpha_1^2 \sigma_1^2 + 2\alpha_1 \alpha_2 \sigma_1 \sigma_2 r_{12} + \alpha_2^2 \sigma_2^2} \tag{4}$$

where $\sigma_1$ and $\sigma_2$ is the market risk of crops 1 and 2. And $r_{12}$ is the correlation coefficient between the prices of the two crops. $\mu$ is the rate of profit of the farm under the two crops and $\sigma$ is the risk under diversification [1]

This provides as an interesting tool to examine risks under different crop-mix scenarios. For example if the prices of two crops have high positive correlation of $r_{12} = 1$, then:

$$\sigma = \sqrt{\alpha_1^2 \sigma_1^2 + 2\alpha_1 \alpha_2 \sigma_1 \sigma_2 + \alpha_2^2 \sigma_2^2} \tag{5}$$

$$\sigma = \sqrt{[(\alpha_1 \sigma_1) + (\alpha_2 \sigma_2)]^2} = \alpha_1 \sigma_1 + \alpha_2 \sigma_2 \tag{6}$$

This implies that, if there is high positive correlation with the prices of two crops, risk increases linearly with the size of the two crops.

[1] $\sigma$ is computed using the theory of 'variance of sum'.Which is:
$var(x+y) = E[(x-\overline{x}) + (y-\overline{y})]^2$
$= E(x-\overline{x})^2 + 2E[(x-\overline{x})(y-\overline{y})] + E(y-\overline{y})^2$
$= \sigma_x^2 + 2\sigma_{xy} + \sigma_y^2$
With weights $w_1$ and $w_2$
$w_1^2 \sigma_x^2 + 2w_1 w_2 \sigma_{xy} + w_2 \sigma_y^2$

Now, let us consider the case where $r_{12} = -1$. Then

$$\sigma = |(\alpha_1 \sigma_1) - (\alpha_2 \sigma_2)| \tag{7}$$

It can be shown that $\sigma$ can be zero under the condition that

$$\alpha_1 = \frac{\sigma_2}{(\sigma_1 + \sigma_2)} \tag{8}$$

That is any market price risk can be totally eliminated if the weights of the two crops in the basket is assigned by $\alpha_1 = \sigma_2/(\sigma_1 + \sigma_2)$ and $\alpha_2 = 1 - \alpha_1$

The 2-crop case given above and be easily extended to n commodities. Similarly,in place of a farmer we can think of region as a whole, since household level data on diversification is not available. This provides us with a framework to examine the level of diversification. However we have to be cautious while applying this framework in the case of crop selection, for the precise reason that agricultural market is not as simple as financial market where price determined by laws of demand and there exist free mobility of capital. The decision by a farmer depends on multiple factors, apart from prices, and also due to the fact that farmers as an economic agent are a much more diverse and heterogeneous group compared to standard agents in the financial markets. The most important factor that we must take into account is the fact that agriculture is not organized strictly on capitalist principles in developing countries in Asia, including India. The fact that the farmer is the owner of means of production and the supplier of labour at the same point of time makes him distinctly different from the economic agents, operating in financial markets, whose behavior are sought to be explained by the portfolio theory.

There are also several factors which determines pattern of diversification. First and the most important of such factors is the market. Apart from price responses equally important are market infrastructure and the institutional arrangements. Transport, communication facilities, delivery system of input and credit play important role in cropping decisions of agricultural producers. The agronomic conditions and technology availability are the other two important factors which conditions crop diversification. Soil, water availability, geographical features (e.g. altitudes, slope, drainage characteristics, etc.) and climatic factors (e.g. distribution of rainfall, humidity, maximum temperature, etc.) has to be taken as 'given' while making the production decisions. However introduction of appropriate technology in some circumstances can modify these conditions and hence can influence cropping pattern. The most important technology change which exerts remarkable impact on cropping pattern is irrigation. The other factor which influences the nature of cropping pattern and the extent of diversity are the public interventions. Food security being one of the major concerns for policy makers, a whole set of policy interventions (e.g. price policy, credit policy, etc.) are directed to favour the production of foodgrain to achieve self sufficiency in terms of food availability. As a result the non-cereal agricultural crops are discriminated, which limits the scope of diversification (Vyas, 1996).

However, financial portfolio theory provides some useful concepts which can be used to examine whether the ex post crop selection decisions have been effective in minimizing risk in agriculture for Indian states.

# 4 Data and Methodology

We explore the period 1995-96 to 2006-07 for 14 major states in India and 31 principal crops. The data on area under principal crops, yield and farm harvest prices was sourced from various issues of *The Statistical Abstract of India* and *The Production of Principal Crops in India*. Crop-wise gross irrigation data was available from the *Statistical abstract of India* and procurement data from *Ministry of food and public distribution*.

As a first step, the study analyzed the scenario of crop diversification in India using Herfindahl Index.The Herfindahl Index (HI) can be defined as following:

$$H = \sum_{i=1}^{n} p_i^2 \tag{9}$$

Where, $p_i$ is share of each crop defined as,

$$p_i = \frac{A_i}{\sum_{i=1}^{n} A_i} \tag{10}$$

Here, $A_i$ is acreage area under each crop; $\sum_{i=1}^{n} A_i$ is total acreage area and the value of H ranges from 0 to 1. While, unity implies complete specialization, zero implies high diversification. Hence as Herfindahl Increases, diversification in a particular region increases and as HI decreases, diversification in that region increases.

We compute portfolio risk $\sigma$ (in terms of price and yield), using the crop acreage and correlation among these crops as same as in equation 2.

**Objectives:** The main objectives of this study can be summarized as:

1. To identify major states in India which are showing high crop diversification,
2. To develop a measure to capture risk incurred due to diversification,
3. To examine whether crop diversification has helped in minimizing risk incurred due to cropping.

Usage of secondary data restricts our study to only macro level. Acknowledging the above the role of multiple factors in crop cultivation, the scope of our study is limited only to analyzing the ex-post risk associated with variations in yield and price in case of cropping. This restricts us from understanding the decision making of individual farmers, which could have been delved into through a primary survey of households which collects data on all crucial aspects of cultivation and the associated decisions. Also, being a state level study, the discrepancies among the regions in a state arising out of geographical and climatic conditions also could not be captured.

However the motivation of the study is to demonstrate the application of Markowitz's model in agriculture so as to arrive at a measure of risk, which will help in understanding the efficiency of diversification at the state level in India.

# 5 Results and Interpretation

We found that, Karnataka, Maharashtra and Andhra Pradesh, and West Bengal are the states which show high level of dynamism with respect to crop diversification. This is because; these states are showing decrease in Herfindahl Index over the period of time. Gujarat, Rajasthan and Madhya Pradesh are also some other states showing comparatively low HI, however looking at the change we find the HI in these states are increasing over the years. Orissa, Kerala, Punjab and Haryana are some of the states having high HI and also less variation in HI over the years (see Table 1 and 2).

While analyzing the cropping pattern in details of the selected states we found in all the four states there is a tendency to move towards wheat and

Table 1: Herfindahl Index of Major States in India (1995-96 to 2006-07)

| **States** | **1995-96** | **1996-97** | **1997-98** | **1998-99** | **1999-00** | **2000-01** | |
|---|---|---|---|---|---|---|---|
| Kar | 0.104 | 0.098 | 0.098 | 0.097 | 0.108 | 0.092 | |
| Guj | 0.117 | 0.110 | 0.116 | 0.123 | 0.126 | 0.131 | |
| Mah | 0.156 | 0.155 | 0.158 | 0.143 | 0.147 | 0.147 | |
| MP | 0.148 | 0.157 | 0.158 | 0.157 | 0.165 | 0.162 | |
| Raj | 0.153 | 0.155 | 0.152 | 0.146 | 0.157 | 0.175 | |
| AP | 0.168 | 0.179 | 0.175 | 0.185 | 0.196 | 0.181 | |
| TN | 0.194 | 0.195 | 0.186 | 0.183 | 0.201 | 0.172 | |
| UP | 0.203 | 0.205 | 0.210 | 0.212 | 0.228 | 0.223 | |
| Har | 0.202 | 0.202 | 0.206 | 0.217 | 0.253 | 0.250 | |
| Ker | 0.276 | 0.249 | 0.288 | 0.364 | 0.321 | 0.381 | |
| Bih | 0.334 | 0.329 | 0.333 | 0.340 | 0.347 | 0.346 | |
| Pun | 0.345 | 0.337 | 0.351 | 0.371 | 0.388 | 0.382 | |
| WB | 0.552 | 0.527 | 0.538 | 0.533 | 0.591 | 0.477 | |
| Ori | 0.408 | 0.455 | 0.570 | 0.652 | 0.647 | 0.620 | |
| **States** | **2001-02** | **2002-03** | **2003-04** | **2004-05** | **2005-06** | **2006-07** | **Mean** |
| Kar | 0.102 | 0.108 | 0.091 | 0.090 | 0.089 | 0.089 | 0.097 |
| Guj | 0.131 | 0.140 | 0.121 | 0.127 | 0.122 | 0.124 | 0.124 |
| Mah | 0.155 | 0.146 | 0.142 | 0.147 | 0.141 | 0.128 | 0.147 |
| MP | 0.166 | 0.170 | 0.162 | 0.162 | 0.161 | 0.164 | 0.161 |
| Raj | 0.175 | 0.159 | 0.185 | 0.165 | 0.168 | 0.168 | 0.163 |
| AP | 0.185 | 0.153 | 0.138 | 0.146 | 0.175 | 0.180 | 0.172 |
| TN | 0.208 | 0.220 | 0.144 | 0.185 | 0.200 | 0.203 | 0.191 |
| UP | 0.225 | 0.238 | 0.225 | 0.226 | 0.228 | 0.225 | 0.221 |
| Har | 0.237 | 0.245 | 0.236 | 0.235 | 0.234 | 0.247 | 0.230 |
| Ker | 0.282 | 0.285 | 0.265 | 0.276 | 0.269 | 0.415 | 0.306 |
| Bih | 0.348 | 0.331 | 0.329 | 0.315 | 0.326 | 0.332 | 0.334 |
| Pun | 0.368 | 0.380 | 0.386 | 0.386 | 0.384 | 0.378 | 0.371 |
| WB | 0.535 | 0.531 | 0.495 | 0.501 | 0.505 | 0.495 | 0.523 |
| Ori | 0.635 | 0.665 | 0.601 | 0.607 | 0.577 | 0.583 | 0.585 |

Table 2: Level and change in Herfindahl Index for the States

| **States** | **Mean** | **Change** |
|---|---|---|
| Maharashtra | 0.147 | -1.22 |
| Karnataka | 0.097 | -1.20 |
| andhra pradesh | 0.172 | -1.00 |
| West Bengal | 0.523 | -0.92 |
| Bihar | 0.334 | -0.30 |
| Tamil Nadu | 0.191 | -0.03 |
| Madhya Pradesh | 0.161 | 0.62 |
| Gujarat | 0.124 | 0.87 |
| Kerala | 0.306 | 0.92 |
| Punjab | 0.371 | 1.03 |
| Uttar Pradesh | 0.221 | 1.07 |
| Rajasthan | 0.163 | 1.24 |
| Haryana | 0.230 | 1.66 |
| Orissa | 0.585 | 2.19 |

rice which are less uncertain crops, as the share of these crops are increasing in all of these states. However a trend to move towards cash crop is also becoming dominant among the highly diversified states. Also in case of the three above mentioned states, except West Bengal there is also a tendency to move towards pulses, sugarcane, maize and cotton, Jowar, which are cash crops in nature. West Bengal still have very high share of rice, which points towards assured irrigation facilities (see Table 3). However such claim needs to be probed further through a micro level analysis, which is beyond the scope of the present study.

Next, we explore the relationship between crop diversification and risk. We start with identifying the major crops of each state. We compute the price risk and yield risk for each state in the year 2005-06, using the formula of portfolio variance. We have computed the weighted average (mean) of farm harvest prices, its SD which we consider as portfolio risk . We also compute CV, which gives a unit free measure of risk showing the relationship between variability of price/yield and expected price/yield (mean). The result shows that, emerged cropping pattern in the state of Gujarat, Maharashtra and Orissa has incurred high yield risk, while high price risk is seen in the case of Tamil Nadu and Kerala (see table 4 and 5). To draw a

Table 3: Major crops of the states

| **States** | **Major Crops** |
|---|---|
| Mah | Rice, Jowar, Maize, Tur, Gram, other pulses, groundnut, cotton, Sugarcane, Wheat , Bajra |
| Kar | Rice, Jowar, Maize, Ragi, Tur, Gram, other pulses, groundnut, cotton, Coconut, Sugarcane, Wheat , Bajra |
| AP | Rice, Jowar, Maize, Tur, Gram, other pulses, groundnut, cotton, sesame, chilies, Sugarcane, Tobacco. |
| WB | Rice, wheat, jute, Rapeseed & mustard, potato, other pulses, sesame |
| Bih | Rice, Wheat, Other pulses maize ,Potato, Sugarcane, Rapeseed & Mustard |
| TN | Rice, Sugarcane, Other pulses, Jowar, coconut, Maize, Bajra, Tur, Banana, Ragi, Sesame, Groundnut, cotton |
| MP | Rice, Wheat, Other pulses, Gram, Maize, Jowar, Rapeseed & Mustard, Small millets, Cotton, Linseed |
| Guj | Groundnut, Cotton, Bajra, Rice, Wheat, Castor seed, Tur, Maize, Other Pulses, Rapeseed & Mustard, Jowar, sesame, gram |
| Ker | Coconut, Rice, Natural Rubber, Black Pepper, Banana, Coffee |
| Pun | Wheat, Rice, Cotton, Maize |
| UP | Wheat, Rice, Sugarcane, Other pulses, Gram, Maize, Bajra, Tur, Potato, Barley, Rapeseed & Mustard |
| Raj | Wheat, Other pulses, Gram, Maize, Bajra, Rapeseed & Mustard, Cotton |
| Har | Wheat, Rice, Sugarcane, Cotton, Gram, Bajra, Rapeseed & Mustard |
| Ori | Other pulses, Rice, Groundnut, Maize, Chilies, Ragi, Tur |

Table 4: Mean, SD and CV of Farm harvest prices of Principal crops in the selected states

| STATES | MEAN | SD | CV |
|---|---|---|---|
| Andhra Pradesh | 1038.04 | 225.13 | 21.69 |
| Bihar | 461.92 | 86.98 | 18.83 |
| Gujarat | 1232.44 | 227.71 | 18.48 |
| Haryana | 907.67 | 237.17 | 26.13 |
| Karnataka | 914.53 | 190.62 | 20.84 |
| Kerala | 2728.38 | 2051.22 | 75.18 |
| Madhya Pradesh | 920.85 | 256.56 | 27.86 |
| Maharashtra | 929.73 | 301.58 | 32.44 |
| Orissa | 430.93 | 103.96 | 24.12 |
| Punjab | 680.67 | 256.79 | 37.73 |
| Rajasthan | 945.19 | 270.24 | 28.59 |
| Tamil Nadu | 664.05 | 1027.95 | 154.8 |
| Uttar Pradesh | 617.48 | 183.55 | 29.72 |
| West Bengal | 570.77 | 162.11 | 28.4 |

relationship between HI and risk, we compare CV (for both price and yield) and HI. The comparison is demostrated through graph 1 and 2.

Computing price risk for all the states, we see that Gujarat, Bihar, Karnataka and Andhra Pradesh have the lowest CV of price for their portfolio of crops, while Kerala and Tamil Nadu are the states with very high CV. Haryana, Madhya Pradesh, Maharashtra, Punjab, Rajasthan, Uttar Pradesh, West Bengal, Orissa are the states with moderate CV of price. Interestingly, out of four states with low price risk, namely Andhra Pradesh, Gujarat and Karnataka are also the states having comparatively low HI, implying high crop diversification. In case of Kerala the state is not only having high price risk, but also exhibits high Herfindahl Index implying low crop diversification, while Tamil Nadu having highest price risk, exhibits moderately low HI. Although the above facts hint towards a negative relationship between price risk and crop diversification, however it is difficult to generalize. In case of Bihar, although it has low crop diversification however the price risk is also low and also in case of Madhya Pradesh and Maharashtra although the crop diversification is relatively high but it does not show low price risk. Hence With regard to price-risk, we cannot generalize on whether diversifi-

Table 5: Mean, SD and CV of yield of Principal crops in the selected states

| STATES | MEAN | SD | CV |
|---:|---:|---:|---:|
| Andhra Pradesh | 33.54 | 6.17 | 18.4 |
| Bihar | 21.26 | 4.01 | 18.86 |
| Gujarat | 11.41 | 5.39 | 47.27 |
| Haryana | 37.66 | 4.95 | 13.13 |
| Karnataka | 36.25 | 9.58 | 26.43 |
| Kerala | 37.07 | 5.34 | 14.42 |
| Maharashtra | 32.82 | 13.52 | 41.2 |
| MP | 11.12 | 3.2 | 28.76 |
| Orissa | 13 | 6.11 | 47 |
| Punjab | 35.68 | 4.39 | 12.31 |
| Rajasthan | 10.19 | 3.53 | 34.64 |
| Tamil Nadu | 114.58 | 14.38 | 12.55 |
| Uttar Pradesh | 84.07 | 7.76 | 9.23 |
| West Bengal | 32.14 | 4.94 | 15.37 |

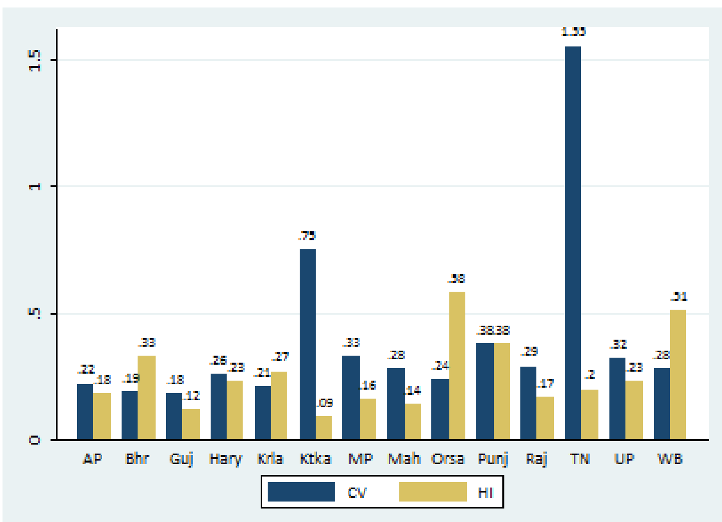


Figure 1: Diversification and Price risk

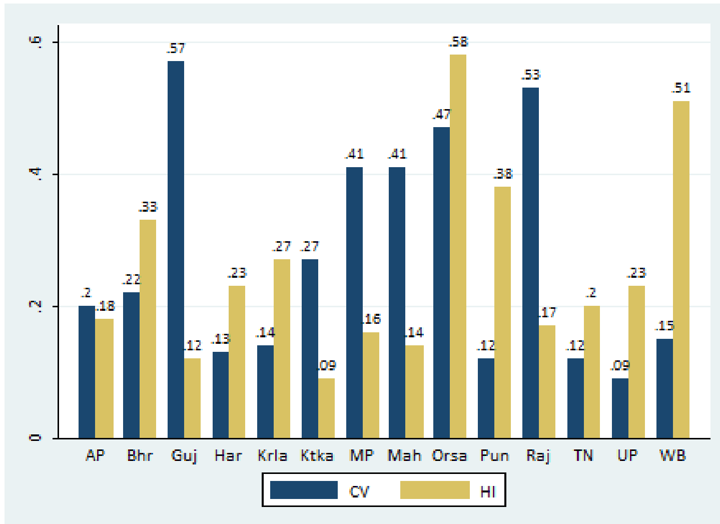


Figure 2: Diversification and yield risk

cation leads to price risk or not. Such generalization tends to break down for obvious reasons. And that is the role of Procurement of food grain support price mechanism. We know wheat and rice are the crops which are procured by government at high level and this activity helps in bringing down the volatility in prices. Hence states having a portfolio of crops, with high share of wheat and rice will tend to show lower price risk compared to others states having lower share of such prices.

From this discussion we can infer that, it is not the level of diversification but the type of diversification that is affecting price-risk. For instance, look at the cropping pattern of Kerala - Rubber, coconut, rice, coffee, etc are the major crops. This shows there is a high share of cash crops, the prices of which are highly integrated with the world markets. This can lead to high volatility of prices as several factors operate in the world markets. In the case of Tamil Nadu, the crops that are contributing to high price risk are Tur, sugarcane and groundnut. These are the crops which exhibit high volatility in prices and do not fall under procurement activity; also Tamil Nadu is one of those states where lower share of rice is procured.

Replacing price with yield to measure portfolio risk, here we explore the relationship between crop diversification and the yield risk of that diversified portfolio. The results are given in table 5 and graph 2.

A quick look at the graph 2 and table 5, gives one the impression that

Table 6: Spearmans Correlation of Yield Risk and Price Risk with Herfindahl Index

| | Correl. | P-value |
|---|---|---|
| Yield Risk | -0.6956** | 0.0083 |
| Price Risk | 0.207 | 0.4776 |

there might be an inverse relationship between Herfindahl index and yield risk. That is yield risk increases with diversification. The states of Rajasthan, Madhya Pradesh, Gujarat, Maharashtra and Karnataka which has high diversification are also the states with high yield risk. Whereas states such as West Bengal, Punjab, Bihar, etc which have low diversification has low yield-risk. An exception to this is Orissa, which has both high Herfindahl Index and high yield risk. The case of Orissa requires a separate exploration and a generalization might not be possible.

Further exploration of result shows that, the relationship between crop diversification and price risk although cannot be generalized due to a low and insignificant correlation. The relationship between crop diversification and yield risk is significantly positive. The computed partial correlation coefficient shows significant negative correlation between Herfindahl Index and yield risk of -0.6956 and is significant at 5% level.

# 6 Conclusion

From the above results we broadly can conclude that, the crop diversification is increasingly adopted by Indian states, among whom it Maharashtra, Karnataka, Andhra Pradesh are the states showing high level of crop diversification and is also increasing over the time. Crop diversification in India has although occurred in terms of adopting less uncertain crops such as rice and wheat, however significant level of diversification has also been towards cash crops such as cotton, sugarcane etc. However, investigating the relationship between crop diversification and cropping risks (yield as well as price), we find that the diversification in Indian states have not been able to reduce yield risk and hence cannot be termed *efficient* in nature.

However our study is not without limitations. Most importantly, diversification and risk hedging is a strategy that happens at the farm level. But, our analysis is at a macro level. Our measures do not capture what happens to the farmer, but examines only what are the macro level trends in diversification and overall risk for crop cultivation. At the same time our analysis helps in pointing out which crops are risky and which are not. So an extension of this study would be to look at farm level data to see how farmers devise risk hedging strategies to protect their livelihoods. A major issue with this study is that, we take a strict neo-classical approach to the whole problem. The mean-variance approach is built on strict assumptions such as efficiency of the financial market, free mobility of capital and information etc. In an agricultural economy these assumptions easily break-down. But, our analysis is not aimed at dictating what is best. Instead, the approach has been one to explore the association between diversification and risk, under certain assumptions. We did not therefore take into consideration the role of institutional factors, availability of irrigation facilities, changing food habits and market demand for crops etc. It is true that the factors which decide which crop to grow will be a function of host of local factors including historical lock-in effect.

However, the point highlighted here is simple. It is to illustrate that: suppose, the crops in a particular un-irrigated region are crops needing large amounts of water and are, therefore, highly monsoon dependent. Given the vagaries of the Indian monsoon, it will be preferable to have a risk hedge with crops which performs well even under less irrigated circumstances. So during a good monsoon the high yielding crop performs and during a lean period not everything will be lost because of the risk-hedge from the arid crop. This is the wisdom from Markowitz, and it is this dimension that we expect to capture through diversification for it to be an effective survival strategy for the farmer. Our study actually enables us to assess, through the applied use of certain tools from the Markowitz model, whether the emerging pattern of crop diversification across states in India has been efficient with regard to prices and yields. From a different lens, the results also points out the extent to which non-price and non-yield factors are responsible for the cropping pattern that has emerged in India in the recent years.

# References

[1] Akca, Hasan and Murat Sayili. (2005). Risk and Uncertainty (Variability) in Wheat Production in Turkey. *Journal of Applied Science*, 5(1): 101-103

[2] Birthal, P.S, P.K. Joshi, and Devesh Roy. (2007). Diversification in Indian Agriculture towards High-Value Crops: The Role of Smallholders. *IFPRI Discussion Paper 00727*, International Food Policy Research Institute, Washington, D.C, U.S.A

[3] Deshpande, R.S., Pradeep Mehta, and khalil Shah. (2007). Crop Diversification and Agricultural Labour in India, *Indian Journal of Labour Economics*, October- December. Vol.50, No.4.

[4] Government of India. (2007) *Annual Report (2006-2007)*. Chapter II, Ministry of Food and Public Distribution. Government of India

[5] Government of India. (Various years). *Farm Harvest Prices of Principal Crops in India*. Directorate of Economics and Statistics, Ministry of Agriculture, New Delhi

[6] Government of India. (Various years). *Statistical Abstract India*. Central Statistical Organisation, Ministry of Statistics & Programme Implementation, New Delhi www.mospi.gov.in

[7] Gemech, Firdu, Sushil Mohan, Alan Reeves, and John Struthers. (2009). Market Based Price-Risk Management: Welfare Gain of Coffee Producers from Efficient Allocation of Resources. Paper presented at DSA conference (March 2009), University of Scotland, Paisley

[8] Linter, J. (1965). Security Prices, Risk, and Maximum Gains from Diversification. *Journal of Finance*, 21:587-615.

[9] Luenberger, David G. (1998). *Investment Science*. Oxford University Press, New York

[10] Markowitz, Harry M. (1952). Portfolio Selection. *The Journal of Finance*. 12:77-91, March

[11] Penson, John, Rulon Pope, and Micheal Cook. (1986). *Introduction to Agricultural Economics*. Prentice Hall, New Jersey

[12] Rao, P. Parthasarathy, P.S. Birthal, P.K. Joshi, and D. Kar. (2004). Agricultural Diversification in India and Role of Urbanization. *MITD discussion paper no.77*, International Food Policy Research Institute, Washington, D.C, U.S.A

[13] Robinson, L.J., and J.R. Brake. (1979). Application of Portfolio Theory to Farmer and Lender Behavior. *American Journal of Agricultural Economics*, (61):158-164, February

[14] Segovia, J.E. Tirindad, S Cruz Rambaud, and C.B. Gracia Gracia. (2005). A Model for Determining Efficient Portfolio Cropping Plans in Organic Farming. *Spanish Journal of Agricultural Research*. 3(2): 159-167

[15] Sen, Suchitra, and Raju Sarawati. (2006). Globalisation and Expanding Markets for Cut-Flowers: Who Benefits?. *Economic and Political Weekly*, 41(26):2725-2731

[16] Sharpe, W. (1970): *Portfolio Theory and Capital Markets*. McGraw-Hill, New York.

[17] Toledo T., Roger, and Alejandra Engler P. (2008). Risk Preferences Estimation For Small Raspberry Producers in The Bo-Bo Region, Chile. *Chilean Journal of Agricultural Research*, April-June, 68:175-182

[18] Vyas, V.S. (1996) Diversification in Agriculture: Concept, Rationale and Approaches. *Indian Journal of Agricultural Economics*, 51(4): 636-643.

[19] World Bank (1990) *Agricultural Diversification and Policies and Issues from East Asian Experiences*. Policy and Research Series, Agriculture and Rural development Department, The World Bank, Washington, D.C