AN ECONOMIC ANALYSIS OF DEMAND AND SUPPLY DYNAMICS OF MAIZE IN INDIA

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CERTIFICATE

This is to certify that the thesis entitled, "**AN ECONOMIC ANALYSIS OF DEMAND AND SUPPLY DYNAMICS OF MAIZE IN INDIA"** submitted in part fulfillment of the requirements for the degree of **DOCTOR OF PHILOSOPHY** in **ECONOMETRICS** to Tamil Nadu Agricultural University, Coimbatore is a record of bonafide research work carried out by **Mrs. R. PANGAYAR SELVI** under my supervision and guidance and that no part of the thesis has been submitted for the award of any other degree, diploma, fellowships or other similar titles or prizes. However, part of the thesis work has been published in peer reviewed scientific journals of National/ International repute.

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(R. Pangayar Selvi)

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LIST OF ABBREVIATIONS

Symbol		Expansion
ADF	:	Augmented Dickey Fuller test
ADL	:	Autoregressive Distributed Lag
AIC	:	Akaike Information Criterion
A_{NLA}	:	Number of Live Animals in India
A_{NLARW}	:	Number of Live Animals in the Rest of the World
ARCH	:	Autoregressive Conditional Heteroscedasticity
ECM	:	Error Correction Mechanism
ER_{INR}	:	Annual Maize Trade Weighted Exchange Rate
FAO	:	Food and Agricultural Organization
FPE	:	Error Final Prediction
FR	:	Feed and Residual
FSI	:	Food Seed and Industrial use
GARCH	:	Generalised Autoregressive Conditional Heteroscedasticity
GDP	:	Gross Domestic Product
HQ	:	The Hannan & Quinn Criterion
M_{CRW}	:	Total Consumption in the Rest of the World
M_{DC}	:	Total Domestic Consumption in India
M_{ES}	:	Ending stocks in India
M_{IE}	:	Indian maize exports
MP	:	Indian Maize Price
M_{RWE}	:	Rest of World Maize Exports
M_{RWES}	:	Ending Stocks in the Rest of the World
OLS	:	Ordinary Least Square
OSP	:	Overall Study Period
PGRP	:	Post Green Revolution Period

PLP	:	Post Liberalization Period
PPP	:	Public Private Partnership
RF	:	Indian Average Annual Rainfall
RPO	:	Indian Population Relative to the Rest of the World Population
SBC	:	Schwartz Bayesian Criterion
SP	:	Sorghum Price
TDC	:	Total Domestic Consumption
USDA	:	United States Department of Agriculture
VECM	:	Vector Error Correction Mechanism

ABSTRACT

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Maize is an important cereal crops in the world. It provides staple food to many races. In developed countries maize is predominantly consumed as second-cycle produce, in the form of meat, eggs and dairy products. However, in a processed form it is also found as fuel (ethanol) and starch. In developing countries maize is a major source of income to farmers among whom many are resource-poor. Maize is very much important to the economy due to its wide range of uses. Considering the economic importance of maize, the study was undertaken with an overall objective to examine the past and present performance of the crop, supply and demand dynamics, export potentials and domestic and international market integration. The specific objectives of the study are: (i) to assess the general trend of maize crop production, consumption as food, feed and industrial manufacturing and exports; (ii) to investigate the supply and demand dynamics and the effect of maize exports; (iii) to measure the degree of price volatility in the domestic markets for maize; and (iv) to estimate the price transmission between international maize markets and domestic markets and also to evaluate the temporal and spatial dimensions of maize crop exports.

To understand the trends in area, production, productivity, domestic consumption, price and export of maize crop growth rates were estimated to three time periods Post Green Revolution (1970-1991), Post Liberalisation (1992-2013) and the overall study period (1970-2013). Considering the area, a large amount of 60.63 per cent increase in area was observed during overall study period compared to other two periods. Also the

fluctuations were 16.16 per cent during overall study period and this was high when compared to other periods. But average area, linear and compound growth rate was high during post liberalisation period. Also the result of harmonic analysis of the area indicates that no significant cyclical fluctuations existed in the maize area during all the three study periods.

During the post green revolution period the increase in productivity of maize crop accounted for only 7.81 per cent, but during post liberalization and overall study period the scenario entirely changed as productivity of maize increased by 46 and 91 per cent respectively. Though the average productivity, linear growth rate and compound growth rate were higher during the post liberalization period the fluctuation in terms of productivity was found to be higher during the overall study period. Also the harmonic analysis shows the existence of seven year cycle during post green revolution period and also a significant ten year cycle for the overall study period were observed at 5 per cent level. No cyclical fluctuation was found for the post liberalization period.

The increase in production of maize during post green revolution period was 7.67 per cent and it was increased to 142.06 and 223.14 per cent during post liberalisation and overall study period. It could also be seen that average production of maize has doubled during the post liberalization period. The coefficient of variation of production was found to be lower during the post green revolution period (17.29 %) when compared to other two periods. It was seen from the linear trends, the output added was higher during post liberalization period and it was about 684.3 thousand tonnes annually. Similarly the compound growth rate was higher during that period. Also from harmonic analysis it was evident that only during the post green revolution period production has a seven year cycle, which lost its significance when aggregated with the post liberalization period.

The Total Domestic Consumption (TDC) here includes consumption of maize for Feed and Residual (FR), and for Food, Seed and Industrial use (FSI). The analyses were done separately on FR and FSI for all the three periods. When compared to FR, FSI and TDC for all the three periods, the increase in consumption of maize for FR was higher during post liberalisation period and found to 241.38 per cent. At the same time the average consumption of maize was comparatively higher in TDC, 13.24 million tonnes during the post liberalization period.

Comparatively fluctuations were found to be lower in the consumption of maize for FSI during all the three periods. The growth rates of consumption of maize for FR, FSI and TDC were significant both in absolute and compound terms during all the three periods. The linear trend during all the three periods was high for TDC. The compound growth rates of consumption for FR, FSI and TDC during the post green revolution period were 10.62, 0.77 and 1.77 per cent per annum respectively. The same trend was also observed during the post liberalization period. The compound growth rate was higher in FSI (9.62 % per annum) during the overall study period. In harmonic analysis during post green revolution period significant seven year cycle was observed and no fluctuations were observed during post liberalization period. But during the overall study period six to seven years and ten year cycles were identified. Considering the domestic price and international price the linear growth rate was high during post liberalization period compared to other periods. Whereas the compound growth rate in domestic price was high during post liberalisation period (7.15 % per annum) and in international price it was high during overall study period (7.77 % per annum).

The results of harmonic analysis for domestic price showed the evidence of seven year cyclical fluctuations during the post green revolution period and no fluctuations during post liberalization and overall study periods. While the prices exhibited cyclical fluctuations, seasonally they were quite stabilized. The seasonal indices were calculated for the monthly average prices of maize in the selected five different domestic markets and the results showed that the price was above average at the time of harvest of *rabi* season and below average at the time of harvest of *kharif* season.

The average stock of maize was high during post liberalization period and it was 488.59 thousand tonnes but the fluctuation was high and unstable during all the three periods. The linear and compound growth rate was high during post liberalisation period than other two periods. The results of harmonic analysis indicated that no significant cyclical fluctuations existed during the post liberalisation and the overall study period but seven year cyclical fluctuation was observed during the post green revolution period.

It could be seen that the average export of maize was 4.402 thousand tonnes during the post green revolution period which increased significantly to 1293.86 and 838.87 thousand tonnes during the post liberalization and overall study period. High fluctuations in growth dimensions were also observed. This trend confirmed that the growth in export was not stable. The linear and compound growth rate of exports during the post green revolution period was negative then increased greater extent in other two periods. The same trend was exhibited in the Indian share of maize exports to the world export and in the rest of the world export. No fluctuations in growth dimensions were observed and the world export was stable. This trend confirmed that the growth in world export was stable. The harmonic analysis indicated that no significant cyclical fluctuations existed in the maize export.

Food problems are among the most important problems facing countries and may affect the political and economic relations between countries. Maize is one of the important goods that human beings depend on for both food and manufacturing and it gains importance as population increases. This study examines the effect of maize export from India. This study investigates the effect of maize exports through an estimation of a system of maize export equation and the results indicates that the intercept was significant at 5 per cent level indicating that the export would be 4327 thousand tonnes while all the variables were kept constant. Also if the ending stock of maize in India and rest of world consumption change by 1000 MT in a given year, Indian maize export would increase by 295.3 MT two year later and 9 MT, other factors held constant. If the number of live animals in India and rest of the world animals changes by 1000 head in a given year, Indian maize export decreases by 10 MT one year later and 2 MT. The Indian consumption, rest of the world maize ending stocks and rest of the world maize exports changes by 1000 MT, Indian maize exports decrease by 141 MT, 7 MT and 5 MT respectively, other factors held constant. Also if the annual maize trade weighted exchange rates increase by one rupee, Indian maize exports decrease by 78.6 thousand MT. If the price of maize and sorghum in India changes by one rupee in a given year, Indian maize export increases by 197 MT one year later and decreases by 199 MT, other factors held constant.

The cointegration analysis was used to test the integration of maize markets. In our study five domestic and two international maize markets were considered. The results of correlation indicate that all the markets were highly correlated and all the markets were highly volatile. The lag length was selected as two using the Akaike Information Criterion (AIC). Having confirmed that the price series were stationary in their first differences using Augmented Dickey-Fuller (ADF) test, cointegration between the markets was tested using Johansen-Juselius maximum likelihood procedure for the presence of short run and long run relationship between the domestic and international maize markets. It was found that Nizamabad and Argentinean maize markets were integrated with other markets each with two cointegrating equations. The existence of cointegration between markets confirms that there was a long run relationship between markets.

Since cointegration tests indicate only the existence of long run relationship among the markets, Granger Causality tests were used to analyse the direction of relationship among different maize market price series. The results revealed that in two cases Chhindwara, Nizamabad and United States, Udumalpet, there exists bidirectional causality. In cases of other markets unidirectional causality of prices was observed.

Accordingly, the VECM results revealed the existence of short and long run disequilibrium. The estimated error coefficients revealed that in Udumalpet market disequilibrium got corrected within a month by changes in its own prices with speed of convergence at 28 per cent in the long run path. But for other markets the speed of convergence ranged from 20 per cent to 57 per cent for short run price movements to become stable along long run equilibrium path in one or two month lagged period. Further the error correction estimates for Argentina market revealed that it was not at all affected by international maize market prices in the long run equilibrium path and it was found to be a separate market. At the same time the short run disequilibria of the Argentinean market with relation to the markets of Nizamabad and Davangere were found significant at two months lag period and the speed of convergence was at 57 and 35 per cent respectively.

As an outcome of the study the suggestions put forth are increasing production through productivity and also parallelly increasing *rabi* production. Further efforts must be taken to establish Exclusive Export Promotion Zones and specialty commodity boards to promote in entire sphere viz., production of value added products for exports, optimal stocks, quality on par with international standards etc. These efforts will pave way for high employment generation and substantial contribution to agricultural GDP and national economy.

Introduction

CHAPTER I

INTRODUCTION

Agriculture is the world's oldest and largest industry. It employs more than one billion people and generates over 1.3 trillion dollars worth of food annually. The world population crossed seven billion in the year 2011, with an average life expectancy of 66.57 years and signals project that it would cross 9 billion by 2025 A.D. With the increase in population in geometric proportions, agricultural productivity is to be maintained on par with it despite rampant diversion of arable lands to non-agricultural uses. It is to be noted that at present 800 million people in the developing countries, or 15 per cent of the total world population, are insecure in their food supplies (FAO, 2013).

Expanding the prospects of agriculture in developing and underdeveloped economies is the prime focus. The probability of increasing agricultural share in the world trade basket is high in these countries. At the same time the problems of food insecurity and that are widely prevalent in these countries blur the prospects. Even in a mixed economy like India, economic insecurity continues to hamper upon the development of agriculture sector.

India is one of the few countries where agricultural dependent population exceeds 58 per cent of the nation’s total population. The country has a vast population of 1.27 billion representing 17.32 per cent of the world's population. But the country shares only 4.2 per cent of world’s water resources and 2.3 per cent of global land. With the population growth rate at 1.58 per cent, India is predicted to have more than 1.53 billion people by the end of 2030 (Census, 2011).

Today agriculture solely supports 58 per cent of the population, as against about 75 per cent at the time of independence. In the same period, the contribution of agriculture and allied sector to the Gross Domestic Product (GDP) has fallen from 61.5 to 12.7 per cent (2013-14). Moreover per capita availability of resources is also about 4 to 6 times less as compared to world average. This is expected to decrease further due to increasing demographic pressure and urbanization spree.

India has recorded impressive achievements in agriculture during three decades since the onset of green revolution in late sixties. This enabled the country to overcome widespread hunger and starvation; achieve self-sufficiency in food; reduce poverty and bring economic transformation to millions of rural families. The situation, however, started turning adverse around mid-nineties, with slowdown in growth rate of output, which then resulted in stagnation or even decline in farmers' income leading to agrarian distress.

Though, at present, 51 per cent of India's geographical area is already under cultivation as compared to 11 per cent of the world average, the present cropping intensity of 136 per cent has registered an increase of only 25 per cent since independence. Further, drylands constitute 65 per cent of the total net sown area. There is also an unprecedented degradation of land to the tune of 107 million ha.

Diminishing marginal returns have already set in the case of groundwater resource and in the rate of growth of total factor productivity. To arrest this deceleration and to double agricultural productivity, a target of 4 per cent growth in agriculture has already been fixed by the successive planning commissions. Thereby agriculture in the 21st century faces multiple challenges: it has to produce more food, fuel and fiber to sustain a burgeoning population.

Maize: The Crop of Future

Demand for cereals, for both food and animal feed is projected to reach about 3000 million tonnes by 2050, up from nearly 2100 million tonnes in 2013-14. Wheat (479 million tonnes) and rice (409 million tonnes) account for the bulk of human consumption of cereals whereas world feed use itself is estimated to absorb 850 million tonnes of cereals in 2013-14. Based on the current projections for world utilization and for a rebuilding of world stocks, the world cereal stocks-to-use ratio is estimated at 22.8 per cent.

Maize is the third most important cereal crop in the world. It gets cultivated in tropics, sub-tropics and temperate regions. More than seventy countries (including 15 developed and 58 developing) produce maize having more than one lakh hectares. Maize enjoys the status as one of the highest yielding among world's major crops of its own nature viz., efficient utilization of radiant energy and fixations of carbon dioxide from the atmosphere. USA is the largest maize producing country whereas both USA and China are the major maize consuming countries. In the world level, China is ranked first and USA ranked second in area of maize with the contribution of 20.19 and 19.73 per cent respectively.

India occupies fifth and seventh position in area and production of maize respectively (Table 1.1). United States of America, China, Brazil, Mexico, Argentina and India together account for 73 per cent of the world maize production. USA is the leading producer of maize with almost 36 per cent of the global production and India contributes around 2 per cent of global production. USA is the largest exporter of maize while India contributes to 3 per cent of global trade. Global maize production for 2013-14 was at 989 million tonnes.

Utilization of Maize

Among all the cereal crops, maize deserves a special place as apart from being traditionally consumed as a food crop now it is being acknowledged as a reliable feed crop and a valuable fuel crop. Maize based cropping systems serve as staple food for consumption in much of sub-Saharan Africa, Central America, the Andean region, and many of poorer parts of Asia. More than 3500 products of daily application are derived from maize. Thereby maize is still consumed as a major staple crop in many parts of the world as the very word maize refers to “one that sustains life”. Maize grains are rich in vitamins A, C and E, carbohydrates, essential minerals, and contain 11.1 per cent protein. They are also rich in dietary fiber and calories which are a good source of energy.

Varieties of maize including sweet corn, dent corn, flint corn, popcorn, flour corn and pod corn are consumed overwhelmingly. As the crop has a nutritional value for both animals and humans, it is basically utilized for three purposes – as food, as feed for animals and as raw material for industry. Livestock producers also tend to favour maize as a base for their animal feed as this protein-rich grain help bring animals to market weight faster. Moreover maize also happens to be cheaper than other feed options as a result of progressive subsidies of the government. About 60 per cent of maize produced in the US is being consumed by livestock sector alone.

Table 1.1:Production, Consumption, Exports and Imports of Maize in Top Ten Countries in the World during 2013-14

SI.No.	Production				Consumption				Exports				Imports			
	Country	Quantity Million Tons	% to total	Rank	Country	Quantity Million Tons	% to total	Rank	Country	Quantity Million Tons	% to total	Rank	Country	Quantity Million Tons	% to total	Rank
1.	United States	354	36	1	United States	295	31	1	United States	51	39	1	European Union	16	13	1
2.	China	218	22	2	China	212	22	2	Brazil	22	17	2	Japan	15	12	2
3.	Brazil	79	8	3	European Union	76	8	3	Ukraine	20	16	3	Mexico	11	9	3
4.	European Union	64	6	4	Brazil	55	6	4	Argentina	13	10	4	Korea, South	10	8	4
5.	Ukraine	31	3	5	Mexico	32	3	5	Russia	4	3	5	Egypt	9	7	5
6.	Argentina	25	3	6	India	20	2	6	India	4	3	6	Iran	6	4	6
7.	India	24	2	7	Japan	15	2	7	European Union	2	2	7	Colombia	5	4	7
8.	Mexico	22	2	8	Egypt	13	1	8	Paraguay	2	2	8	Taiwan	4	4	8
9.	South Africa	15	1	9	Canada	13	1	9	South Africa	2	2	9	Algeria	4	3	9
10.	Canada	14	1	10	Indonesia	12	1	10	Serbia	2	1	10	China	3	3	10
11.	Rest of World	141	14		Rest of World	204	22		Rest of World	7	5		Rest of World	40	32	
	Total	**989**			**Total**	**946**			**Total**	**129**			**Total**	**123**		

Source: USDA, 2014

Several industries like starch, milling, alcoholic beverages, food sweeteners, oil and proteins are based on maize products and byproducts. Recently, there has been interest in using maize for the production of ethanol as a substitute for petroleum based fuels. In addition to this, several cottage industries are also flourishing on the byproducts of maize.

Status of Maize Crop in India

In India maize is cultivated throughout the country and is now ranked as the third most important food grain crop, after wheat and rice. The maize area has slowly expanded over the past few years to about 9.4 million ha. in 2013-14. The major growing states that contribute to maize production in India are Karnataka (18.8 %), Andhra Pradesh (16.8 %), Maharashtra (11.2 %), Tamil Nadu (7.8 %), Rajasthan (7.7 %), Bihar (7.4 %), Uttar Pradesh (6 %), Madhya Pradesh (5.9 %) and others (18.4 %) (Statistical Year Book, India 2013).

Broadly, maize cultivation can be classified into two production environments: (1) traditional maize growing areas, including Bihar; Madhya Pradesh; Rajasthan; and Uttar Pradesh (BIMARU), and (2) non-traditional maize growing areas, including Karnataka; Andhra Pradesh and Tamil Nadu (KAPTN). In traditional areas, the crop is often grown in marginal eco-regions, primarily as a subsistence crop to meet food needs. In contrast, maize in the non-traditional areas is grown for commercial purposes i.e., mainly to meet the feed requirements of the booming poultry sector.

In India the crop is generally grown in two seasons. The first is *kharif*, for which sowing starts in June and harvested during October onwards. Karnataka, Andhra Pradesh, Gujarat, Maharashtra and Orissa have *kharif* crops. The contribution of *kharif* maize is around 75 per cent to the total production. The second season is *rabi*, for which sowing starts in December and harvested during March. *Rabi* crop is mainly grown in Bihar and coastal Andhra Pradesh. In Tamil Nadu maize production starts in the month of January and peaks by the beginning of March. Tremendous choice is available to farmers as regards to varieties maturing in 85 days to more than 200 days with variability in grain colour and texture. Paroda and Kumar (2000) predicted that area under maize would grow further to meet future food, feed, and other demands, especially in view of the booming livestock and poultry producing sectors in the country. Since, opportunities are limited for further expansion of maize area, future increases in maize supply will be achieved through the intensification and commercialization of current maize production systems.

Maize gives moderate average grain yield (24.5 qt /ha.) as compared to major cereals such as wheat (31.2 qt /ha.) and rice (36.4 qt /ha.). The average productivity of maize in India has shown an impressive increase from 627 Kg/ha. in 1951- 52 to 2450 Kg/ha. in 2013-14. During 2011-12, Tamil Nadu registered the highest productivity of maize 6.04 tonnes/ ha. followed by Andhra Pradesh (4.23 tonnes / ha.), Punjab (3.98 tonnes/ha.), West Bengal (3.72 tonnes/ha.) and Karnataka (3.03 tonnes/ha.).

At present maize produced in India exhibits a pattern of consumption viz. human Consumption (23 %), poultry feed (51 %), cattle feed (12 %) seed production (1 %) and other industries mainly starch, breweries, dextrose, corn syrup, corn oil (13 %). In India the demand for maize is also going up as the demand for poultry feed is expanding. The poultry industry and the livestock feed units are concentrated to a high degree in Tamil Nadu and hence the state is one of the major consumers of maize. Since Tamil Nadu's production is not sufficient to meet the demand, poultry firms are procuring the maize from Andhra Pradesh, Karnataka and Bihar.

Overarching Popularity of Maize in India

Maize has traditionally been grown as a staple food destined primarily for home consumption. However, in recent years significant changes have occurred as a result of the increasing commercial orientation of the agricultural economy and demand for maize is rising on account of its diversified uses

As of Table 1.2 it could be observed there was an overall decadal increase in the cereal crops. Among the serial crops maize registered significant decadal increase in area (25.5 %), production (52.2 %) and productivity (21 %) when compared to wheat and rice. Maize being the fastest growing cereal in India, its true potential is yet to be realized. Productivity is among the lowest in the world, although in terms of output it ranks sixth in the world. The increasing production has come on the back of expanding acreage and relatively not on any gains in productivity. Among the cereals it ranks fifth in area, fourth in production and third in productivity.

Table 1.2: Status of Area, Production and Productivity of Important Cereals in India during the Past Three Decades

(in percentage)

Particular / Year	2000-01 to 2010-11	2000-01 to 2010-11	2000-01 to 2010-11
	Wheat	**Rice**	**Maize**
Decadal increase in area	10.8	- 6.3	25.5
Decadal increase in production	15.9	4.8	52.2
Decadal increase in productivity	4.5	12	21

Source: Directorate of Maize, 2012

Such overarching is the popularity of maize that many Indian states have deployed part of the Second Green Revolution funds announced by the Centre in 2010 to put together a Public Private Partnership (PPP) to promote hybrid maize. For instance, Odisha government in the year 2011 has collaborated with multi-national companies like Monsanto, Mahyco and Charoen Pokphand the state and managed to cover 30,000 hectares with hybrid seeds last year by offering marginal and small cultivators, mostly tribal folk, seed kits that are adequate for an acre (0.4 ha). Odisha is not the only state caught up in the maize mania. There is Gujarat, Rajasthan, Jammu and Kashmir and Madhya Pradesh, and a number of states focusing on introducing maize crop to new hinterlands. A major shift in maize cultivation has been observed in recent years. Shorter duration, less cost of cultivation, less water requirement and less risk compared to other crops are the causes for the shift towards maize cultivation in the country.

Non-traditional maize growing areas, especially Tamil Nadu and Andhra Pradesh, have the highest average productivity of maize in the country. Hybrids have found ready acceptance here in all probability because the huge demand for the cereal allowed farmers to invest in high-cost seed and other inputs. The poultry industry and the livestock feed units are concentrated to a high degree in the south and about half the maize output gets absorbed by chicken feed industry.

The major push for the maize fields to keep expanding is the poultry industry. India is among the top five egg producers in the world (57 billion annually) and the ninth largest producer of poultry meat. With the assembly lines for broilers revving up ever more every year and turning out 42 million birds a week, the pressure from this industry, which contributes an estimated Rs. 45,000 crore to the national income, is fuelling investment in maize cultivation as well as crop research.

Thus in many ways the maize cultivation reflects the pushes and pulls of India's fast developing economy: the astronomical growth of the poultry industry and in a lesser degree the starch industry, the notching up of global records in production while research in agriculture lagged woefully, the slow assimilation of tribal communities into the mainstream, and above all the changing dietary habits of a burgeoning middle class that is eating more eggs and chicken.

On the other hand, structural changes in consumption pattern coupled with rising per capita income would continue to boost demand for maize as feed. Maize needs added attention due to other reasons as well. There has been much diversification of maize utilization in the recent years.

Price Volatility Crisis in Maize

Historically, food markets have been subject to much instability in prices. This price volatility has had large effects on farmers, market participants and consumers. Higher commodity prices benefit sellers (including grain farmers), but they hurt buyers (including consumers, and dairy/livestock farmers who face higher feed cost). Market instability makes anticipating future price patterns difficult and creates significant price risk/uncertainty for market participants. There is no long-term trends toward increased volatility but notes that the "implied volatility" associated with futures prices of wheat, maize, and soybeans has been rising steadily since 1990. Instability in the price of staple foods is an important source of risk in developing countries.

Three factors contribute to the strong link between food price volatility and risk for poor farm households. First, the variation in staple food prices tends to be higher in developing countries than in other regions (Minot 2011). Second, poor households allocate a large share, often more than 60 per cent, of their budgets to food, so a given variability in food prices has a large effect on purchasing power (FAO *et al*., 2011). Third, the share of the population that depends on agriculture for its livelihood is generally larger in developing countries than in other regions.

Within rural areas, semi-subsistence farmers are partially insulated from the effect of fluctuations in staple food prices, while cash-crop farmers, commercial grain producers, wage laborers, and those with nonfarm enterprises are more vulnerable (Benson *et al.,* 2008). In addition, the researches reveal that price volatility is lower for processed and tradable foods than for non tradable foods and price volatility is actually higher in countries with the most active intervention to stabilize prices.

Thus it necessitates greater attention to be given to the level of food prices in the region rather than volatility per se, and regional and international trade can play a useful role in reducing food price volatility, and that traditional food price stabilization efforts may be counterproductive.

In comparing price volatility across countries, it is convenient to focus on maize for two reasons. First, the database contains a large number of maize price series. Second, maize is the most important source of calories in many African countries, particularly in Eastern and Southern Africa and Northern and Eastern parts of India (FAO, 2010) and a commercial crop in many other parts of the world. For this reason, the volatility in the price of maize is more politically important than volatility in the price of other food commodities.

Problem Focus

Various crop production techniques introduced under the umbrella of Green Revolution in the mid-1960s made a major impact on raising aggregate crop output by means of increasing productivity and intensity of cultivation in India (Jose, 2008). In the same period, irrigation availability has doubled and cropping intensity has increased significantly across the country. This may be due to the decision of the government to accord high priorities to agriculture by making large investments in irrigation projects, agricultural research and extension (Bhalla, 2009).

As liberalization brought in strong private participation, focus was shifted from food crops to high-value crops (Jishnu, 2011). This seems to be the reason for increased acreage under maize. Moreover, central and state governments were also keen on improving the growth rate in agriculture. As a result, the products of green revolution (including hybrid seeds, plant nutrition, crop protection and extension services) were also catered to crops like maize. In this era of globalization India has to learn to manage production in a cost effective manner and come up with a concrete policy on domestic consumption and export to increase its exposure and realization of higher prices in the export trade with better quality maize.

Growth in both the population and income is expected to increase the demand for food and other agricultural produce in the coming years. Domestic demand for most of the agricultural products was expected to increase at an annual rate of 2.75 per cent of which 1.75 per cent on account of population growth and one per cent on account of increase in per capita income (Naik, 2001). Therefore, to capitalize the foreseen opportunities, increase in maize production should match the growing demand in order to prevent future imports. The required growth rate in output should take place in a cost effective manner so as to compete effectively with the global exports.

On the other hand, although the domestic market is expanding with increasing consumption the Indian growers, processors, and traders could focus their attention to cultivate and expand the domestic market as a buffer against the vicissitudes of export performance (Deodhar and Vijay, 2004).

Having all the above said favourable settings like availability of abundant natural resources, strong economic fundamentals, India’s emergence as an economic power, increasing exports, sufficient foreign exchange reserves, satisfactory balance of payment position, availability of huge labour force, increasing population and purchasing power of the people, changing taste and preferences of the consumers, desire of the state and central governments to extend their resources for the upliftment of the food, seed and industrial use of maize paved a strong base. Utilizing this base, government should look forward in the direction of modernization to increase production, productivity, demand in both internal and external markets, product differentiation and minimizing the cost of production to square the competitors, so as to increase the market share and attaining the supremacy in world maize economy now enjoyed by USA.

The studies available on maize crop have largely been concentrated on specific aspects like supply, domestic consumption, prices and exports in a partial setting, which serve their limited purposes. In the present study keeping in view all the above aspects and the buzzword in this era of globalization is competition and the bottom line is competitiveness, an attempt has made to relate and analyse these aspects of the food, seed and Industrial use of maize crop in a comprehensive manner. For this purpose, besides time series analysis an integrated export demand model is used, integrating the components of supply with the components of demand in a competitive equilibrium setting.

Objectives

In this regard the specific objectives of the study are:

i. to assess the general trend of maize crop production, consumption as food, feed and industrial manufacturing and exports,

ii. to investigate the supply and demand dynamics and the effect of maize exports,

iii. to measure the degree of price volatility in the domestic markets for maize and

iv. to estimate the price transmission between international maize markets and domestic markets and also to evaluate the temporal and spatial dimensions of maize crop exports.

Hypothesis

The study is based on the premises of the following hypotheses

1. The maize production, consumption of food and exports are increasing in nature.
2. The supply and demand are significant and the effect of maize export are also significant.
3. There is a price volatility in the domestic and International markets for maize.
4. Both domestic and International markets of maize are highly integrated.

Scope of the Study

This study would provide a clear understanding about the pattern of change and relationship between area, production, productivity, consumption, price and export during Post Green Revolution period, Post Liberalisation period and overall study periods. The results of the present study would indicate areas for policy considerations and help the policy makers in formulating suitable programmes, devising strategies towards the development of production and marketing of maize in India and also pave way to increase the efficiency of agricultural markets to transmit the price signals effectively to producers.

Limitations of the Study

An economic study of this nature has few limitations partly relating to the quality of data that are collected for different purposes and mostly of the researcher in various respects. The results of this study are, of course, subject to these riders.

The preparation of this report is organized under six chapters as follows:

Chapter I	:	Introduction-deals with the background, problem focus, specific objectives, scope and limitations
Chapter II	:	Concepts and Review-review of the past related studies and the conceptualization of the same for the study on hand.
Chapter III	:	Methodology-The method of data collection and the various methods of analysis employed to explore the study are discussed.
Chapter IV	:	A profile of the maize crop and its related industry- Brief description of the various components of maize crop and its related industry with particular reference to the study area have been attempted.
Chapter V	:	Results and Discussion-the results of the analysis undertaken are presented, discussed and interpreted.
Chapter VI	:	Summary and Conclusion-findings of the study are summarized, conclusions are drawn and the policy implications have been indicated.

Review of Literature

CHAPTER II

REVIEW OF LITERATURE

In any research, it is important to look into the past studies conducted on the related problems in order to find out the present status of research in that area and identify the gaps if any in these studies. Further the knowledge of these studies would in turn help the investigator to give an appropriate direction to the study on hand. Keeping these things in view, the following concepts and past research work related to the present problem are briefly reviewed in this chapter under the following sections.

Concepts

1. Growth rate
2. Production and productivity
3. Market
4. Market integration
5. Horizontal integration
6. Vertical integration

Review of past studies

1. Past studies on measurement of horizontal integration
2. Past studies on measurement of vertical integration
3. Past studies on cointegration.
4. Past studies on ARCH and GARCH model
5. Supply response, demand response and export demand
6. Past studies on Post Green Revolution.
7. Past studies on Post Liberalization
8. Past studies related to Maize

Growth rate

Growth is the nature of change of the economic variables in the long run. Growth rates are used to measure the past performance of the economic variables and describe the trends over time.

Blyn (1967) used the linear, semi-log, log inverse and double log functional forms to estimate the trend in area and yield under oil seeds in different states of India. The normal statistical procedure to obtain a measure of growth of area and production of crops over a period is to postulate a hypothetical function which would adequately describe the series of area and production over time and to estimate its parameters which would offer a measure of growth over the period. Growth rate is generally expressed in two forms, viz., linear and compound. The linear form is obtained by fitting a straight line to the yearly data and estimating the parameters. The compound growth rate is obtained by fitting a straight line to the logarithms of the data and estimating the slope of the line.

Growth rate can either be arithmetic (simple) or geometric (compound). The simple growth rate is expressed in either absolute terms or in relative terms, while the geometric (compound) growth rate is normally expressed in percentage terms.

Rao *et al.*, (1981) studied that growth analysis of state-wise area, production and productivity of rice in India. In this study an attempt was made to study the effects of area, productivity and their interaction towards increasing the rice production. Data on area, production and productivity under rice for different states were taken from the publication entitled "estimates of area and production of principal crops in India, 1954 -55 to 1964 - 65 and subsequent reports published by directorate of economics and statistics, ministry of agriculture, Government of India. The productivity was computed as the ratio of production to area.

Mohan and George (1993) defined growth rate as the rate of change per unit time, usually a year. The growth rate was measured statistically by estimating different functional forms of growth over time, such as linear, semilog, Gompertz curve, logistic curve etc.

Jesy Thomas (1996) has defined growth rate as the rate of change per unit time and worked out the compound growth rates based on exponential, log quadratic and linked exponential models for studying the acceleration or otherwise for the different periods under question.

Pervez (2001) analyzed the growth in area, production and yield in the major crops of Pakistan for a period 1970-71 (period I) to 1984-85 (period II). The study revealed that the increase in crop production was contributed largely by area than by productivity in Punjab and Sindhu during period I. Sindh region recorded a higher growth in area, production and yield as compared to Punjab in period II. It was also observed that Punjab recorded a low degree of instability in growth rates in most of the crops as compared to Sindh region in period II.

Varghese (2004) worked out the trend in area, production and productivity of cardamom in Kerala for a period from 1970-71 to 2002-03 using semi-logarithmic growth equation. The area under cardamom registered a negative percentage annual trend growth rate of -1.216 which was statistically significant. The output grew at an average annual trend growth rate of 4.14 per cent and yield registered an average annual growth rate of 5.51 per cent during the said period.

Lathika and Ajith (2005), analysed the growth trends in area, production and productivity of coconut in India of all the coconut producing states and union territories, for which the period has been divided into two sub-periods as phase I (1951 to 1995) and phase II (1996 to 2002).

Dhakre and Amod Sharma (2010) studied the growth analysis of area, production and productivity of maize in Nagaland. In his study he examined the stability over time in Nagaland in area, production and productivity of maize mean, standard deviation and coefficient of variation. He also studied the compound growth rate and he found that there was maximum decrease in area in 1990-2000 and maximum increase in 2000-01. Similarly maximum increase in production and productivity was during 1988-89. Among area, production and productivity of maize the instability was highest for the production. Growth rates were significant.

Priya *et al*., (2011) calculated the compound growth rates of area, production and productivity of sugarcane crop in India. All India sugarcane data on production, productivity and total area cultivated during the period of 1930-2006 has been used for the computation of growth rates. The deficiencies in the existing method of calculating the compound growth rate has been pointed out. As an alternate, methodology using the non-linear growth models has been discussed for computing the compound growth rates. The parameters of the model have been estimated using non-linear estimation procedure. In the present study three popular growth models Logistic, Gompertz and Monomolecular have been used for estimation of the parameters. The results of the parameter estimates and goodness of fit measures indicated that among the three models Logistic model is appropriate for the present study. The compound growth rates have been calculated for Logistic model. The compound growth rate for sugarcane production is 2.96 per cent. For area and productivity of cane, the growth rates have been estimated as 1.73 per cent and 1.12 per cent respectively.

Sonnad *et al.*, (2011) addressed the impact of World Trade Organisation (WTO) on domestic oilseeds production. The specific objective was to analyze the temporal growth in area, production and productivity of major oilseed crops in India. The formulated hypothesis was growth rate of area, production and productivity of major oilseed crops in the post-WTO period is less compared to pre-WTO era. The results of the study have shown that area under rapeseed and mustard, soyabean, sunflower and castor increased with an overall annual compound growth rate of 2.13, 17.61, 9.15 and 1.85 per cent respectively. The increase in productivity of all nine selected oilseed crops put together from pre-WTO period to post-WTO period, was 140 kg per ha. The overall growth of productivity was positive in all the oilseed crops except sunflower. The mean production of the nine oilseeds put together had increased from 9.99 million tonnes during Pre-Technology Mission on Oilseeds (TMO) period to 17.68 million tonnes in pre-WTO period and to 22.33 million tonnes in post-WTO period. To attain self sufficiency in edible oils and to achieve nutritional security, State and Central government should map out programmes on the line of TMO to increase and maintain sustainable growth in productivity of all oilseed crops in rainfed areas.

In the present study, growth rate has been defined as the rate of change of a variable over time, the time being usually a year. Both linear and exponential forms were used to study the growth rate of area, production, productivity, domestic consumption, prices-domestic and international and quantity exported.

Production and Productivity

Smith (1934) defined production as the creation of utilities or commodities and services in order to gratify human wants.

Heady (1952) used the term productivity to denote physical productivity.

Black (1953) considered productivity as a power to contribute to a product and remarked that capacity and efficiency were the two dimensions of productivity.

Bhattacharjee (1955) defined productivity as the output per unit of farm business.

Bishop and Toussaint (1958) emphasised production as a process whereby some goods and services called inputs were transformed into other goods and services called outputs.

Saxon (1965) defined productivity as the ratio of total output to all inputs including intermediate products.

According to Heathfield (1971), a productive activity may be defined as one which increased the degree of compliance between the quantity, form and distribution of commodities and the given preference pattern.

Kargaonker (1977) defined productivity as the ratio of output to input.

Pandya (1977) considered agricultural productivity in terms of output per unit of input. In otherwords it was the output for every kilogram of improved variety of seed grown, for every litre of irrigation water used, for every kilogram of fertilizer applied, for every litre of herbicides and insecticides applied and for every unit of power employed for farm operation.

Singh (1977) reckoned productivity as yield per hectare of land.

Acharya and Nair (1978) defined productivity as the contribution of all the inputs they being combined in the sane composite fashion.

Costa (1980) defined production as an activity, which changed a good into different good.

Saini (1980) stated that productivity was the output per unit of land and it could be measured as output per unit area rather than gross cropped area because the former would automatically take care of the effect of intensity of cultivation of land associated with different size classes of firms.

Singh (1980) observed productivity as the outflow per unit of resource (input).

Endosomwan (1987) regarded productivity as a simple and universal concept which reflected the relationship between outputs and inputs expended in any work situation.

According to Ayoola (1990), productivity referred to the output per unit of input in physical terms. Therefore it is a trite economic assumption that productivity applied to each and every productive unit.

Verter and Eyler (1990) defined productivity as a measure of performance of production activity and referred to the amount of output produced per unit of input and according to them inputs stood for weighted sum of various inputs whereas output stood for weighted sum of various products.

According to Monga (1991), productivity involved comprehensive holistic phenomena encompassing all elements required to improve products or output satisfaction of customers and inputs, optimisation of resources and inputs.

According to experts of the Department of productivity and Labour Relations of U.S (1992), total productivity was the optimal achievement of economic and social benefits through the appropriate use of labour, capital and other resources to provide quality goods and services. The three elements which contributed to total productivity included labour productivity, capital productivity and social productivity.

Labour productivity was the ratio between output of quality goods and services and the labour input required to produce that output. It involved the level of employee’s skills and knowledge and the use to which these were put in order to produce the goods and services of the organisation.

Capital productivity was the ratio between the output of quality goods and services and the capital input required to produce that output. It is referred to the quality and quantity of building plant equipment, technology and the resources devoted to research and development.

Social productivity was the relationship between socially desirable outcomes and the way in which all the resources were utilised in producing quality goods and services. It referred to the social impact of the processes involved in producing goods and services and the processes involved in producing goods and services and social impact of these goods and services themselves.

Johl and Kapoor (1996) pointed out that production is a process of transformation of certain resources or inputs like; land, labour, seeds, fertilizers, irrigation water into products like wheat, paddy and milk.

According to Ahuja (1997) production in economics is not merely confined to effecting physical transformation but also covered the rendering of services such as transporting, financing wholesaling and retailing.

Dewett and Chand (2001) defined production as the transformation of inputs into outputs.

According to Koutsoyiannis (2003) production would indicate combination of factor inputs required for the production of one unit of output.

In the present study, productivity and production have been conceptualised as the yield of maize in kilogram per hectare, and in million tonnes respectively.

Market

Adlowe (1953) defined market as the entire area within which the forces of demand and supply of a given commodity or services were interacting in effective exchanges in establishing prices. Thus whenever and wherever buyers and sellers are brought together and whatever the means of achieving communication, market would exist.

According to Pyle (1956), the concept of market includes both place and region in which buyers and sellers were in free intercourse with each other.

The American Marketing Association (1960) defined market as an expression of the aggregate forces or conditions within which buyers and sellers would make decisions resulting in the transfer of goods and services consequent to the aggregate demand of the potential buyers of a commodity or service.

As per Clark and Clark (1962), a market would be found at every point at which a specific commodity would be concentrated for sale. A market would be a centre about which or an area in which the forces leading to exchange of title to a particular product operate and towards which and from which the actual goods would tend to travel.

Bell (1966) defined market as a public place in which goods and services were brought and sold.

Bain (1967) referred market to a closely inter related group of sellers and buyers.

Cundiff and Still (1968) followed the definition of The American Marketing Association.

Elling (1969) defined market as a place where physical transfer of merchandise would take place.

Lipsey (1971) considered market as an area in which buyers and sellers negotiate the exchange of a well defined commodity.

Narver and Savitt (1971) referred the term market to the contract between demanders (buyers) and suppliers (sellers) for transferring ownership or use of a factory, goods or services.

Rosenberg (1972) observed the economic reality of a market and defined it as "the gap which would separate producer and consumer".

Mamoria and Joshi (1975) opined that the term market was derived from the latin word marcatus meaning merchandise, traffic, trade or a place where business was conducted.

Bressler and King (1980) defined market as an area of setting within which producers and consumers would be in communication with one another, where supply and demand conditions operated and title of goods were transferred.

Hill (1980) described market as some sphere or space, where the forces of demand and supply would be at work, the price would be determined or modified, the ownership of goods or services would be transferred and certain physical and institutional arrangements would be exchanged.

Arvind (1982) viewed market as a set of all actual potential buyers of a product.

According to Freeman (1983) a market need not be a place but a group of individuals or firms that would communicate regularly among themselves for the purpose of conducting exchange. They neither need to meet face to carry on exchange, if other means of communication existed nor need to meet the physical transfer of goods exchanged; because what was exchanged was only the right of ownership and not necessarily the possession.

Stanton (1984) and Nair *et al.*, (1986) defined market as concentration of people with needs to be specified, money to spend and willingness to spend on it.

Samuelson *et al.*, (1995) referred market as a mechanism by which buyers and sellers would interact to determine the price and quantity of a good or service.

According to Saravanan (1996), market was described as a place where exchange of commodities took place between sellers and buyers.

Kerr *et al.*, (1997) defined market as a social institution that would facilitate the free exchange of commodities between buyers and sellers, usually for money, but sometimes for barter too. Markets in this sense do not refer to a specific location where goods and services would be exchanged, but rather the process by which the exchange would take place.

Ramakumar (1998) referred market as the entire sphere of social and institutional arrangements within which the forces of demand for and supply of a commodity and its products would operate.

Perreault *et al*., (2002) referred to market as a group of potential customers with similar needs who are willing to exchange something of value with sellers offering various goods and or services *i.e.*, ways of satisfying those needs.

Acharya and Agarwal (2004) defined market in terms of the existence of fundamental forces of supply and demand and are not necessarily confined to a particular geographical location.

Kotler and Keller (2005) reported that market is a place for potential exchange. It consists of all the potential customers sharing a particular need or want and might be willing and able to engage in exchange to satisfy that need or want.

In the present study, market for maize is defined as the place where exchange of maize from the producer to an intermediary and to the end user takes place in the marketing channel. The study is about the prices of different international markets and domestic markets.

Market Integration

Market integration is defined as the degree of price transmission between two, either vertically or spatially, related markets. The degree of measurement of spatial integration between spatially separated markets had evolved over time. Many of the early studies applied to agricultural markets in developing countries appealed to the simple idea that prices in spatially separated markets should be highly correlated.

Cummings (1967) opined that integration implied the association of prices between markets. Association of prices over time show seasonal integration of prices and association of prices between markets show spatial integration of prices.

Granger and New Bold (1969) typically conducted causality tests within the vector auto-regression (VAR) models framework. The approach was used to test for spatial price integration in terms of lead and lag relationships among dynamically interrelated prices.

According to Lele (1971), market integration was the interrelationship between price movements in two markets. The degree of correlation can be taken as an indicator of the extent to which the markets were integrated.

Roa and Subbarao (1976) considered that the markets were integrated over space when the territorial price difference did not exceed the transport costs plus the remuneration for the services of the trader.

Harris (1979) found that the use of correlation coefficients to test for market integration had many flaws because common components like population growth, climatic patterns, and inflation might include systemic effects across markets. Other synchronous common factors such as monopoly procurement of agricultural products at identical prices from different markets might also induce systemic effects in price series.

Monke and Petzel (1984) used regression-based procedures to test spatial price integration.

Delgado (1986) defined market integration as the existence of stable price spreads among markets in a given season, despite considerable variation in prices.

Dynamic regression models, notably pioneered by Ravallion (1986), were alternatives to dynamic versions of standard regression models and Granger Causality tests. If the difference in prices between the two regions was only because of transport cost then the markets were said to be spatially integrated.

Arshad (1990) studied the applicability of the Ravallion method and causality tests in measuring market integration and ascertaining the nature of price relationships in the Malaysian crude palm oil market and found a highly integrated market in the short-run. Local factors were proved statistically insignificant. Pierce causality tests indicated an instantaneous or feedback relationship. This suggested that each region absorbed new information as and when it became available. The reason for this attribute was the setting up of palm oil futures market in Kuala Lumpur, which had increased the accessibility of market information.

Gemtessa (1991) analysed the integration of Ethiopian coffee prices with world prices using the correlation coefficient. The bivariate correlation coefficient between the two market prices of coffee revealed that they moved together in the same direction. The lagged cross-correlations of domestic prices and world prices of coffee for the period 1979-80 to 1987-88 indicated that the world prices of coffee had a stronger influence on the domestic prices than that of domestic price influence on world prices.

Time-series techniques were widely used to test for the dynamic nature of interregional commodity trade and arbitrage activities. These tests typically used one or more techniques such as Granger Causality tests (GC), dynamic regression tests, Impulse Response Analysis of structural or non-structural Vector Auto Regression (VAR analysis) models and cointegration analysis.

According to Taddasse (1992), market integration was the interrelation between the prices of the concerned commodities over time and it mostly relied on the nature and extent of competition in the market.

Mundlak and Larson (1992) and Gardner and Brooks (1994) found that the use of regression-based tests had several shortcomings. The models were intrinsically static in nature because adjustment lags were not explicitly recognised and contemporaneous arbitrage conditions were assumed to hold. Also, non-stationarity of price data might invalidate standard econometric tests thus giving misleading results regarding the degree to which price signals were being transmitted from one to another market. The limitations related to the neglect of transaction costs and price variation within the transaction cost band also applied to regression tests.

Acharya and Agarwal (1994) defined three basic kinds of market integration viz., horizontal integration, vertical integration and conglomeration.

Horizontal Integration: This occurred when a firm or agency gained control of other firms or agencies performing similar marketing functions at the same level in the marketing sequence.

Vertical Integration: This occurred when a firm performs more than one activity in the sequence of the marketing process. It is a linking together of two or more functions in the marketing process within a single firm or under a single ownership.

Conglomeration: A combination of agencies or activities not directly related to each other when it operates under a unified management might be termed as a conglomeration.

Alexander and Wyeth (1994) utilized the empirical applications of GC tests for their study. Granger causality tests might provide some inferences about the existence of statistically significant lead/lag linkages among prices. However, GC tests indicated only whether the relationship between contemporaneous and lagged prices was statistically different from zero. Inferences from GC tests did not reveal the nature of the relationship. Thus, it was necessary to supplement Granger causality test results with other inferential procedures. Other limitations associated with correlation coefficients and standard regression approaches to testing for market integration could also be applied to GC tests.

Silvapulle and Jayasuriya (1994) demonstrated the use of multiple cointegration technique as a test for spatial market integration. They argued that this technique would overcome many of the limitations of previous methods. An application of the technique to Philippines rice markets indicated that, the markets were generally well integrated in the long-run with Manila as the dominant market.

Amanulla and Kamaiah (1995) examined the Indian stock market efficiency using two approaches, namely the Ravallion and co-integration and error correction approaches. The results showed that there was no evidence in favour of market efficiency of Mumbai, Chennai and Kolkata stock exchanges, while contrary evidence was found in case of Delhi and Hyderabad.

Baharumshah (1995) studied the market integration on the prices of wet cocao beans in different major regional markets with a non-parametric observation known as Philips-perron test. The results suggested that region-wise markets were segmented or less than fully integrated. This lack of market integration in intra- regional trade was not specific to particular commodity but rather a market specific problem. Integration could be enhanced focussing on transport and communication linkages.

Mendoza and Rosegrant (1995) examined the dynamics and efficiency of Philippines maize markets through the application of Auto Regressive Conditional Heteroscedasticity model (ARCH), to time series data. The findings of the study revealed that there existed imperfect market integration for Philippine maize markets and indicated that there may be substantial benefits (1) in developing better infrastructural facilities to effectively link production and market centres and (2) in improving market knowledge by providing more relevant, accurate and timely public market information.

Mohanty *et al.*, (1996) used the fractional co-integration analysis for nine pairs of international commodity price series. The results showed that these series were fractionally co-integrated even when the hypothesis of co-integration has been rejected. Of the nine cases, fractional co-integration supported the existence of the law of one price in eight cases, compared with three cases in the standard co-integration process.

Taylor (1996) used the co-integration analysis to address the pricing and informational efficiency of United States and Thai rice markets for the period 1987-91. The findings of the study indicated that the long-run equilibrium in the international rice markets was influenced by the Thai, Texas and future markets.

According to Baharumshah *et al.,* (1997), there existed a stable equilibrium relationship between the price series who's linear combination or stationery even though they may be individually non-stationery but the non-co integrated time series did not move together in the long-run and where in consistent with the law of one price.

Accoriding to Knetter and Pinelopi (1997), a perfectly competitive market should be fully integrated. Lack of integration is referred to as segmentation. A market is said to be geographically segmented, if the location of the buyer and seller influences the terms of transaction in a substantial way.

Sairam *et al.,* (1999) defined market integration as the interrelationship between price movements in different markets.

Edgar (2000) analyzed the market integration for agricultural commodities before and after the trade reform period and found that there was disequilibrium in the groundnut market prices for Mumbai and Chennai in the pre reform period

As described by Baffes and Gardner (2003), there were so many evidences around the world for price transmission into domestic commodity markets i.e with respect to transmission of world price changes to domestic markets during the global trade reform process. They have indicated Ghana's rice, Madagascar's wheat and rice, Egypt's maize, Columbia's maize and Argentina's wheat as examples for the penetration of world prices.

According to Reddy (2006), market integration refers to a situation in which prices of a commodity in separated markets move together, thereby offering smooth transmission of price signals and information.

The present study considers market integration as the interrelationship between the domestic and international maize market prices. Market integration between the international maize markets and the domestic maize markets are studied in order to know the long run association between the markets.

Horizontal Integration

Narasimham *et al.,* (1988), Nasurudeen and Subrmanian (1995) and Rafiulla (1995) defined horizontal integration as integration between different oil prices, in their analysis on prices of oilseeds and oils.

Ostrow and Smith (1988) explained horizontal integration as the ownership achieved by acquisition or internal expansion of additional business units at the same channel of distribution level.

Pearce (1992) considered horizontal integration to take place when the firm at the same stage of the production process would merge to form a single business organisation.

Acharya and Agarwal (1994) opined that horizontal integration would occur when a firm or agency gains control over other firms or agencies performing similar marketing functions at the same level in marketing sequence. In this type of integration, some marketing agencies would combine to form a union to reduce their effective number and the extent of actual competition in the market. However, in most markets, there would be a large number of agencies which do not effectively compete with each other.

Nasurudeen and Subramanian (1995) and Rafiulla (1995) considered horizontal integration as the interrelationship between price movements of different commodities in one and the same market over a period.

Kotler (2000) found horizontal integration as a company's move to acquire one or more competitors to increase the business's sales and profits, provided that the government does not bar this move.

The Money World Dictionary (2002) quoted horizontal integration as the merger of two or more companies which are in the same line of business. If the merged business went on to take over Safeway, which would be more horizontal integration.

The Google Lexicon (2002) found that horizontal integration would occur when a company expands its business products that are similar to current lines.

In the present study, horizontal integration is defined as the relation between prices of different Indian maize markets among themselves and with international maize markets.

Vertical Integration.

Narasimham *et al.,* (1988) defined vertical integration as the relationship between the prices of different forms of one and the same commodity. To be more specific, they argued that vertical integration would occur in oil market when the prices of the raw material viz., oilseed and that of final products namely oil and cake were inter-related in one and the same market.

On the contrary, Ostrow and Smith (1988) explained vertical integration as the ownership achieved by merger or internal expansion of the marketing channel intermediaries connecting the manufacturer / producer with the consumer.

Pearce (1992) followed the same and defined vertical integration as a situation wherein the activities of a firm would extend over more than one successive stage in the production process of transforming raw materials into final goods.

Anita (1993) defined vertical integration as the interrelationship between price movements of a commodity at lower level markets and the terminal market.

Acharya and Agarwal (1994) followed Narasimham *et al.,* and explained that vertical integration would occur when a firm performs more than one activity in the sequence of the marketing process. It would be a linkage between two or more functions in the marketing process within a single firm or under a single ownership.

Nasurudeen and Subramanian (1995) and Rafiulla (1995) followed Narasimham *et al.,* in their definition on vertical integration.

Kotler (2000) referred vertical integration as the strategy of the companies to integrate backward or forward to earn profits in their business. Vertical integration would often lower costs and the company would gain a larger share of the value added stream.

Courtland and John (2002) defined vertical integration as the process of developing a marketing system that would include both the source of production and the distribution capabilities.

The Money World Dictionary (2002) quoted vertical integration as the extension of a firm's activities into earlier (backward integration) or later (forward integration) stages of production of its goods or services. It also opined vertical integration as the process by which a firm would acquire a business or carry out a business which would make it its own supplier, or its own distributor.

A study by Baffes and Gardner (2003) described that with respect to transmission of world price changes to domestic markets during the global trade reform process, there were so many evidences around the world for price transmission into domestic commodity markets. Ghana's rice, Madagascar's wheat and rice, Egypt's maize, Columbia's maize and Argentina's wheat were few examples for the penetration of world prices.

Nielsen (2005) used a Vector Auto Regressive (VAR) model in Error Correction form (ECM) to analyse landing prices among the main fishing nations, using co-integration tests and tests for the Law of One Price (LOP) to determine the degree of market integration. A partially integrated European first-hand market for whitefish was identified and as a part of this, a perfectly spatially integrated cod market. The existence of this relatively loose market integration was explained by the presence of rigidities on the supply side. The implications were discussed in relation to reductions in EU whitefish Total Allowable catches and quotas and the market policies applied.

In the present study, vertical integration is defined as the extent of association of wholesale prices of maize in major Indian markets.

Past Studies on Measurement of Horizontal Integration

Aulakh and Singh (1979) examined the price spread in wheat for selected markets of Punjab. Their analysis was based on market structure approach. They have studied the spatial market integration in two ways: Firstly, the absolute price differential between two markets had been compared to the cost of shipment from one market to another. The price spread effect between the two markets, under assumptions of competition, was expected to be equal to zero, when the price spread between the two markets was no greater than the cost of shipment. The second approach, also based on competitive market structure, insisted in determining the correlation coefficient of prices in two markets as a measure of spatial integration. Their study showed that the price spread effect was close to zero and also that the correlation coefficient between market prices were high, which led them to conclude that the wheat markets in the Punjab were reasonably well integrated.

Kumar and Singh (1979) evaluated the extent of market integration and efficiency in paddy marketing in Varanasi District and tested the hypothesis. The investigation led them to support their hypothesis that wholesale and terminal markets for agricultural commodities were closely interrelated.

Nadda and Swarup (1979) examined the extent of market integration in apple markets in India. The value of correlation coefficient was considered as a measure to judge spatial integration and two markets were considered as perfectly integrated when the correlation coefficient of prices ruling in the two markets is one. The study revealed that the primary and terminal markets for apple varieties like royal delicious were reasonable well integrated.

Delgado (1986) used the variance components approach to test the food grain market integration in Northern Nigeria and arrived at three conclusions. First the differences in price behaviour between the adjacent projects of Funtua and Gusau were sufficiently great so as to preclude pooling them jointly for consideration as a unified market system. Second, within each project, there were apparent seasonal differences in food grain market integration between the harvest and post harvest periods. The reverse conclusion is not necessary valid for the post harvest period, but at least the evidence is consistent with the hypothesis of market integration thus defined. A fourth result is the finding that the variance of detrended and deseasonalised food grain prices was different in the harvest and post harvest seasons. One immediate consequence is to suggest caution when using bivariate correlation coefficients as a statistical technique to investigate market integration. Even when used with detrended and deseasonalised data, their statistical interpretation is based on the assumption of constant variance for each series. Thus, even a low value cannot be used as an argument to show the absences of integration, since under these circumstances there is no criterion of what is low.

Narasimham *et al.,* (1988) studied the relationship in prices between various oils and relationship between the prices of oil and oil cake with its own seed in Bombay market. Daily prices for one year of edible oils, oilseeds and its cakes and non-edible oils, oilseeds and cakes were considered for the study. The hypothesis of complete oil prices integration was not fully accepted. Price integration in many cases was found to be unidirectional indicating that situation would be possible only in one direction and not both ways. The study indicated that although the market share of groundnut oil was the largest, its price varied with changes in the prices of other oils, while its own price influenced other oils to a limited extent. Only cottonseed oil and linseed oil prices appeared to be dependent on groundnut oil prices. The study also depicted that price interactions between different products could be unidirectional, bi-directional or non existent.

Arshad (1990) studied the applicability of the Ravallion method and causality tests in measuring market integration and ascertained the nature of price relationships in the Malaysian Crude Palm Oil Market and suggested a highly integrated market in the short run. Local factors were proven to be statistically insignificant. Both Sims and Haugh-Pierce causality tests indicated an instantaneous or feedback relationship. This clearly showed that each region absorbed new information as and when it became available. The reason for this was attributed to the setting up of Palm Oil Futures Market in Kuala Lumpur, which had increased the accessibility to market information.

Shah and Habibullah (1994) tried to determine whether the prices of black and white pepper in a market were in parity with prices in a reference market. Co-integrated tests were applied to spatial price relationship among markets. The results proved that regional pepper markets in Malaysia were highly integrated. They found that the distance between the markets was not an impediment to efficient adjustment of price to new information.

Nasurudeen and Subramanian (1995) and Rafiulla (1995) attempted to estimate the extent of horizontal integration of oil prices using the Koyck’s distributed lag model. The analysis revealed that the assumption of complete oil price integration could not be fully accepted.

Ramakumar (1998) attempted to examine the spatial integration of coconut markets in Kerala using the co-integration analysis. The results showed that the three major regions in Kerala were integrated spatially for coconut, copra and coconut oil implying that any change in price in one market would immediately influence the other markets. The author used co-integration tests to test the market integration.

Borah and Dutta (2000) tried to explain the variation in prices over years and market integration of jute in five major markets of Assam. The results showed that the seasonal price variations were occurring with some regularity within the year. The trend in agricultural prices was associated with the general price level. There existed a high level integration between the markets under study.

Past Studies on Measurement of Vertical Integration

Narasimham *et al.,* (1988) studied the relationship of process of oilseeds with its own oil and cakes in Bombay market. Daily prices for one year of oilseeds, oils and oil cakes were considered for the study using Koyck's distributed lag model. The results indicated that groundnut kernel prices, castor seed prices, linseed prices, gingelly seed prices and kardi seed prices were influenced by their own oil prices. But only groundnut kernel, linseed and kardi seed prices were influenced by their own oil cakes.

Gupta and Arora (1991) attempted to examine the various quantitative relationships between prices of oils and oilseeds by estimating the degree of vertical integration of oilseed prices to prices of oils and oilseeds. The Koyck's distributed lag model was used to analyse the data obtained from Kanpur market in U.P. The results gave a clear, identification of oils and oilseeds where in unidirectional, bidirectional or no integration existed in price formation.

Ravi *et al.,* (1991) studied the price behaviour of groundnut in wholesale markets of Karnataka. The study made use of time series data on prices and arrivals of wholesale groundnut markets in Karnataka and oil and oilcake prices in Bombay terminal market. Regression method was attempted. The analysis indicated that market price of groundnut was influenced to a large extent by groundnut oil and oilcake prices rather than the local market arrivals. This explained that stabilisation of groundnut prices would not be possible by regulating the market arrivals without stabilising the edible oil prices.

Anita (1993) examined how oil prices at lower level markets would adjust with a change in oil price in the terminal market, the extent of short run and long run effects and the lags in adjustment to realize the long run effects. Koyck's distributed lag model was used, so that the adjustment lag in days would be known between local market and the terminal market. Correlation coefficients were computed between the prices at the local market and the prices in the terminal market with various lags. The study was confined to four selected markets in Gujarat. Daily price in a given market would be influenced by groundnut oil prices in the immediately high level market. Thus the groundnut oil prices were proved to be integrated vertically.

Nasurudeen and Subramanian (1995) attempted to estimate the extent of market integration of oil and oilseed prices in Bombay market using the Koyck's distributed lag model. The results of vertical integration confirmed the hypothesis that changes in oilseed price was linked to changes in its oil and cake price. The Bombay oilseed market showed the characteristics of perfect market condition by this quick adjustment to price changes.

Rafiulla (1995) examined the integration of groundnut and gingelly oilseed prices to their oil and oilcake prices in Tamil Nadu. The results of study indicated the existence of integration between the prices of groundnut and gingelly seeds with prices of concerned oil and previous day's prices of respective seed. In other words, there existed a vertical integration between oilseed and concerned oil prices in Madras market of Tamil Nadu. Koyck's distributed lag model was used for analysis of market integration.

Past Studies on Cointegration

Lütkepohl (1991) indicates that the order of lag length of the variables to be included in the model was determined by the information criteria known as Akaike's Information Criteria (AIC) / Schwarz Bayesian Criteria (SBC). The information criterion has been widely used in time series analysis to determine the appropriate length of the distributed lag. As a user of these information criteria as a model selection guide, the model with the smallest information criterion should be selected. The minimum values of the AIC/ SBC would decide the optimal lag length of the variables.

Francis *et al.,* (1997) studied the degree of price substitutability among the vegetable oils traded on the international market. The market prices of these were not likely to diverge greatly from each other, at least in the long run. In his study, the world prices of eight vegetable oils over a period of time were scrutinized to establish an understanding of the long run co movements utilizing multivariate cointegration frame work analysis. Co movements amongst oils were found by various tests based on cointegration space.

Kanwar (2000) used Johansen's and Juselius method of unrestricted Vector Auto Regression model to identify the long run relationship between agricultural and industrial sector in the Indian economy. He found that agriculture, infrastructure and service sector were weakly exogenous with respect to long run parameters.

Kuruvilla (2001) used multiple cointegration analysis by using per capita agricultural GDP, agricultural exports, gross capital formation in agriculture, index of agricultural production and trade policy. He found that these variables were cointegrated with three cointegrating vectors and series were causally related.

Sharma (2001) studied the causality between GDP on one hand and exports on the other, to analyze the impact of trade liberalization on the exports, imports and GDP. The objective of his exercise was to test the Export Led Growth (ELG) hypothesis for India empirically. He found that at the 10 per cent significance level, it could be marginally accepted the hypothesis that growth in income caused growth in real exports. There is weak evidence suggesting that the direction of causality ran from GDP to exports, which further strengthened the case against the Export Led Growth hypothesis for the case of India. He analyzed the interactions between agriculture and industrial sectors in India using Cointegration and Granger causality test. The analysis revealed that the dependence between industry and agriculture is mutual rather than one way for the Indian economy.

Rajesh (2002) used Johansen's and Juselius method of multiple cointegration analysis for assessing the market integration of major spices such as pepper, cardamom, turmeric, Chillies and ginger in pre and post liberalization period. The markets were integrated in post liberalization period for pepper, turmeric and ginger where as chillies and cardamom markets were not cointegrated in the post liberalization period.

Hoffman (2005) developed a futures price forecasting model to provide monthly forecasts of the season average price, which was a summation of weighted forecasts of Producer Prices received for each month of the marketing year. The season average price consisted of several components: futures prices, farm prices received, basis values (farm price received less futures), and marketing weights were used to forecast the counter-cyclical payment rate for corn, soybean and wheat. He first derived the season average price, and then determined the effective price and counter cyclical payment rate. The forecasted season-average prices-received were derived from monthly futures contracts traded during the marketing year. For each year of marketing, the monthly forecast started with the nearby futures contracts, except when the contract expires during the current month, in which case the next nearest contract month was used. Then, the monthly price of futures contracts were adjusted by the basis to calculate the United States monthly farm price forecast. That was weighted based on volumes and monthly marketing reported by USDA. He used the mean absolute percentage error to assess the forecast model accuracy.

Kumar (2006) estimated the price linkages in major edible oils of India and indicated that only three major oils namely, groundnut, mustard and coconut were found to have long run association. The estimates of ECM were significant for groundnut, mustard and soybean and the speed of price adjustment was fast for groundnut.

Long and Wang (2008) studied the dynamic relationship among futures price, spot price of Shanghai metal and futures price of London with the cointegration theory, Granger causality tests, residue analysis and variance decomposition on the VECM. The study showed that the three have a long equilibrium relationship.

Pradhan and Bhat (2009) investigated price discovery, information and forecasting in Nifty futures markets. This study compared the forecasting ability of futures prices on spot prices with three major forecasting techniques namely ARIMA, VAR and VECM model.

Romprasert (2010) studied the Cointegration error correction model of Agricultural futures in Thailand to identify the appropriate fundamental factors affecting the change in daily and monthly time period applicable in estimating rubber prices, particularly on demand-supply factors.

Ali and Gupta (2011) examined the efficiency of the agricultural commodity markets by assessing the relationships between futures prices and spot market prices of major agricultural commodities in India. Result showed that cointegration exists significantly in futures and spot prices for all the selected commodities except for wheat and rice.

Nadeem and Mushtaq (2012) in their study Role of Agricultural Research and Extension in Enhancing Agricultural Productivity in Punjab, Pakistan, estimated long run relationship between agricultural research and TFP (Total Factor Productivity) by using cointegration technique for 1970- 2005. The results of the long run relationship between TFP and agricultural research indicated that agricultural research had a significant and positive impact on TFP.

Past studies on ARCH and GARCH model

Most of the statistical tools are designed to model the conditional mean of a random variable. The tools evolved for modeling the conditional variance, or volatility, of a variable are Auto Regressive Conditional Heteroscedasticity (ARCH) and Generalized Auto Regressive Conditional Heteroscedasticity (GARCH) models.

Engle (1982) introduced Auto Regressive Conditional Heteroscedasticity (ARCH) model which is specifically designed to model and forecast conditional variances. The variance of the dependent variable is modeled as a function of past values of the dependent variable and independent or exogenous variables. If the error variance is related to the squared error term in the previous period it is termed as Auto Regressive Conditional Heteroscedasticity.

Bollerslev (1986) introduced Generalized Auto Regressive Conditional Heteroscedasticity (GARCH) model. In the time series analysis of forecast variance and volatility of error variance, the variance of the dependent variable is modeled as a function of past values of the dependent and independent variables. If the error variance is related to squared error terms several periods in the past is known as Generalized Auto Regressive Conditional Heteroscedasticity.

Caesar and Fletcher (2002) analyzed both production instability (originating in exporting countries) and consumption instability (originating in importing countries) and found that the steady expansion of Chinese exports, which were negatively correlated with exports from Argentina and the United States, was a stabilizing force in the late 90's. In the groundnut oil market, the influence of Senegal on world prices remained significant.

Guillermo (2004) examined the impact of alternative price stabilization policies for edible oils and oilseeds in India on the farmers growing oilseeds, the consumers of edible oils and the processing sector with the help of a multi market equilibrium dynamic simulation model. Price stability in the edible oil sector is important at least for two reasons. It can help realize the growth potential in the production of edible oils and improve the nutritional security of Indian households. While efficiency considerations suggest the linking of domestic to world prices, extreme fluctuations in price have to be avoided, for they can lead to undesirable consequences both at the macro and micro levels.

Guida (2005) examined the forecasting performance of GARCH models using agricultural commodities data. He found that the predictive ability of GARCH models used with agricultural commodities data was not well established. However, it was not meaning that GARCH models are useless for agricultural commodities forecasts, but they need more specifications in the variance equation to truly capture the trend of the volatility.

Raymond (2006) estimated the volatility in the primary commodity prices– persistence in the response to the shocks and in volatility since primary commodities constituted for 40 per cent of the world trade. The fluctuations in the short run and long run behaviour of the price of these primary commodities have important implications for the global economy and economic performance of the countries heavily dependent upon these commodities. He used the ARCH models to empirically examine the persistence and asymmetry in the commodity prices in the Sub Saharan Africa and analyzed the short run and long run price movements for groundnuts. The volatility of prices tended to vary over time and evidence of long term persistence and volatility in the price series of groundnuts.

Supply response, Demand response and Export demand

Konandrea *et al.,* (1978) studied the relation between U.S. export demand and the exchange rate. Their research focused on estimation of export demand function for the

U.S. wheat. The results indicated that exchange rate changes have had a significant impact on the U.S. wheat exports.

In a study Narayana and Shah (1984), employing ARIMA estimations of expected prices and yields, Nerlovian response functions were estimated for large and small farms in Kenya. Results showed that (expected) yield levels, rather than expected prices affect the supply response of small farms, whereas large farms react more strongly to prices.

As per Lahiri and Roy (1985), Agriculture in many developing countries was predominantly rain-dependent and unless rainfall was introduced into the supply-response functions carefully the equations could be mis-specified leading to bias in the computation of elasticities. Rainfall was modelled carefully in this study in a non-linear fashion which took into account the detrimental impact on output of both droughts and floods. The new specification had the added advantage that ‘optimum’ rainfall requirement could be estimated from the structure. It was also possible to construct a rainfall index to capture the ‘pure’ effect of rainfall after accounting for changes in other variables such as prices and irrigation.

Rao (1989) in his study surveyed the literature on agricultural supply response to prices in developing countries. Empirical estimates of elasticities depended both on the methodology adopted and on country-specific factors relating to technology, economic structure and macro constraints. This study established some general conclusions on supply responsiveness within these limitations. Supply response to output prices at the aggregate and at the crop levels was considered first. Crop-specific acreage elasticities ranged between zero and 0.8 in the short run while long-run elasticities tend to be higher-between 0.3 and 1.2. Yield elasticities were smaller and less stable than acreage elasticities. Clearly, inter-crop pricing could be relied upon to effect shifts in the commodity composition of agricultural output. Evidence also suggested that supply elasticities vary systematically with such factors as price and yield risks, multiple-cropping, the importance of the crop, farm incomes, farm size, tenancy and literacy.

Muscatelli *et al.,* (1990) investigated the debate regarding the robustness of estimates of export demand and supply elasticities for Less Developed Countries (LDCs) and Newly Industrialised Emerging (NIEs) obtained by recent empirical studies.

The empirical findings reported in the paper suggest that price elasticities of demand were indeed low, and that there were strong and significant income effects on export demand. Furthermore, using a variety of modelling approaches, they demonstrated that the choice of estimation method and normalization need not lead to drastically different conclusions regarding the size of the price elasticity of demand for NIE exports. While this point against the “small-country assumption” usually made regarding LDC/NIE exports, they argued that the preferred development strategy for LDCs need not necessarily be an inward-oriented.

According to Diebold and Lamb (1997), estimates of the response of agricultural supply to movements in expected price displayed curiously large variation across crops, regions, and time periods. This anomaly may be traced, at least in part, to the statistical properties of the commonly-used econometric estimator, which has infinite moments of all orders and may have a bimodal distribution. They proposed an alternative minimum-expected-loss estimator, establish had its improved sample properties, and argued for its usefulness in the empirical analysis of agricultural supply response.

Since the Information on supply price elasticities are acknowledged as being very important for decision makers at the macro and micro levels, Omezzine and Al-Jabri (1998) took an empirical investigation of vegetable growers’ responses to prices in Oman. They developed a single supply response function incorporating adaptive expectation model for prices. Results indicated that growers adjust relatively fast to changes in expected prices. However, these adjustments were rather low for some crops in the short and long-run. Grower’s production decisions had also shown a significant response to prices of other products competing for farm space and other production resources. These results supported efforts aimed at market development and crop enhancement programs.

Söderling (2000) in his study, examined a sample of 38 manufacturing firms from Cameroon for the period 1980-95. A production function and an export function were estimated in order to study the determinants of Total Factor Productivity (TEP) and export performance. The results demonstrated a mutually reinforcing relation between productivity and manufacturing export performance. Moreover, the study provided evidence indicating that adequate management of the real exchange rate was a crucial factor for the promotion of manufacturing exports. The performance of the manufacturing sector in Cameroon had deteriorated substantially since the mid-1980s. This decline was to a large degree explained by Dutch disease symptoms and inward-looking policies for the manufacturing sector, resulting in a highly overvalued Real Effective Exchange Rate (REER). Based on the estimated export and production functions, a simple dynamic model was constructed to assess the cost of this REER overvaluation, in terms of both productivity and exports.

Sharma and Tiwari (2001) estimated the export demand and supply elasticities of India's tea exports using Two Stage Least Squares model (2SLS) for the period 1966 – 1999. The results suggested that the export price and world price affected the export demand of tea significantly. The elasticity coefficient of –0.5 suggested that with 1 per cent decrease in export price of tea, the demand for tea export would rise by 0.5 per cent. The supply function fitted for export of tea from India showed that the export supply of tea is significantly affected by fluctuations in the production of tea and the domestic demand.

Lim *et al.,* (2002) forecasted the demand for international tourists travelling to Australia from the countries of Hong Kong, Malaysia and Singapore during 1975-1989 using the steps of the Box and Jenkins Autoregressive integrated moving average (ARIMA) model. As measures of the accuracy of forecasting, they used the mean absolute percentage error and root mean squared error (RMSE). To check for the stationarity of the international tourism time-series data they used Augmented Dickey Fuller test to assess whether unit roots exist and whether they would need to take differences in the data.

Aydin *et al.,* (2004) examined the export supply and import demand for the Turkish economy using both single equation and vector auto regression frameworks. The long run and short-run specifications of exports and imports were estimated using the least square estimators and the conventional set of explanatory variables. The long-run elasticity estimates of trade flows with respect to their regressors were also reported. Exports were determined by the unit labour costs, export prices and the national income. The analysis revealed the real exchange rate as a significant determinant of imports and the trade deficit, but not of exports.

Alamri (2010) investigated the effect of corn exports through an estimation of a system of corn export equations. U.S. corn exports were impacted by U.S. ending stocks, number of live animals for export in the U.S. , total U.S. domestic consumption, rest-of-world ending stocks, number of live animals for export in the rest of the world, rest-of-world corn exports, total consumption in the rest of the world, annual corn trade weighted exchange rates and U.S. corn prices. Lagged variables were included to improve their significance and make the signs align with expectations. The U.S. corn price and annual corn trade weighted exchange rates were the most important variables to impact U.S. corn exports. He evaluated the forecasting by Root Mean Square Error (RMSE) and Mean absolute error. The results showed that the model had the ability to forecast.

Past studies on Post-Green Revolution

Duvick and Cassman (1999) in their study Post–Green Revolution trends in yield potential of temperate maize in the North-Central United States, concluded that there has been increase in yield potential of maize (*Zea mays* L.) hybrids released in the north-central United States since the advent of the "Green Revolution" that began in the late 1960s. By evaluation of maize breeding efforts, changes in plant traits of commercial hybrids, and by comparison of statewide average yield trends and yield trends in sanctioned yield contests they support the hypothesis that maize yield potential has increased.

Evenson and Gollin (2003) in their study assessing the impact of the green revolution, 1960 to 2000, concluded that over the period 1960 to 2000, international agricultural research centers in collaboration with national research programs, contributed to the development of "modern varieties" for many crops. These varieties have contributed to large increases in crop production. Productivity gains, however, have been uneven across crops and regions. Consumers generally benefited from declines in food prices. Farmers benefited only where cost reductions exceeded price reductions.

Larson *et al.*, (2004) examined instability in area, yield and production for major crops in India by dividing the period1950-51 to 2001-2002 into a pre-green revolution (1951-1965) and Post-Green Revolution (1968-2002) periods. The paper reported that production instability for foodgrains had increased by 153 per cent and yield instability increased by 244 per cent between the two sub periods. He concluded that the widespread adoption of green revolution technology increased instability in yield and production of foodgrains.

Kumar (2005) tried to explain the basic reasons behind the increasing allocation of land towards Boro-rice, Potato and Mustard in West Bengal during the Post-Green Revolution period. His Study revealed that expansion of irrigation, growth of chemical fertilizers and technology in other fields were the main factors responsible for the relatively rapid expansion of cultivation of boro-rice, potato and mustard in West Bengal.

Sharma *et al.,* (2006) estimated variability in production and yield by choosing smaller set of years, viz., 1981-82 to 1990-91 and 1991-92 to 2000-01. The authors concluded that the production of individual crops and total food grains had become more stable in the 1990s compared with the 1980s. Further, the results of the two studies on instability were somewhat contradictory in the sense that Larson et al., reported a rise in the instability over time whereas Sharma et al., reported a decline in instability overtime.

Laidlaw (2008) found that the industrialization and monoculture introduced to India by the Green Revolution had resulted in low water tables and soil that had been depleted of nutrients essential for growth. Additionally, these techniques sparked a vicious cycle in which farmers were forced to spend more and more money on chemicals to counteract what monoculture and heavy fertilizer applications have done to their land.

Ray and Ghose (2014), in their study, Production efficiency in Indian agriculture: An assessment of the post green revolution years, used the nonparametric method of Data Envelopment Analysis (DEA) to obtain Pareto-Koopmans measures of technical efficiency of individual states over the years 1970–71 through 2000–01 in a multi-output, multi-input model of agricultural production. They disaggregated overall efficiency into two distinct components representing output and input efficiencies and identify the contribution of individual outputs and inputs to the measured level of overall efficiency. Introduction of modern inputs had been a major component of the process of modernization of Indian agriculture. They examined to what extent different states succeeded in utilizing the modern inputs compared to the traditional inputs. Variations in the DEA efficiency scores across states and over years was explained in terms of differences in various institutional and demographic factors in a second stage regression analysis.

Past studies on Post-Liberalization

Golub and Finger (1979) showed that the reciprocal elimination of trade barriers between developed and developing countries would raise output in developing countries more than that it would decrease output in developed countries. Trade liberalization influenced not only tariff revenues but also real exchange rates. Reduction in trade protection tended to depreciate the equilibrium real exchange rate, which in turn improved competitiveness of exports. An increase in import tariffs increased the relative price of imported goods.

Kumar (2001) found that production of oilseeds and pulses might be adversely affected in a free trade scenario given the lower world prices and the import dependence might be increasing in the coming years.

Emami (2002) studied the role of trade liberalization in promoting economic globalization and growth. He found that the net effect of higher tariffs was to transfer wealth from consumers to producers and the government. In contrast, by permitting the efficient use of resources within and across national borders, lowering tariffs improved the availability of more products at lower prices, thereby enhancing public welfare.

Gulati and Sudha (2002) explained that unilateral liberalization of agricultural trade in countries like India has been argued to have been politically unsustainable as farmers were subjected to large world price swings and import surges of commodities heavily subsidized by the developed nations.

According to Raghavalu (2003), India with its large production of agricultural and allied products, vast domestic market, and well developed institutional mechanism could forge the domestic markets with the global markets. Implementation of Agreement on Agriculture has been a mixed blessing for India. It created environment for trade reforms and for initiating trade liberalization in agriculture which was considered desirable for the country.

Storm (2003) in his work, demonstrated the realistic analysis of consequences of including agriculture in India’s trade reforms although it substantially improved efficiency and productivity in agriculture, the resulting increase in agricultural income was not large enough to offset the decline in the non agricultural growth.

Bernard *et al.,* (2004) found that the tariff protection could shelter farmers from import surges in periods when world prices drop significantly. Tariffs are often the only instrument of intervention that developing economies have to respond to the effects of the developed nations.

Shinoj *et al.,* (2008) examined the comparative advantage of India in agricultural export vis-a-vis Asia in the post reform era. From 1991 to 2004, ten major agricultural commodities group were studied. India was able to maintain comparative advantage in commodities like cashew and oil meals, but tea, coffee, spices, marine products were negatively affected.

Patil *et al.,* (2013) studied the structural transition in Karnataka agriculture during post liberalization era. They reasoned that the development and adoption of new agricultural technologies have a significant influence on the crop-mix which is more prominent in agriculturally developed regions. A dynamic change has been witnessed in agricultural sector in the state, particularly during post liberalisation period.

Past Studies on Maize

Cleasby *et al.,* (1993) found that climatic variation was the major determinant of export supply of yellow maize. Their results also supported the *a priori* expectations that local yellow maize producers were price takers on the world market and that export supply reacted sluggishly to changes in the lagged producer price of yellow maize.

Goletti and Babu (1994) studied the extent of market integration of maize markets in Malawi in order to understand how the markets had been affected by market liberalisation. Several measures of integration were introduced to study the problem and it was found that liberalisation had increased market integration.

Schimmelpfenning *et al.,* (1996) used an error correction model to investigate South African supply response of maize and sorghum. They concluded that the maize area planted in the short run or in the long run depended on two sets of variables. Maize production was influenced by its own price, price of substitutes like sorghum and sunflowers, and intermediate input prices and rainfall. Sorghum was found to be a secondary crop dominated by expected changes in the maize variables, and the area planted depended simply on intermediate input prices and rainfall over both the short and long run.

Wiseman *et al.,* (1999) used cointegration analysis to test whether the South African futures market for white maize was efficient. For effective price discovery tests were also conducted to assess whether or not white maize futures prices were unbiased predictors of future spot prices. There was no long run relationship between white maize futures and spot prices for 1997, but there was evidence of a long run relationship between these price series in 1998. Furthermore, the 1998 futures price was an unbiased predictor of future spot prices for both the annual and three month contract. This could be evidence of a market learning process and a progression towards efficiency, which has seen a marked increase in market liquidity (contract volumes traded) since late 1996.

Hansen and Seo's (2002) used multivariate threshold cointegration model used to characterize integration between selected maize markets in Benin over the period of market liberalization. Observed transaction costs for market pairs were compared with the estimated thresholds obtained from the multivariate model.

Kalamkar *et al.,* (2002) examined the growth in area, production and yield of principal - crops in India over the period of 49 years (1949–50 to 1997–98). The growth rates were worked out for major crops by using exponential function. The magnitude of variability was calculated through the coefficient of variability and contribution of area and productivity to increase in production was worked out by using decomposition analysis. It was observed that the growth rates of area, production and yield of principal crops in India over the period were positive and significant. High growth in production was accompanied by increased variability in production and the risks associated with the production of these crops. The yield effect was the most important factor for an increase in production of rice, jowar, bajra, maize, gram, cotton and sugarcane.

Penzhorn and Arndt (2002) indicated the extent of market integration between major Mozambican maize markets. Parity bounds model, (PBM) developed by Baulch (1997) was used for testing the state of food market integration. The results pointed to a failure of spatial arbitrage conditions between the Maputo and Chimoio markets about 23 per cent of the time over the period.

Chambers (2004) described the importance of products like corn, sorghum, barley, and oats in the United States. He found that farm prices were depressed by rising carryover stocks and that the price of a single good is influenced by the interaction of supply and demand for the entire feed grain complex because feed grains were highly substitutable. Chambers used a statistical test to identify structural change occurring in the corn market after 1996: he used Ordinary Least Square to estimate a corn price relationship, then a Chow test to assess if the predicted and actual values were significantly different. He developed season-average farm price forecasts that account for structural change in the feed grains sector. He thought this would occur because the structural change in the feed grains sector has affected from changing farm policy, global competition and changing consumer preferences. Chambers provided a framework to forecast the season-average, farm level prices and gauge the consistency of supply, demand, and price forecasts. His Chow forecast test first estimated a subsample of the model, which was used to predict the values of the dependent variable in the remaining subsample. He used the corn price forecasting model from Westcott and Hoffman to test for structural change. Finally, he found that the forecast price models track actual prices well for corn, sorghum, barley, and oats.

Thanh Ha *et al., (*2004) found that the maize production had risen sharply since 1990 in Vietnam, when the government began to strongly support and promote maize hybrid technology. Vietnamese farmers also widely adopted higher-yielding hybrid maize varieties. This was a timely response to Vietnam's growing livestock and poultry industry, which in turn generated an increasing demand for more maize to use as feed. This further verified that the lion's share of the production was demanded by feed industry and the development of this sector was mainly enthused by improved seed.

Sekar (2004) examined the issue of volatility of agricultural prices, with regard to the possibility of transmission of international price volatility to domestic markets. An attempt was made to measure the degree of price instability of important agricultural commodities in major domestic and international markets, compared the patterns of variability in the two, and looked at the implications for Indian producers and consumers.

In the national level, according to Joshi *et al*., (2005), maize yield improvement in recent years was credited to adoption of modern maize varieties. The southern state of Karnataka was categorised as non-traditional maize growing area, which were mostly commercial and more favorable production environments. They realised that hybrids (improved seed) outperformed local and composite cultivars both in terms of yield and profitability. Hybrids were popular mostly in Andhra Pradesh and Karnataka, where the seed sector was strong. Though the crop is suitable for dry-land farming, the role of irrigation was not ignored by the scholars. Timely rainfall or proper irrigation enhances maize output.

Singh *et al.*, (2005) made an attempt to look into the mechanism of movement of spot and futures prices for two important food crops wheat and maize in Indian agriculture. The Augmented Dickey Fuller (ADF) test was used for both the crops to check the stationarity of the time series data. Most of the series were observed to follow the stationary pattern at the first difference. The cointegration test was attempted to find out whether there existed a long run relationship between spot and futures prices of various contract months for maize and wheat crops. However, there existed a short run disequilibrium between these two. It was observed that the futures contract behaved in an expected manner and there existed a mechanism for long run equilibrium in the maize as well as wheat crops. This phenomenon of price convergence for both maize and wheat crops clearly stated that the farmers were mitigating price risk as spot prices and future prices converges.

Wasim (2007) revealed that the influence of HYV seed on production, yield and area for major food crops in Punjab of Pakistan was found to be mixed. Its contribution on production, area and yield growth for wheat was remarkable. However, the adoption of HYVs had helped to accelerate the growth rate of production and yield of maize for few periods from 1965 to 1978 out of the long forty years period taken for the study in Punjab of Pakistan from 1951-52 to 1994-95.

Fortenberry *et al.*, (2008) developed a set of reduced form equations to estimate the effect of ethanol production on the national average corn price. The reduced form model depended on five equations (corn supply, corn price, feed demand, export demand and food, alcohol and industrial demand) which were estimated by three-stage least squares (3SLS), with the exception of the supply equation, which was estimated by OLS. Testing for autocorrelation was done by application of the Breusch-Godfrey Lagrange Multiplier test. They found that the supply, export and price equations exhibited first order autocorrelation. They corrected for that problem by adding a one period lagged dependent variable to the right hand side of these equations. The equations he used to estimate the system are as follows:

Supply = f(one period lagged corn price and one period lagged interest rate)

Feed = f(corn price, soybean meal price and number of animals on feed)

Exports = f(corn price, Foreign wheat production, per capita GDP of major U.S. corn importers, and exchange rates)

Food, alcohol and industrial uses = f (corn price, ethanol production in the U.S, population and linear trend)

Then Price equation is determined by supply and demand simultaneously.

In the case of corn exports, they modeled the behavior as a function of corn price, wheat production in other countries, per capita GDP of major U.S. corn importers, and exchange rates. It had two endogenous variables (corn export and price of corn) and seven exogenous variables (wheat production in the rest of world, the dollar index, the per capita GDP of the main corn importing countries, lagged corn export, D1 D2 and D3 are quarterly dummies for the 1st quarter, the 2nd quarter and the 3rd quarter, respectively).

Hasan *et al.,* (2008) measured the change and instability in area, production, and yield of two major cereal crops wheat and maize in Bangladesh that both were unstable crops, maize showed very instability in its area and production because of its increasing tendency in the recent years.

Kim and Doucouliagos (2008) employed realized volatility and covariation methods to estimate a vector autoregression (VAR) model utilizing realized volatility and correlation estimates (instead of prices) for corn, soybean and wheat futures prices. They argued that this method was less restrictive than GARCH models and did not depend on the underlying model assumptions. Volatility spillover effects were evaluated through generalized impulse responses. The three estimated volatilities were closely related over time based on the existence of volatility spillover effects from one commodity to the others.

Jayasinghe *et al.,* (2009) using export demand function and gravity model for data on 48 countries investigated the determinants of world demand for U.S. corn seeds, and the cost of export trade to different destination. They analysed in detail the trade costs impeding export flows to various markets, including costs associated with distance, tariffs, and sanitary and phytosanitary (SPS) regulations. They concluded all trade costs matter, mostly tariffs, and have a negative impact on U.S. corn seed exports.

Dhakre and Sharma (2010) analysed the growth of area, production and productivity of maize in Nagaland. Maximum decrease in area under maize crop was (-) 16.02 per cent found in the year 1999-2000 and maximum increase in area under maize crop was 30.23 per cent in the year 2000-01, whereas maximum increase in production and productivity of maize crop in Nagaland was 103.05 and 101.26 per cent in the year 1988-89 in the 1988-89 respectively Among area, production and productivity of maize the instability was highest for the production. Growth rates were significant at 1 per cent level of significance.

Saghaian (2010) analyzed causal relationships across five US price series: corn, soybeans, wheat, ethanol and crude oil obtaining mixed results. That is, directed acyclic graphs (DAGs) of the residuals of the VEC model indicated that there were no causal links between energy and agricultural markets. However, results of Granger causality tests indicated crude oil prices Granger cause corn, soybeans, and wheat prices.

Vasisht and Bhardwaj (2010) in their study, an analysis of Volatality of Agricultural Price: A case study of maize, concluded that there existed a long run price equilibrium relationship between spot and future prices and the Granger test detected unidirectional causality from futures to spot markets.

In Haryana, Yadav *et al.*, (2011) found that with the reduction of groundwater, the farmers were shifting from unprofitable rice cultivation towards maize cultivation as it could be managed with 3–4 light irrigations. They also explored the role of HYV seed in maize crop cultivation, but the state faced the shortage of good hybrid seed. Similarly, Karnataka a dry land farming state and shortage of water or rainfall found to be one of the important factors responsible for switching over many of the farmers from rice to maize cultivation in the state.

In the study of crop diversification in India, Singha and Chakravorty (2013) explored that the introduction of new hybrid seed (HYV) was one of the most important factors for significant growth of maize crop in the state. Further, though the crop is suitable in the drier region, the role of timely rainfall was also found to have significance on the yield level.

Saghaian *et al.*, (2014) empirically estimated the export demand of U.S. corn and soybeans to three main destinations, China, Japan, and EU, in the current context of energy and agriculture linkages and production of ethanol from corn. A log-linear equation was used to estimate the export demand estimation of U.S. corn and soybeans. Data for the U.S. and its three main importer markets were gathered for the 1980-2011 period. The results of the logarithmic model estimates showed that china had the most elastic demand. China had the highest income elasticity of 2.5, while the income elasticity for Japan and EU were close to 1. The parameter estimates for price of soybean as a cross price was significant for China and EU, and parameter estimates for price of corn as a cross price was significant only for Japan. The positive sign revealed soybeans and corn to be substitutes in those countries.

Methodology and Model

CHAPTER III

METHODOLOGY AND MODEL

Consistent with the hypotheses and objectives set forth, the methodology is designed in any research study. In this section, method of collection of data and analytical techniques employed in the present study are outlined. Details of sampling techniques adopted for selection of markets, sources and methods of data collection, procedure followed to measure the important variables used in the study and the econometric models employed for the analysis of data are presented in this section.

This study primarily focuses on the use of time series techniques in understanding the time related properties of maize area, production, productivity, domestic price, international price, annual maize trade weighted exchange rate, stock holding, domestic consumption (Feed and Residual (FR), Food, Seed and Industrial use (FSI)), exports, total consumption in the rest of the world , sorghum price, annual average rainfall and population. Traditional econometric techniques are utilized and at the same time when these traditional econometric techniques are found to be inadequate while trying to make inferences with time ordered observational data, other techniques are used. Intention of the present study is to estimate export demand of maize in India and the price transmission from international maize markets to the domestic markets and the resultant impacts on the domestic prices. A brief account of various other quantitative tools used, broadly categorised as time series methods in the literature, is also presented.

Sources of Data

The present study was carried out based on secondary sources of data. The required information for the study was collected from the secondary sources for maize on domestic markets from the various issues of Agricultural Situation in India and authenticated published sources of the Government of India. The Agricultural Marketing Information Network (AGMARKNET), Statistics Division of Food and Agricultural Organization of United Nations (FAOSTAT), United Nations Conference on Trade and Development (UNCTADSTAT), Online data base of United States Department of Agriculture (USDA) are helpful in getting the data on production, supply and distribution and international prices of maize crop for the study. Other related information are sourced through India Stat web site (www.indiastat.com) and the data relating to maize area, production, productivity, domestic consumption, domestic price, international price, stock holding, exports, rest of the world supply and market prices were collected from the Data Statistics and Digest published by the above mentioned sources.

The US$ deflator taken form Reserve Bank of India and Oanda Corporation (an online International For-Ex dealing organisation) were used to deflate the International market price. Then the prices were converted into domestic currency using official foreign exchange rates. The econometric analysis was carried out using the Econometric Views 7.0 software package (Eviews, 2013).

Collection of Data

To study and understand the growth rates in area, production, productivity and domestic consumption of Maize crop, the necessary data were collected from 1970-71 to 2013-14 and was categorized into Post Green Revolution (1970-1991) and Post Liberalization (1992-2013) periods. Trend equations were also fitted to examine the pattern of such growth dimensions for the above mentioned two time periods and also to the overall study period.

Since export of maize was started from 1980, time series data for Indian maize exports from 1980 to 2013 was used in the analysis. Most of the data were available in the USDA database. The number of animals in India and the rest of the world were available in FAOSTAT; only the number of cattle, hog, and chicken were collected because only these animals are fed maize (Carter *et al.,* 2006). The annual maize trade weighted exchange rate was collected from the Economic Research Service (USDA website).

Among the various domestic markets for maize crop, major markets were chosen to represent maize markets of India. For the selection of domestic and international markets for maize prices purposive sampling was adopted. The selection of domestic and international markets was based on the volume of transaction, availability of data and also considering the experts opinion. Equal representation was given to the major maize growing belts in India while selecting the domestic markets for maize. Among the domestic markets two from traditional area like Chhindwara (Madhya Pradesh) and Kota (Rajasthan) and three from non-traditional areas like Nizamabad (Andhra Pradesh), Davangere (Karnataka) and Udumalpet (Tamil Nadu) were selected and also two international maize crop markets like Argentina and United States were selected for the study. Monthly time series data for the prices of maize from 2003 to 2013 for domestic and international markets were collected.

Tools of Analysis

An account of the tools of analysis employed in the present study is given below:

Percentage analysis was carried out to study the domestic consumption to production, export to production, Indian maize export to world maize export, maize export earnings to total Indian export earnings, export earnings to GNP and similar other parameters.

Growth Rates

The slope of a linear trend is a fixed value per unit time period. Often, particularly over long span of time, this is an inadequate description. A time series increasing by a constant percentage has the growth properties of compound growth rate. In the present study, the area under maize, production, productivity, domestic consumption, volume of export, export earnings, domestic prices and export auction prices for the two time periods (post green revolution and post liberalization) and also for the overall study period, were analysed for growth trends with the help of the model,

$$Y_t = Y_0 (1 + r)^T e^u$$

Where, Y_t = Value at time 't'

Y_o = Initial value

r = growth rate

T = Time in years 0, 1, 2 ……..n and

u = is the random error term

For the purpose of estimation, the equation was expressed in logarithmic form:

$$\ln\ Y_t = \ln\ Y_0 + T\ln(1+r) + u$$

$$Y_t = a + bT + u$$

Where, $Y_t = \ln Y_t$

$$a = \ln Y_0$$

$$b = \ln(1+r)$$

Then steeper the regression line that is the larger the value of b the higher the compound growth rate, r. The value of r was readily obtained as follows:

Since, $b = \ln(1+r)$

$$e^{b} = 1 + r$$

$r = e^{b} - 1 =$ Anti ln of b-1

The semi log function is linear in parameters (linear relationship between Y and t), and hence, it can be fitted by the method of Ordinary Least Square (OLS) Technique.

The compound growth rate (r) is obtained by the following formula and generally expressed in terms of percentage.

r = [(Anti ln of b)-1] X 100

The standard error of regression coefficients ‘a’ and ‘b’ were obtained by using the formula,

$$Su = (1 - r^2).n.(\sigma^2 y)$$

$$SE(a) = \sqrt{\frac{1}{n} + \frac{\overline{X}^2}{n\sigma^2 X}}\ .\sqrt{Su}$$

$$SE(b) = \sqrt{\frac{Su}{n\sigma^2 X}}$$

The t-value to estimate the significance of r value was obtained by,

$$t = \frac{r^2\sqrt{n-2}}{\sqrt{1-r^2}}$$

Time Series Analysis

The basic aim of the present study is to understand the pattern underlying the components of the maize crop and use the knowledge for forecasting. To this end, some of the time series tools are applied and each of them are discussed below. The time series analyses were to be carried out to study the temporal price variation. The time series referred to a sequence of measurement of movement of economic variables over time. In the present study, the domestic prices for maize, the export prices for maize, production, productivity, volume of export, and the like were the subjects for time series analysis. The generally identified four major components, namely, trend factor (a), cyclical factor (b), seasonal factor(c) and a fourth irregular variation (d) have been applied to reveal the hidden patterns. A functional approach was employed in studying these variations, in the present study.

Secular Trend

Trend is a quantitative description of the central tendency of past values. It is a smooth, regular, long-term movement of the data showing the tendency to increase or decrease over a long period. In the present study, the area under maize production, productivity, domestic consumption, volume of export, and domestic auction prices, were plotted on scatter diagrams, and the trend for annual average export auction price was observed to be linear. And hence a linear trend equation was fitted, of the form,

$$Y = a + bt + u$$

Where, Y = Price of maize per unit

t = the time variable, in years 1, 2, 3 . . . n

a, b.....= parameters

u = random error term.

for the two time periods (post green revolution and post liberalization) and also for the overall study period in the case of annual average export auction prices and annual average domestic auction prices, '*a*' and '*b*' are the parameters to be determined through least squares method.

However, a quadratic equation was also fitted of the form

$$Y = a + bt + ct^2 + u$$

Using the same variables to find if that could explain the variation better; however, with an additional parameter '*c*' to be estimated.

The Seasonal Factor

The widely used, conceptually simple method to distil the seasonal factor is the method of moving averages with constant weights equal to 1/(2m+1), (2m+1) being the length of fluctuations. In the case of seasonal fluctuations, it is generally 12 months. The moving averages were computed as,

$$X'_t = \frac{\sum_{i=-m}^{m} X_{t+i}}{2m+1}$$

The above procedure is equivalent to fitting a straight line to (2m+1) consecutive observations by the method of least squares.

In terms of X = T * S * C * I, the process of the above equation implies the separation of the trend and cyclical factors, the seasonal and random factors being averaged out. In other words, omitting time subscripts in the above equation, transforms X = T * S * C * I to

$$X' = T * C.$$

Dividing X = T * S * C * I by X' = T * C results in seasonal and random factors being separated from X = T * S * C * I as,

$$X'' = \frac{X}{X'} = \frac{T * C * S * I}{T * C} = S * I$$

The random factor in the above equation was removed by averaging over the corresponding seasons, finally resulting in the seasonal component. This fluctuates around 100 per cent and any slight discrepancy is corrected by uniform algebraic manipulations in all seasons.

The Cyclical Factor

Fourier analysis is used for the analysis of cyclical factor and the same is followed in the present study. This tool provides an assessment of the amplitude as well as periodicity of the cycles based on some parametric tests.

Harmonic Model

The harmonic model was applied to the annual price data in order to detect the presence of any long term cycles in the maize prices. In order to test the length of the cycle, Fourier coefficients need to be computed. Given a time series $X_1, X_2, X_3, \ldots X_n$ with a period of length T, the deviations of the actual value from the trend value could be represented as,

$$Y_t = 1/2\, A_0 + \sum_{j=1}^{n} \left(A_j \, Cos \frac{360\, j}{T} + B_j \, Sin \frac{360\, j}{T} \right)$$

Where Y_t denotes the series;

T denotes time,T=1,2,..,n

A_0, A_j *and* B_j are constants and are given by,

$$A_0 = \sum_{t=1}^{n} \frac{X_t}{N}$$

$$A_j = \frac{2\left[\sum_{t=1}^{n} X_t \, Cos\left(\frac{360\, j}{T} \right) \right]}{N}$$

$$B_j = \frac{2\left[\sum_{t=1}^{n} X_t \, Sin\left(\frac{360\, j}{T} \right) \right]}{N}$$

In practice, it was found more convenient to group the data as shown below for investigating a given period P, where mP was equal to N or the nearest integer below N.

	X_1	X_2	...	X_P
	X_{p+1}	X_{p+2}	...	X_{2P}
	$X_{(m-1)(p+1)}$	$X_{(m-1)(p+2)}$	...	X_{mP}
Sums	U_1	U_2	...	U_P

If a term of period P was present in the series, the column total $(U_{j,\, j=1,2,..p})$ would indicate the periodic effects, but if the remaining element was random, the effect of summing 'm' rows would be to reduce the relative contribution of that element to the column totals.

Similarly, if there are other elements with different periods, they will be out of phase in successive rows and tend to cancel out in the totals. Hence, if there were enough rows, the total (U_j) would reveal the periodic effects and would reduce marking effects, if any, resulting from random components or oscillatory components of different periods, which would prevent discernment of the periodic effect in the primary series. The Fourier coefficients A_P and B_P were computed from the formulae.

$$A_P = \frac{2\left[\sum_{j=1}^{P} U_j \, Cos\left(\frac{360\,j}{P}\right)\right]}{mP}$$

$$B_P = \frac{2\left[\sum_{j=1}^{P} (U_j \, Sin\left(\frac{360\,j}{P}\right)\right]}{mP}$$

The squares of the amplitude R_P^2 was obtained by adding Fourier coefficients A_P^2 and B_P^2. Hidden periodicities were found out by periodogram analysis. The Fourier analysis helped to compute the square of amplitude for each specified period by assuming several periods. The significance of the amplitude was tested by periodogram. The procedure for testing involves first to compute the square of the amplitude (R_P^2). If no periodic fluctuations were observed, then mean square amplitude for a random series without periodic fluctuations would be arrived at by,

$$R_m{}^2 = \frac{4\sigma^2}{N}$$

where σ^2 is the variance of the series X_t.

Then the indicator of the cycle, K was calculated as follows,

$$K = \frac{R_P^2}{R_m{}^2}$$

The above conceptual framework provided a detailed account of trends and their determinants in maize consumption, production and trade over the two time periods (post green revolution and post liberalization) and also for the overall study period.

Model Development and Specification for Indian Maize Export Demand

The purpose of this study is to examine the effects of maize exports from India. This research investigates the effect of maize exports through an estimation of a system of maize export equations.

Based on the literature review above and theoretical reasoning discussed below, the Indian maize export model is derived from supply and demand equations in this section. The supply model, showing total Indian production, is a function of ending stocks in India (which is the same as beginning stocks in the next year), the number of live animals in India, number of live animals in the rest of the world, total consumption in the rest of the world, Indian maize price substitute crop sorghum price and annual average rainfall

$$Q_S = d_0 + d_1 M_{ES} + d_2 A_{NLA} + d_3 A_{NLARW} + d_4 M_{CRW} + d_5 MP + d_6 SP + d_7 RF + \varepsilon_{1t} \quad (1)$$

where

M_{ES} is ending stocks in India,

A_{NLA} is the number of live animals in India,

A_{NLARW} is the number of live animals in the rest of the world,

M_{CRW} is total consumption in the rest of the world,

MP is Indian maize price,

SP is sorghum price which is the substitute commodity for maize

RF is Indian annual average rainfall.

The live animal variables could have been specified as price variables as well, but an overall index for the rest of the world is much harder to obtain than is the quantity figure. These variables act as expectations for maize producers of the market the following year.

The demand model is a function of Indian maize exports, total domestic consumption in India, ending stocks in the rest of the world, rest of world maize exports, annual maize trade weighted exchange rate, MP is Indian maize price , SP is the substitute crop sorghum price and RPO is the Indian population relative to rest of the world population. This equation includes the main determinants of the total domestic and world demand for Indian production.

$$Q_D = b_0 + b_1 M_{DC} + b_2 M_{RWES} + b_3 M_{RWE} + b_4 ER_{INR} + b_5 MP + b_6 M_{IE} + b_7 SP + b_8 RPO + \varepsilon_{2t} \qquad (2)$$

where

M_{DC} is total domestic consumption in India,

M_{RWES} is ending stocks in the rest of the world,

M_{RWE} is rest-of-world maize exports,

ER_{INR} is the annual maize trade weighted exchange rate,

MP is the Indian maize price,

M_{IE} is Indian maize exports,

SP is sorghum price

$RPO = \frac{PO_{IN}}{PO_{RW}}$ is the Indian population relative to the rest of the world population.

To reach the Indian maize export model from previous specifications, models (1) and (2) above are substituted into the equilibrium relation between supply and demand:

$Q_D = Q_S$, and thus, the combined equation is

$$0 = d_0 + d_1 M_{ES} + d_2 A_{NLA} + d_3 A_{NLARW} + d_4 M_{CRW} + d_5 MP + d_6 SP + d_7 RF + \varepsilon_{1t} - (b_0 + b_1 M_{DC} + b_2 M_{RWES} + b_3 M_{RWE} + b_4 ER_{INR} + b_5 MP + b_6 M_{IE} + b_7 SP + b_8 RPO + \varepsilon_{2t})$$

We put M_{IE} on left hand side

$$b_6 M_{IE} = d_0 + d_1 M_{ES} + d_2 A_{NLA} + d_3 A_{NLARW} + d_4 M_{CRW} + d_5 MP + d_6 SP + d_7 RF + \varepsilon_{1t} - b_0 - b_1 M_{DC} - b_2 M_{RWES} - b_3 M_{RWE} - b_4 ER_{INR} - b_5 MP - MP - b_7 SP - b_8 RPO - \varepsilon_{2t}$$

And

$$b_6 M_{IE} = d_0 - b_0 + d_1 M_{ES} + d_2 A_{NLA} + d_3 A_{NLARW} + d_4 M_{CRW} + d_5 MP + d_6 SP + d_7 RF - b_1 M_{DC} - b_2 M_{RWES} - b_3 M_{RWE} - b_4 ER_{INR} - b_5 MP - MP - b_7 SP - SP - b_8 RPO - \varepsilon_{2t} + \varepsilon_{1t}$$

After the algebra presented above, the coefficient b_6 is positive on the left hand side, and will not affect the expected directions that are reviewed in the next section. Dividing through by b_6 yields

$$M_{IE} = \left(\frac{d_0 - b_0}{b_6}\right) + \frac{d_1}{b_6} M_{ES} + \frac{d_2}{b_6} A_{NLA} + \frac{d_3}{b_6} A_{NLARW} + \frac{d_4}{b_6} M_{CRW} + \frac{d_5}{b_6} MP + \frac{d_6}{b_6} SP + \frac{d_7}{b_6} RF - \frac{b_1}{b_6} M_{DC} - \frac{b_2}{b_6} M_{RWES} - \frac{b_3}{b_6} M_{RWE} - \frac{b_4}{b_6} ER_{INR} - \frac{b_5}{b_6} MP - \frac{1}{b_6} MP - \frac{b_7}{b_6} SP - \frac{1}{b_6} SP - \frac{b_8}{b_6} RPO - v_t$$

Then we conclude that the estimating model will be:

$$M_{IE} = a_0 + a_1 M_{ES} + a_2 A_{NLA} - a_3 M_{DC} - a_4 M_{RWES} + a_5 A_{NLARW} - a_6 M_{RWE} + a_7 M_{CRW} - - a_8 ER_{INR} - a_9 MP - a_{10} SP + a_{11} RF - a_{12} RPO - v_t$$

where,

$$a_0 = \left\{\frac{d_0 - b_0}{b_6}\right\}, a_1 = \frac{d_1}{b_6}, a_2 = \frac{d_2}{b_6}, a_3 = \frac{b_1}{b_6},$$

$$a_4 = \frac{b_2}{b_6}, a_5 = \frac{d_3}{b_6}, a_6 = \frac{b_3}{b_6}, a_7 = \frac{d_4}{b_6}, a_8 = \frac{b_4}{b_6},$$

$$a_9 = \frac{1}{b_6}, a_{10} = \frac{1}{b_6}, a_{11} = \frac{d_7}{b_6}, a_{12} = \frac{b_8}{b_6}$$

Expected Directions and Hypothesis Tests: From the above discussion, the general specification of the estimating equation, before adding lags, is:

$$\begin{aligned} M_{IE} = {} & a_0 + a_1 M_{ES} + a_2 A_{NLA} - a_3 M_{DC} - a_4 M_{RWES} + a_5 A_{NLARW} - a_6 M_{RWE} + a_7 M_{CRW} - \\ & - a_8 ER_{INR} - a_9 MP - a_{10} SP + a_{11} RF - a_{12} RPO - v_t \end{aligned}$$

where

M_{IE} is Indian maize exports,

M_{ES} is ending stocks in India,

A_{NLA} is the number of live animals in India,

M_{DC} is total domestic consumption in India,

M_{RWES} is ending stocks in the rest of the world,

A_{NLARW} is the number of live animals in the rest of the world,

M_{RWE} is rest of world maize exports,

M_{CRW} is total consumption in the rest of the world,

ER_{INR} is the annual maize trade weighted exchange rate ,

MP is the Indian maize price,

SP is the sorghum price,

RF is Indian average annual rainfall

$RPO = \frac{PO_{IN}}{PO_{RW}}$ is the Indian population relative to the rest of the world population.

The expected signs on the variables are given in the equation above. The reasoning for each expected direction and the associated hypothesis test is given in the following:

H_{01}: $a_1 > 0$ Ha_1: $a_1 \leq 0$

The variable M_{ES} is ending stocks in India, which should have a positive effect: if M_{ES} increases, it will lead to an increase in M_{IE}, probably in the next year. Higher stocks will cause downward pressure on prices and then will cause the export market to react with higher sales.

H_{02}: $a_2 > 0$ Ha_2: $a_2 \leq 0$

The second variable A_{NLA} is the number of live animals in India. The expected sign on A_{NLA} is positive as well because an increase in A_{NLA} will infer greater exports of live animals, leading to increased feeding from maize in the importing countries, which will then increase M_{IE} of maize to support that feeding. On the other hand, the number of animals raises the domestic need for feed maize and could be negatively related to M_{IE}. The latter effect may be the more sizable influence, but this will be determined by the resulting sign on the regression results.

H_{03}: $a_3 < 0$ Ha_3: $a_3 \geq 0$

The third variable is M_{DC}, which is total domestic consumption in India. The expected sign of M_{DC} is negative, as an increase in M_{DC} will decrease M_{IE} because there is less production available for export; internal prices will rise, giving India a less competitive position in the world market.

H_{04}: $a_4 < 0$ Ha_4: $a_4 \geq 0$

H_{05}: $a_5 > 0$ Ha_5: $a_5 \leq 0$

H_{06}: $a_6 < 0$ Ha_6: $a_6 \geq 0$

H_{07}: $a_7 > 0$ Ha_7: $a_7 \leq 0$

Four variables that account for behaviour in the Rest of the World (RW) are included. M_{RWES} is ending stocks in the rest of the world, A_{NLARW} is the number of live animals in the rest of the world, M_{RWE} is rest-of-world maize exports, and M_{CRW} is total consumption in the rest of the world. The expected sign is negative on M_{RWES} and M_{RWE}, and positive on A_{NLARW} and M_{CRW}. Naturally, if ending stocks in the world (excluding India) are higher, the opportunity for Indian exports is lower and thus a negative sign is appropriate. Also, if exports from the rest of the world are higher, other things being equal, the exports from India will be lower and thus the sign should also be negative. On the positive aside, it is clear that rising world consumption will raise the exports from India. A major part of world's consumption (and in fact likely to be highly correlated) is the feed given to livestock, and so that variable should be possibly correlated but will certainly be positive as is the consumption variable.

H_{08}: $a_8 < 0$ $\quad$ Ha_8: $a_8 \geq 0$

H_{09}: $a_9 < 0$ $\quad$ Ha_9: $a_9 \geq 0$

ER_{INR} is the annual maize trade weighted exchange rate, which has an expected negative sign. If the Indian Rupee exchange rates get stronger, importing countries from India will decrease the quantities and look to other competitive countries. The variable in the model, MP, is the Indian maize price, which also has an expected negative sign, because if the Indian domestic Maize price increases, the producer will raise the amount of maize inside India. On the positive side the domestic consumers will prefer the competitive crop sorghum and hence surplus will available for exports.

H_{010}: $a_{10} < 0$ $\quad$ Ha_{10}: $a_{10} \geq 0$

There is an inverse relation between sorghum price (SP) and export of maize. The competitive crop for maize is sorghum. If the price of sorghum increases the consumer usually go for maize. In that case domestic consumption of maize will increase so that the export of maize will decrease. So the sign is negative.

H_{011}: $a_{11} > 0$ $\quad$ Ha_{11}: $a_{11} \leq 0$

RF is average annual rainfall in India , which has an expected positive sign. If the rainfall increases the maize production will increase which results in higher exports.

H_{012}: $a_{12} < 0$ $\quad$ Ha_{12}: $a_{12} \geq 0$

Here RPO represents Indian population relative to the rest of the world population. Naturally if the population is higher, the maize consumption in will also increase. So the export will reduce and thus have a negative sign. The lifestyle of the people in feeding habits towards milk products, meat and eggs which result in increase in the demand for livestock products of which the demand keeps on increasing with population pressure. To meet out the needs of the ever increasing livestock population the production as well productivity of feed is to be increased.

Estimation of Price Volatility

The issue of price volatility has assumed critical importance today in the context of agricultural trade liberalisation. One of the major arguments advanced against agricultural trade liberalisation is that it would lead to transmission of international price volatility into domestic markets.

There are various ways of measuring price instability. There is no consensus as to what constitutes the correct method of measurement. The naïve approach involves treating all price movements as indicative of instability by calculating standard deviation of the price index. This approach does not account for predictable components like trends in the price evolution process thereby overstating the uncertainty. A better and useful method of measuring instability is by using the ratio method. In this method, the instability of the series is calculated by measuring the standard deviation of log (Pt / Pt-1) over a period, where Pt is price in period 't' and Pt-1 is the price in period t-1. The third approach is the one which distinguishes between predictable and unpredictable components of price series, but the price volatility is assumed to remain time invariant. The fourth approach distinguishes not only between predictable and unpredictable components of prices but also allows the variance of unpredictable element to be time varying. Such time varying conditional variances can be estimated by using a Generalised Autoregressive Conditional Heteroscedasticity (GARCH) model (Bollerslev, 1986).

In the present study the price volatility for maize in the domestic markets was estimated through GARCH model. In analyzing the time series data the conditional variance of the forecast error term is not constant resulting in the violation of OLS assumptions. The tools described in this section differ by modeling the conditional variance, or volatility, of a variable. More efficient estimators can be obtained if heteroscedasticity in the errors is handled properly.

Autoregressive Conditional Heteroscedasticity (ARCH) models are specifically designed to model and forecast conditional variances. The variance of the dependent variable is modeled as a function of past values of the dependent variable and independent or exogenous variables. ARCH models were introduced by Engle (1982) and generalized as GARCH (Generalized ARCH) by Bollerslev (1986). These models are widely used in various branches of econometrics, especially in financial time series analysis.

The GARCH Specification

The GARCH model had two distinct specifications-one for the conditional mean and one for the conditional variance are provided and the standard GARCH (1,1) specification was presented below:

$$Y_t = \gamma_0 + \gamma_1 X_{1t} + ... + \gamma_k X_{kt} + e_t \quad (1)$$

$$\sigma_t^2 = \omega + \alpha e_{t-1}^2 + .\beta \sigma_{t-1}^2. \quad (2)$$

The mean equation (1) was a function of exogenous variables with an error term. The conditional variance equation (2) was a function of three terms namely:

(i) The mean: ω

(ii) Volatility from the previous period (measured as the lag of the squared residual from the mean equation): e_{t-1}^2 (the ARCH term)

(iii) Last period's forecast variance: σ_{t-1}^2 (the GARCH term)

An ordinary ARCH model was a special case of a GARCH specification in which there were no lagged forecast variances in the conditional variance equation. The ARCH component (α) indicating the lag of the squared residual from the mean equation and the GARCH term (β) implying the last period's forecast variance, the resultant sum of theses coefficients ($\alpha + \beta$) are presented. The sum of coefficients very close to 1 would indicate the volatility shocks are quite persistent in the series.

For the proposed research study, the volatility for the maize markets are estimated using GARCH (1, 1) process on the domestic maize markets.

Market Integration

The present study aimed to estimate the price transmission between the domestic and international maize markets. The time series on the maize prices are deflated to form real price series. In the case of domestic maize market prices, the series are deflated by wholesale price index for cereals. The US$ deflator was used to deflate the international maize a market prices. Then the prices are converted into domestic currency using official foreign exchange rate.

Stationarity

Before analyzing any time series data, testing for stationarity is a prerequisite since econometric relation between the time series has the presence of trend components (Davidson and Mackinnon, 1993). This involved testing for stationarity of the variables using tests such as Augmented Dickey Fuller (ADF) test. A stationary series is one whose parameters are independent of time, exhibiting constant mean and variance and having autocorrelations that are invariant through time. If the series is found to be non-stationary, the first differences of the series are tested for stationarity. The number of times (d) a series is differenced to make it stationary is referred as the order of integration, I(d). The ADF test mentioned above considers the null hypothesis that a given series has a unit root, i.e., it is non-stationary. The test is applied by running the regression of the following form:

$$\Delta Y_{t\,i} = \mathrm{B}\beta_1 + \delta Y_{ti-1} + \alpha_i \sum \Delta Y_{t-1} + e_t \qquad (1)$$

If the coefficient δ is not statistically different from zero, it implies that the series have a unit root, and, therefore, the series is non-stationary. The determination of order of integration of each variable is required for any time series analyses and, more importantly, for error correction equations, because each variable involved in the estimation of these models must be first differenced stationary series. To verify that the first differenced price series are indeed stationary, Augmented Dickey-Fuller (ADF) unit root tests are used. The null hypothesis of non stationarity is tested using a t-test. The null hypothesis is rejected if estimated variable is significantly negative.

The maize market price series of domestic and international markets were tested for stationarity in the above equation (1), where Y_i denoted price series of domestic and international markets and *i=1,2,...7* (1-DAVANGERE; 2-NIZAMABAD; 3- UDUMALPET; 4- CHHINDWARA; 5- KOTA 5; 6- ARGENTINA and 7- UNITED STATES)

The critical values for this test are negative and larger than the standard t values and are given in Engle and Yoo (1987) and Mackinnon (1991). If the computed value (at level) is smaller than the critical 'tau' statistics, we do not reject the null hypothesis of non-stationary series. In this case, the individual series may be integrated of order 1 or 2 i.e. I(1) or I(2) and may be more than this order. Once the variables are checked for stationarity and are of same order, integration between them can be tested using methods such as Augmented Dickey Fuller Test or Johansen Maximum Likelihood Test in a bivariate as well as multivariate framework. If the estimated value of error term exceeds critical values at one per cent, five per cent and 10 per cent levels of significance, the conclusion would be that the residual term is stationary and hence the two individual series, though non-stationary, are cointegrated in the long run.

Johansen's Multiple Cointegration Framework

It is possible that individual time series of the commodity prices may be non-stationary in levels, but a linear combination of them may be stationary indicating a long run equilibrium relationship between them (Engle and Granger, 1987). If a linear combination of two non-stationary series is stationary, then the two series are considered to be cointegrated. To test whether or not the residual term of the regression between the two time series in question is stationary, cointegration tests start with the premise that for a long run equilibrium relationship to exist between two variables it is necessary that they should have the same inter temporal characteristics.

The ADF test is supplemented by Johansen-Juselius Maximum Likelihood Method. This test is considered to be better than other cointegration approaches as it addresses endogeneity and simultaneity problems being faced in other methods in bivariate models. Also, it is important when cointegration is tested between more than two variables. In this technique, the hypothesis of presence of cointegration vector is formulated on a group of non-stationary series, as the hypothesis of reduced rank of the long run impact matrix. Likelihood ratio and maximum likelihood tests are applied to derive test statistics for the hypothesis of given number of cointegration vectors and their weights. Inference concerning linear restrictions on the cointegration vectors and their weights is performed using usual chi square methods (Johansen and Juselius, 1990 and Johansen, 1988). First, the order of integration is the same for each time series of prices, and then test for cointegration. Only variables of the same order of integration qualify for the pair wise cointegrating relationships. The specific linear combinations tested are the residuals from a static cointegrating regression such as:

$$Y_{ti} = \beta_i + \beta_i X_{ti} + Z_{ti} \qquad (1)$$

where Y_{ti} and X_{ti} are $(i = 1,2,3.,..,7)$ price series in levels and Z_{ti} is the residual term. Testing for cointegration implies testing stationarity of the residual term Z_{ti}. In the current study, the dependent variable Y_{ti} are $(i = 1,2,3,..,7)$ prices of different maize auction markets and the independent variables X_{ti} are $(i = 1,2,3,..,6)$) prices of other six maize auction markets.

For example, the cointegration equation for Udumalpet auction market prices with the other six maize auction markets prices is represented as follows:

$$UDU = \beta_1 + \beta_2 DAV + \beta_3 NZ + \beta_4 CH + \beta_5 KO + \beta_6 AR + \beta_7 US + Z_t$$

In the current study, the relationship between the different maize auction markets prices are studied through the multiple cointegration analysis under error correction framework. The integration of global markets with the domestic markets for maize auction market prices are studied in Johansen’s multiple cointegration frame work. The world maize auction markets price transmissions are analyzed through vector error correction procedures.

Granger Causality Test

Granger causality test has been used to analyze the direction and causal relations between domestic and international market. The Granger (1969) approach to the question of whether X cause Y is to see how much of the current Y can be explained by past values of Y and then to see whether adding lagged values of X can improve the explanation. Y is said to be Granger- Caused by X if X helps in the prediction of Y, or equivalently if the coefficients on the lagged X’s statistically significant.

The equation is

$$Y_t = \alpha_0 + \alpha_1 Y_{t-1} + \alpha_2 Y_{t-2} + ... + \alpha_p Y_{t-p} + \beta_1 X_{t-1} + \beta_2 X_{t-2} + ... + \beta_p X_{t-p} + e_t$$

The null hypothesis is that X does not Granger- cause Y.

Error Correction Mechanism (ECM)

An Error Correction Mechanism (ECM) is a neat way of combining the long run, cointegrating relationship between the levels variables and the short run relationship between the first differences of the variables. It also has the advantage that all the variables in the estimated equation are stationary; hence there is no problem with spurious correlation. The last step in cointegration analysis involved application of error correction mechanism. Since the procedure of differencing results in loss of valuable long run information in the data, an Error Correction (EC) term is introduced in the theory of cointegration that integrates or ties short run dynamics of a series to its long run value. The residuals obtained from the linear equation are introduced as explanatory variable into the system of variables in levels. The error correction term, thus, captured the adjustment towards long run equilibrium.

Engel and Granger (1987) demonstrated that once a number of variables are found to be cointegrated, then there existed a corresponding error correction representation which implied that changes in the dependent variable are a function of the level of disequilibrium in the cointegrating relationship (captured by the error correction term) as well as changes in other variables. The importance of including a constant term without a time trend has been addressed by Bell (1966) and Miller and Russek (1990). Based on their suggestions, ADF equations are estimated with an intercept and no time trend.

If the price series are I (1), then one could run regressions in their first differences. However, by taking first differences, we lose the long run relationship that is stored in the data which implied that use of variables in levels as well. Advantage of error correction methodology is that it incorporates variables both in their levels and first differences. By doing this, ECM captures the short run equilibrium situations as well as the long run equilibrium adjustments between prices. Even if one demonstrates market integration through cointegration, there could be disequilibrium in the short run i.e., price adjustment across markets may not happen instantaneously. It may take some time for the spatial price adjustments. ECM can incorporate such short run and long run changes in the price movements. A generalized ECM formulation to understand both the short run and long run behaviour of prices can be considered by first taking the Autoregressive Distributed Lag (ADL) equation as follows:

$$Y_t = a_{01} X_t + a_{11} X_{t-1} + a_{12} Y_{t-1} + \varepsilon_t$$

By adding and deleting Y_{t-1} , $a_{01} X_{t-1}$, rearranging terms, and using the difference equator, the above equation can be written in the ECM format as follows:

$$\Delta Y_t = a_{01} \Delta X_t + (1 - a_{12}) \left[\frac{(a_{01} + a_{11})}{(1 - a_{12})} X_{t-1} - Y_{t-1} \right] + \varepsilon_t$$

The generalized form of this equation for k lags and an intercept term is as follows:

$$\Delta Y_t = a_{00} + \sum_{i=0}^{k-1} a_{i1} \Delta X_t + \sum_{i=1}^{k-1} a_{i2} \Delta Y_{t-1} + m_0 \left[m_1 X_{t-1} - Y_{t-1} \right] + \varepsilon_t$$

where, $m_0 = \left(1 - \sum_{i=1}^{k} a_{i2} \right)$, and $m_1 = \dfrac{\sum_{i=0}^{k} a_{i1}}{m_0}$

If all the variables are I (1), i.e., they are integrated of order 1, they are stationary in first difference. Therefore, all the summations in the above equations are also stationary. Moreover, if the variables are cointegrated, the ECM term, i.e., the linear combination of variables represented in parentheses is also stationary. The a_{ij} coefficients capture the short run effects and m_j coefficients represent the stationary long run impacts of the right hand side variables. The parameter m_0 measures the rate of adjustment of the short run deviations towards the long run equilibrium. Theoretically, this parameter lies between 0 and 1. The value 0 denotes no adjustment and 1 indicates an instantaneous adjustment. A value between 0 and 1 indicates that any deviations will have gradual adjustment to the long run equilibrium values.

So the Vector Error Correction Mechanism is used to distinguish short term from long term association of the variables included in the model. When the variables are not integrated, then in the short term deviation from this long term equilibrium would feed back to the changes in the dependent variable in order to force the movement according to the long run equilibrium relationship. The long term causal relationship among the maize markets is implied through the significance of the‘t’ tests of the lagged error correction term as it contains the long term information because it is derived from the long term relationship. The coefficient of the lagged error correction term is a short term adjustment coefficient and represented the proportion by which the maize markets adjusted in response to the long run disequilibrium.

Before computing the error correction mechanism, the order of lag for the variables to be included in the models is to be ascertained. The orders of lag for the variables are chosen by the smallest Akaike Information Criterion (AIC)/ Schwartz Bayesian Criterion (SBC) of the maize auction markets price series. In the present study, all the variables are found to have minimum AIC/ SBC values at the first lag. Hence throughout the analyses, first lag of the variables are included wherever necessary.

The commodity prices are said to be integrated because of the globalization process. In view of that, the price linkages between the domestic maize auction markets and the international maize auction markets prices are studied through cointegration and VECM approach.

Profile of the Maize Crop and its Related Industry

CHAPTER IV

PROFILE OF THE MAIZE CROP AND ITS RELATED INDUSTRY

Maize is one of the most versatile emerging crops having wider adaptability. A brief account of the origin of maize crop is presented at the outset and then the forces that have led to the present level of development of the maize crop in India and in its international perspective are outlined and analysed in this chapter.

Taxonomy

Maize belongs to the tribe Maydeae of the grass family *Poaceae*. “*Zea*” (zela) was derived from an old Greek name for a food grass. The genus *Zea* consists of four species of which *Zea mays* L. is economically important. The taxonomy of maize is shown in the following Table 4.1.

Table 4.1: Taxonomy of Maize

Name	Maize
Kingdom	Plantae
Division	Magnoliophyta
Class	Liliopsida
Order	Poales
Family	Poaceae
Genus	Zea
Species	mays

Origin and Distribution

Maize or corn (Zea mays L.) is a plant belonging to the family of grasses (Poaceae). It is a plant of enormous modern-day economic importance as foodstuff and alternative energy source. It can be well said that maize (*Zea mays)* is one of the most important cereal crops in the world agricultural economy. That is why it was recognized as the “crop of future” by Nobel Laureate Dr. Norman Borlaug. Sometimes it is also appreciated as “Miracle crop” with bountiful harvests often resulting in better incomes. The high yield potential of the crop has earned it the sobriquet, “Queen of Cereals”.

There is some controversy on the origin of maize, though it is generally accepted that its centre of origin is located in Mesoamerica, primarily Mexico and the Caribbean. Maize as we know it today had never been found growing in a wild state. Its domestication, probably from a wild teostine form (Euchlaena Mexicana), is believed to have started from 6,000 to 7,500 years ago in the Mexican highlands. Archeological evidence from Mangelsdorf, Reeves, MacNeish and others (reported by Purseglove, 1975) and supported by radiocarbon dating, have indicated the existence of wild maize cobs in Mexico (5200-3400 BC), followed by a gradual extinction of wild maize in favour of modern varieties through a more intensive cultivation. This process led to the gradual transformation of teosinte to its present day form known as maize, a name which is a likely derivative of "mahis", meaning "source of life" for Tanio people, the natives known to have mastered its cultivation.

Maize was the staple food of most pre-Columbian, Mesoamerican, South American and Caribbean cultures, whose life revolved around the milpa (cornfield). The crop still associated with the Mesoamerican people’s identity. Later it spread to North and South America and was brought by Columbus to Spain, from where it was distributed throughout the world.

Maize has been introduced in Africa, and later in other tropical countries, mainly by Portuguese and Arab explorers in West and East Africa, from where it spread inland through the slave-trade routes, and later to Asia. Maize was the major cash crop on the West African Coast at the height of the slave trade in the seventeenth and eighteenth centuries, being used to provision slave ships and the forts where the slaves were assembled prior to shipment overseas. The crop was reported in India during sixteenth century, but had probably been taken at an earlier date by Portuguese. From India, it went to China and later it was introduced in Philippines and the East Indies. It is likely that the Spaniards took it to Manila from Acapulco in the sixteenth century.

Because of its wide climate adaptability maize cultivation expanded rapidly and the grain became soon a part of the local diet as a diversification of traditional root crops (cassava, yams, sweet potatoes) and various small grains. Maize is now cultivated in more than hundred countries.

The maize production has increased everywhere over the past 45-50 years. The main reason for this development were the worldwide promotion for the crop (Green Revolution), improved biotechnological research and the release of high- yielding varieties, and improved hybrid seeds in many developing countries.

Africa

The large and sudden rise in maize cultivation in some African countries-both in terms of yield and in area planted-since the 1980s followed the introduction of new hybrids from the USA and South America, all of them classified as White Southern Dents. The local yellow maize in Africa is derived from early introductions of Caribbean flints and from later ones through CIMMYT in Mexico. In Kenya and Tanzania, where there is a bi-modal rainfall pattern, the predominant maize types adapted to a shorter growing season. In West and Central Africa where this bi-modal rainfall pattern does not exist the cultivars with a longer growth cycle adapted best (Ristanovic, 2001).

The expansion of maize on the African continent has several reasons. First, its taste has been easily accepted by the local population and therefore, it could rapidly replace traditional starchy food like sorghum and millets. It also became important when foodstuffs had to be transported to feed labour and population which were not self–sufficient. Additional reasons for this rapid adoption and expansion include (Purseglove, 1975, Pingali and Heisey, 1999):

- It gives one of the highest yields per person hour of labour spent on it;
- It provides nutrients in a compact form; it is easily transportable;
- The husks give protection against birds and rain;
- It is easy to harvest and does not shatter;
- It stores well if properly dried;
- It can be harvested over a long period, first as immature cobs, but can be left standing in the field at maturity before harvesting;

- Cultivars with different maturing periods are available;
- In terms of taste, many people prefer maize to their local cereals.

About two thirds of all African maize is produced in eastern and southern Africa. South Africa is the largest producer with about 35 per cent of the total regional production. Nigeria is the second most important producer followed by Ethiopia, Tanzania and Kenya. Malawi has made an enormous progress due to the start of an important seed distribution program. The tremendous drop in production since 2000 in Zimbabwe is due to the political unrest in the country.

In sub-Saharan Africa maize production extends over approximately 20 million ha, and the total annual production is about 25 million tons (6 per cent of total world production). In North Africa and the Middle East the only maize producing countries of importance are Egypt and Turkey; it accounts for approximately 15 per cent of all African maize production,

West and Central Africa account for hardly 5.2 million tons. While relatively less important than in eastern and southern Africa, maize still provides a major source of calories, especially in parts of Nigeria, Ghana, Benin and Ivory Coast, and is a major component in the local diet. In these countries maize is almost exclusively grown on small family farms.

Latin America

Except in Brazil and Argentina where part of the crop is cultivated in big estates, most maize in Latin America is grown by small farmers for local consumption. Local maize is grown from sea level to the Altiplano (over 2,000 m) in Guatemala, 2,700 m in Mexico and even to 3,800 m elevation near Lake Titicaca in Bolivia and Peru. It is found from desert oases to zones with more than 5,000 mm rainfall along the western coast of Columbia, and up to about latitude 42^0 S in Chile. At higher latitudes the frost free growing season is too short and the crop does not mature, making it only useful for fodder.

Maize yields under traditional farming in Latin America remain relatively low and suffer from the too limited availability of adapted seed varieties and shortage of labor (Sain and Lopez-Perreira, 1999).

Asia

In south-eastern Asia, maize has never been as dominant as in Africa and South America, mainly because rice was plentifully available as a staple food. Only where the region was too dry for rice production has maize taken its place in the local food economy.

Yield increases as part of the green revolution have nevertheless been most spectacular in Asia, especially between 1965 and 1985, because this resulted directly from the introduction of high-yielding cultivars and a more efficient use of inputs. By the late 1980s, however, crop yields had reached a point of diminishing returns to further intensification, mainly due to a combination of factors such as: degradation of land due to intensive cultivation, declining infrastructure and research investments; and increasing opportunity costs of labour. Additional factors that were responsible for local fluctuations were: (a) market and road infrastructure, and (b) subsidy policies. Yields are nowadays maintained at reasonable levels by the substitution of better knowledge and management skills for higher levels of input use, in particular related to appropriate timing and methods of fertilizer application (Singh and Morris, 1997).

India

Post-Columbian introduction of maize into India by the Portuguese in the sixteenth century or later has been accepted by most of the maize workers. But Carl L. Johannessen (1989) prove this conventional theory wrong and argues that in southern India and China, featuring maize and other new world plants seems to stumbled across some very precise carvings at temples in the Karnataka region of India, which were built during the Hoysala Dynasty, between the 10th and 13th century. In the late sixteenth century it spread all over India, where the people of the mountains were highly dependent on it, and it is the major staple in the north, in the Punjab, in the northwestern provinces. George Watt (1908), a botanist who studied India towards the end of nineteenth century, noted that Makka, that is, maize, was extremely wide spread and was essential for the common people.

Vernacular Names

Bhutta (Bengali), Makai (Gujarati), Maka (Hindi, Marathi, Oriya), Musikinu jola (Kannada), Makaay (Kashmiri), Cholam (Malayalam), Makka Cholam (Tamil), Mokka jonnalu (Telugu)

Botanical Description

Maize is an annual plant, which usually grows to a height of one meter to 3 meters or more in some cases. It belongs to family Gramineae and Genus Zea. Maize is normally a monoccious plant having two types of inflorescence, the female inflorescence which develops into an ear (Cob) the male flowers which contains male inflorescence. The male flowers are borne in a cluster (tassel) on top of end of the stem as a terminal panicle, while the female flowers are borne inside the young cobs which spring from the nodes on the stem usually located about midway on the stalk. Maize is divided into seven groups based on the character of kernels.

Geographic Distribution

Maize is a versatile crop grown over a range of agro-climatic zones. In fact the suitability of maize to diverse environments is unmatched by any other crop. It is grown from 58° N latitude to 40° S latitude, from below sea level to altitudes higher than 3000 m, and in areas with 250 mm to more than 5000 mm of rainfall per year (Shaw, 1988; Dowswell *et al.*, 1996) and with a growing cycle ranging from 3 to 13 months (CIMMYT, 2000). Maize is cultivated throughout the world and occupies the third position next to rice and wheat in area and production. USA, China, Brazil, Mexico, India, Romania, Philippines, Indonesia are some of the important countries cultivate maize crop. In India traditional areas viz. Bihar, Madhya Pradesh, Rajasthan, Uttar Pradesh and the non-traditional areas viz. Karnataka, Gujarat, Andhra Pradesh, Jammu & Kashmir, Himachal Pradesh and Maharashtra are important states that cultivate maize.

Soil Requirement

Deep, fertile, rich in organic matter and well drained soils are the most preferred ones for the crop; however, maize can be grown on a variety of soil types. The soil should be medium textured with good water holding capacity. The crop is very sensitive to water logging and since it is mainly grown during rainy season, care should be taken to assure that water does not stagnate on the soil surface for more than 4-5 hours. Loamy or silty loam soil or silty clay loam soil having fairly permeable sub soil is ideal soil types. Thus, the ideal soil is neither clayey or sandy and has a pH between 6.5 and 7.5 along with an exchangeable capacity of around 20 milli-equivalent/100g, base saturation of 70 to 90 per cent, bulk density of about 1.3 g/cc and water-holding capacity of about 16cm/m depth

Climatic Conditions

Maize cultivation requires warm weather, fertile and well drained soils. It is adapted to grow under diverse climatic conditions. Temperature requirement for germination is 21°C, and for growth, 32°C. Extremely high temperature and low humidity during flowering stage damages the foliage, resulting in poor grain formation. This crop requires a well-distributed rainfall. Therefore, in India, major maize cultivation is taken up in rain-fed conditions, i.e., around 80 to 82 per cent of the annual production comes from the *kharif* season whereas the remaining production comes from *rabi* and summer seasons. Maize is highly susceptible to water logging and moisture stress conditions, particularly during its early stages of growth.

Types of Maize

There are various types of maize, generally classified by properties of their grain endosperm. The most common types of maize include flint, flour, dent, popping, soft, sweet and waxy (Knott *et al.,* 1995). The physical appearance of each grain type was determined by its pattern of the endosperm composition, as well as, quantity and quality of the endosperm.

Zea mays indurata or ‘Flint corn’

Kernel is soft and starchy in the center and completely enclosed by a very hard outer layer. The kernels are usually rounded but are sometimes short and flat. Colour may be white or yellow. This is the type most commonly cultivated in India.

Zea mays indentata or 'Dent corn'

About 95 per cent of production in USA is dent corn. Kernels have both hard and soft starches. The hard starch extends on the sides and the soft starch is in the center and extends to the top of the kernels. In the drying and shrinking of the soft starch, various forms and degrees of indentation result.

Zea mays everta or 'Pop corn'

It possesses exceptional popping qualities. Size of the kernels is small but the endosperm is hard. When they are heated, the pressure built up within the kernels suddenly results in an explosion and the grain is turned inside out.

Zea mays saccharata or 'Sweet corn'

Grown for food and harvested at 70 per cent moisture content. Kernels possess a considerable amount of sugar, which absorbs water, making the cells turgid. On drying, these cells collapse, making the grains shriveled or wrinkled. It has sweeter taste than other corns. It is also a good source of vitamin C and A.

Zea mays amylacea or 'Soft corn'

Kernels are soft and of all colours, but white and blue are the most common. Kernals are easy to grind. Primarily used by natives of Andean Highlands of South America.

Zea mays tunicata or 'Pod corn'

The pod corns are characterized by having each kernel enclosed within a pod or husk. It is a primitive type of corn, having less importance.

Zea mays Ceretina Kulesh or 'Waxy Corn'

Due to waxy appearance of the kernel, it is called as waxy corn. The starch is entirely amylopectin whereas dent has 78 per cent amylopectin and 22 per cent amylose. Hybrids of waxy are raw materials for wet milling starch industry for textile and paper sizing and corn oil.

Composition of Maize

In the last one decade, it has registered the highest growth rate among all food grains including wheat and rice because of newly emerging food habits as well as enhanced industrial requirements. Maize is a crop par excellence for food, feed and industrial utilization. The composition of edible portion of maize (dry) is given in Table 4.2.

Table 4.2: Composition per 100g of Edible Portion of Maize (Dry)

Calories	342.0	Calcium (mg)	10.0
Moisture (g)	14.9	Iron (mg)	2.3
Carbohydrates (g)	66.2	Potassium (mg)	286.0
Protein (g)	11.1	Magnesium (mg)	139.0
Fat (g)	3.6	Copper (mg)	0.14
Fiber (g)	2.7	Amino acids (mg)	1.78
Minerals (g)	1.5	Riboflavin (mg)	0.10
Phosphorus (mg)	348.0	Thiamine (mg)	0.42
Sodium (mg)	15.9	Vitamin C (mg)	0.12
Sulphur (mg)	114.0	Carotene (mg)	90.0

Source: Gopalan *et al.*, 2007.

However, it is deficit in essential amino acid, lysine and tryptophan. To overcome this deficiency, quality protein maize (QPM) with sufficiently higher quantity of lysine and tryptophan has been developed.

Important Varieties of Maize Grown in India

In India considerable work has been done for development of speciality corns such as sweet corn, pop corn, baby corn, quality protein maize with high lysine and tryptophan, green eared corn, high oil corn, waxy-corn, fodder maize, etc. A list of the varieties released in each of these speciality corn types is given below in Table 4.3.

Table 4.3: Varieties of Maize Released under Specialty Type in Maize

Type of Maize	Varieties Developed and Released in India
Sweet Corn	Madhuri, Priya Sweet Corn
Pop Corn	Amber Pop Corn, VL Pop Corn
Baby Corn	Co 1, Him 123, Early Composite, VL 64, PEHM-1 & PEHM-2 etc.
Green eared Corn	Harsha, Ashwini, Varun, Rohini, Megha
Quality Protein Maize	Shakti-1, Shktiman-1, and Shktiman-2.
High Starch Corn	Ganga 111, Histarch, Deccan 103, Deccan 105,Trishulata, Sheetal, paras.
High Oil	HOP-1, HOP-2.
Fodder Maize	African tall, PFM-66, J-1006.

Source: Directorate of Maize Research.

In India, Maize is cultivated throughout the year in different parts of the country. The varieties suitable for different agro-climatic conditions have been developed and are grown in various states as *kharif*, *rabi* or summer crops. Varieties grown in various states are given in Table 4.4.

World and Indian Scenario

Importance of any crop can be judged by its area, production, productivity, utilization and share in trade. Maize is grown all over the world, in more than 100 countries. It is one of the major crops in America, Africa and Asia. United States of America is the major producing country. India also contribute major share to the production of maize.

Area under Maize Crop in Major Cultivating Countries

It has been reported that during the year 2013, the cultivated area under maize in the world was 1,79,750 thousand hectares. The number of maize producing countries in the world has been increasing since 1950 and at present there are more than 110 such countries. Among the principal maize producing countries in the world, China occupies the first place in terms of area with a share of 20.29 per cent, followed by USA, Brazil, European Union, India, Mexico, Ukraine, Nigeria, Tanzania and Argentina with the share

Table 4.4: Varieties Grown in Different States of India

Sl.No.	State	Varieties
1	Andhra Pradesh	Ashwini, Harsha, DHM-15, Varun, DHM-103, Trashulata, Amber, Popocorn, Madhuri.
2.	Assam	Vijay, Navjot, NLD, Kishan, Ganga-5, Rajendra, Macca-1.
3.	Bihar	Vijay composite, Ganga white-2, Ganga-5, Rajenndra HYV, Diyara Composite
4.	Gujarat	Gujarat Maize-1, Gujarat Maize-2, Gujarat Maize-3, Gujarat- safed-2, Ageti-6, Ganga-5.
5.	Himachal Pradesh	Early Composite, Paravati, Naveen Composite, Him 123, Sartaj, Popcorn.
6.	Jammu & Kashmir	Maize GS-2, HIM 123, Apna Makka, Pioneer Series, Kanchan series, Navjot, Mansor, C-6, C-8, C-15.
7.	Karnataka	Agsun-126, AP-407, AB 2001-2002,Deccan 103, CMH-6644, Ganga –11, MMH 3816, VMH-108, Laxmi-4950, Vijay, INH-666, Kanaka, Swarna, VMH-869, G.K.Series, MH Series, VMH Series, Kaveri Series, Pioner.
8.	Madhya Pradesh	Ganga (White)-2, Ganga 5 & 11, Macca-101, 103. M.D.II, M-103&105, Chandan M-3, Navjot, Pusha 2, Mopset, Surya-11, Jawahar Maize-81
9.	Maharashtra	MSSC-1100
10.	Orissa	Bijay, Ganga-1, Ganga-5, Ganga-101,Kishan,Vikaram.
11.	Punjab	F-9572-A,Paras,Prabhat,Kesari,Punjab Sathi.
12.	Tamil Nadu	K1, K2, Col, COH-I, COH-2 ,COH(M)4, Ganga-5, DECCAN, COBC1.
13.	Uttar Pradesh	Ganga-2, Ganga-11, Tarun, Naveen, Kanchan, Sweta, D-765, Surya, Azad, Utlam, Nav Jyoti, Mahi Kanchan, Meerut Pili, Jaunpuri, Sartaz, Prakash, Dacan, Prabhat, Gaurav.
14.	West Bengal	Bijay, Ganga-2, Ganga-5, Ganga-101, kishan, Vikaram.

Source: DEMIC,2007

of 19.74, 8.73, 5.42, 5.23, 3.84, 2.68, 2.36, 2.23 and 1.89 per cents respectively (Table 4.5). India occupies the fifth place in terms of area with an area of 94 lakh ha.

Table 4.5: Area under Maize in Major Cultivating Countries during 2010-2014

('000 hectares)

SI.No.	Country	2010-11	2011-12	2012-13	2013-14	Percentage to world
1.	China	32,500	33,540	35,030	36,318	20.29
2.	United States	32,960	33,989	35,360	35,478	19.74
3.	Brazil	13,800	15,200	15,800	15,700	8.73
4.	European Union	8,341	9,103	9,715	9,741	5.42
5.	India	8,600	8,800	8,910	9,400	5.23
6.	Mexico	7,020	6,070	6,896	6,900	3.84
7.	Ukraine	2,648	3,544	4,370	4,825	2.68
8.	Nigeria	5,000	5,150	4,160	4,250	2.36
9.	Tanzania	3,051	3,288	4,118	4,000	2.23
10.	Argentina	3,750	3,600	4,000	3,400	1.89
11.	others	46,968	49,892	49,217	49,738	27.67
	World	**1,64,638**	**1,72,176**	**1,77,576**	**1,79,750**	**100.00**

Source : USDA, 2014.

Maize is grown over a great portion of China, with the major growing areas located in the northeast and south central regions of the country. Minor growing areas lie between the two major areas, serving to connect the two. Maize on the north China plain is planted from the first of April to the middle of June. The harvesting of maize starts in mid-August and runs through the middle of October. For most of southern China, maize is planted from the first of February through the middle of April. Maize harvest runs from the first of July through the end of August.

Maize is grown throughout the United States Midwest, with concentration mostly around the states of Iowa and Illinois. There are minor growth areas along the East Coast, but the vast majority of U.S. maize is grown in the central maize belt. Maize planting in the mid-west begins in mid-April and runs through the end of May. Maize silks during the months of July and August, and harvest usually runs from the first of October through the end of November.

Maize in Brazil is grown mostly in the eastern region of the nation. The state of Parana produces 18 percent of the nation's total maize, with the state of Rio Grande Do Sul producing 13 percent of the nation's total maize. For the majority of Brazil, maize is planted from the first of October through the end of December. Maize is harvested from around the first of February through the end of June.

To some degree maize is grown throughout all of Mexico, with major production areas concentrated to the greatest extent in the southern regions of the country. The state of Jalisco leads the country in maize production, accounting for 15 per cent of the total maize produced in Mexico. For most of Mexico, maize is planted from the first of May through the end of June. It then silks from mid-July through mid-August. Mexican maize harvest begins around the first of October and runs through the end of December.

The world's area under maize was 112.5 million ha. in 1970 and 179.8 million ha. in 2013. Comparative picture is shown in Table 4.6. Among the countries growing maize, China occupies first place in terms of area and the increase in area was 36.28 per cent during the post green revolution period. It was doubled (72.61 %) during the post liberalization and tripled (129.41 %) during the overall study periods. Similarly, the countries like Nigeria and Tanzania also has exhibited more than 200 per cent increase in area during 1970 to 2013. India's area under maize presents appreciable increase during the period 1970 to 2013 and the world's maize area exhibited a significant rise. While the world maize area increased by 59.75 per cent, India's rose by 60.63 per cent during the overall study period. India's maize area was more or less stagnant with 0.14 per cent increase during the post green revolution period. The increase in area was more or less equal during both the post liberalization (57.64 %) and the overall study periods (60.63 %). In absolute terms, India's total area in 1970 was 5852 thousand ha. which increased to 9400 thousand ha. in 2013.

Table 4.6: Comparative Picture of Area under Maize in the Top Ten Growing Countries during 1970-2013

(in '000 hectares)

SI.No	Country	1970	1991	PGRP % Increase	1992	2013	PLP % Increase	OSP % Increase
1.	China	15,831	21,574	36.28	21,040	36,318	72.61	129.41
2.	United States	23,212	27,851	19.99	29,169	35,478	21.63	52.84
3.	Brazil	10,550	14,030	32.99	12,400	15,700	26.61	48.82
4.	India	5,852	5,860	0.14	5,963	9,400	57.64	60.63
5.	Mexico	8,000	6,995	-12.56	7,536	6,900	-8.44	-13.75
6.	Nigeria	1,260	3,393	169.29	3,371	4,250	26.08	237.30
7.	Tanzania	1,015	1,850	82.27	1,700	4,000	135.29	294.09
8.	Argentina	4,066	2,400	-40.97	2,450	3,400	38.78	-16.38
	World	**1,12,523**	**1,32,498**	**17.75**	**1,33,080**	**1,79,750**	**35.07**	**59.75**

Note: PGR-Post Green Revolution period, PLP-Post Liberalisation period, OSP-Overall study period

Source: USDA, 2014.

Area of Maize Crop in Major States of India

Maize in India is grown in small, inland pockets throughout the country. It is grown in almost all the states of the country, prominently northern and western states throughout the year for various purposes including grain, fodder, green cobs, sweet corn, baby corn, pop corn in peri-urban areas. In India, Maize is usually planted from around mid-May through the end of July. Maize harvest can be expected to begin around the first of November and run through the end of January. During 2011-12, more than 80 per cent of the area under maize was concentrated in nine states among which Karnataka occupied the first place in terms of area (1288 thousand hectares) with a share of 14.7 per cent, followed by Rajasthan, Maharashtra, Madhya Pradesh, Uttar Pradesh, Andhra Pradesh, Bihar, Gujarat and Jammu & Kashmir with the share of 13.0, 10.1, 9.5, 8.6, 8.5, 7.4, 5.7, and 3.5 per cent respectively (Table 4.7).

Table 4.7: Area under Maize in Major Cultivating States of India during 2009-2012

('000 hectares)

SI.No.	State	2009-10	2010-11	2011-12	Percentage to the total
1.	Karnataka	1,349	1,240	1,288	14.7
2.	Rajasthan	1,046	1,097	1,143	13.0
3.	Maharashtra	881	794	891	10.1
4.	Madhya Pradesh	863	832	831	9.5
5.	Uttar Pradesh	787	709	754	8.6
6.	Andhra Pradesh	864	783	744	8.5
7.	Bihar	675	632	646	7.4
8.	Gujarat	516	497	501	5.7
9.	Jammu & Kashmir	314	311	308	3.5
10.	Himachal Pradesh	294	295	297	3.4
11.	Tamil Nadu	281	244	231	2.6
12.	Others	392	1,119	1,148	13.1
	India	**8,262**	**8,553**	**8,782**	**100**

Source: Statistical Year Book, India 2013.

Maize is an important commercial crop in Karnataka. Its adoption became widespread during the green revolution period and its acreage has increased from then on. The districts of Chitradurga, Davanagere, Shimoga, Bellary, Belgaum and Haveri showed a slow but stable increase in area under Maize. Rajasthan (13 %) occupied the second position in area. The arid lands of Rajasthan are specially suited for maize cultivation and it is grown in Udaipur, Bhilwara, Dungurpur, Chittaurgarh and Banswara districts.

Maharashtra with 10.1 per cent of the area under maize in India has captured the next position. The total area under maize crop in Maharashtra, during 2011-12 was 891 thousand hectares. Maize is grown in all the districts of Maharashtra with varying extent. The major maize growing districts are Jalgaon, Aurangabad, Nasik, Solapur, Ahmednagar, Jalna, Dhule, Nandurbar, Kolhapur and Sangli.

Madhya Pradesh has accounted for 9.5 per cent of the total area under maize in India. The major maize growing districts are Mandla, Ujjain, Indore, Ratlam and Jhabua. In Uttar Pradesh (8.6 %) maize is grown in as many as 25 districts but Bulandshahar, Jaunpur, Ghaziabad, Bahraich, Farrukhabad and Gonda are the major maize growing districts.

Andhra Pradesh with a share of 8.5 per cent of the total maize area in India occupied sixth position. Maize is mainly grown in Karimnagar, Warangal, Medak, Nizamabad, Adilabad and Randgareddy districts of Andhra Pradesh. Bihar occupied seventh position with 7.4 per cent share followed by Gujarat (5.7 %), Jammu& Kashmir (3.5 %), Himachal Pradesh (3.4 %), Tamil Nadu (2.6 %) and others (13.1 %). Tamil Nadu ranked eleventh with 231 thousand hectares. Maize is mainly grown in Perambalur, Dindigul, Coimbatore, Salem, Erode, Virudhunagar, Villupuram, Theni, Tiruchirapalli and Tirunelveli districts. These districts together contribute 90 per cent of the total area and production of maize in Tamil Nadu

All India Coordinated Research Project (AICRP) on maize was launched in 1957 with the objective to develop and disseminate genetically superior cultivars and production / protection technologies. AICRP organizes interdisciplinary, interinstitutional, co-operative and systematic testing of newly developed cultivars of both public and private sectors for different agro-climatic zones of the country. The project resulted in refining efforts in varietal improvement. Since 1961, a total number of 187 cultivars including single cross hybrids, composites and multiple parent crosses have been released nationwide. In India, maize is traditionally grown in monsoon (*Kharif*) season, which is accompanied by high temperature ($< 35^0$C) and rainfall. However, with the development of new cultivars and appropriate production technology, winter cultivation of maize has emerged as a viable alternative.

Productivity

The average productivity rate is increasing ever since 1970 and the estimated global average productivity in 2013-14 was 5500 kg per hectare. The productivity rate in New Zealand is hovering around 10.5 to 11.5 tonnes per ha. which is more than double the global average. On the productivity front, the top ten countries are New Zealand, Chile, Jordan, United States, Canada, Switzerland, Turkey, Egypt, Argentina and Taiwan. The productivity rates of top six countries are almost double the world average (Table 4.8).

From the table, it could be seen that New Zealand with only 18000 hectares of area under maize during 2013-14 ranks first in productivity with 11220 kg/ha. China ranks fourteen in productivity while ranking first in area under maize. Similarly, while ranking fifth in area, India ranks fifty fifth position in productivity with an average yield rate of 2450 kg / ha. which is half of the world average. The countries with more area under maize have lesser productivity whereas the countries with lesser area have greater productivity.

Table 4.8: Productivity of Maize in the Top Ten Growing Countries during 2010-2014

(Kg/ha)

SI.No.	Country	2010-11	2011-12	2012-13	2013-14
1.	New Zealand	10,500	11,050	11,110	11,220
2.	Chile	11,980	10,740	10,620	10,140
3.	Jordan	14,500	20,000	10,000	10,000
4.	United States	9,590	9,240	7,740	9,970
5.	Canada	9,750	8,930	9,210	9,590
6.	Switzerland	9,600	9,440	9,190	9,190
7.	Turkey	7,350	8,000	8,380	8,790
8.	Egypt	7,650	7,860	7,730	8,120
9.	Argentina	6,720	5,830	6,750	7,350
10.	Taiwan	5,000	4,290	6,890	6,670
11.	Others	3,759	4,031	4,009	4,224
	World	**5,080**	**5,170**	**4,890**	**5,500**

Source : USDA, 2014.

The productivity rate in India as well as world exhibited a significant rise during the period 1970 to 2013. While the world maize productivity increased by 131.09 per cent, India's rose by 91.41 per cent. Comparative picture is shown in Table 4.9. Among the countries growing maize, New Zealand occupies first place in terms of productivity and the increase was 33.25 per cent during 1970 to 2013. Many of the maize producing countries had registered tremendous increase in productivity rate but the area under maize in these countries was very low. In absolute terms, the average productivity rate is increasing ever since 1970 (1280 kg per hectare) and the estimated all India average productivity in 2013 was 2450 kg per hectare. The percentage increase in productivity rate during the overall study period was (91.41 %) much higher than that of during the post green revolution period (7.81 %). On aggregation the productivity rate has increased more than eleven times than that of during the post green revolution period. Similarly, the world's average productivity of maize was 2380 kg per hectare in 1970 and 5500 kg per hectare in 2013.

Table 4.9: Comparative Picture of Productivity of Maize in the Top Ten Growing Countries during 1970-2013

(in kg/ha.)

SI.No.	Country	1970	1991	PGRP % Increase	1992	2013	PLP % Increase	OSP % Increase
1.	New Zealand	8,420	9,630	14.37	8,790	11,220	27.65	33.25
2.	Chile	3,230	8,500	163.16	8,490	10,140	19.43	213.93
3.	United States	4,540	6,820	50.22	8,250	9,970	20.85	119.60
4.	Canada	5,280	6,710	27.08	5,700	9,590	68.25	81.63
5.	Switzerland	6,110	8,370	36.99	5,840	9,190	57.36	50.41
6.	Turkey	1,600	3,550	121.88	3,560	8,790	146.91	449.38
7.	Egypt	3,790	6,390	68.60	6,000	8,120	35.33	114.25
8.	Argentina	2,440	4,420	81.15	4,160	7,350	76.68	201.23
9.	Taiwan	2,480	5,060	104.03	4,650	6,670	43.446	168.95
10.	India	1,280	1,380	7.81	1,680	2,450	45.83	91.41
	World	**2,380**	**3,720**	**56.30**	**4,020**	**5,500**	**36.82**	**131.09**

Note: PGR-Post Green Revolution period, PLP-Post Liberalisation period, OSP-Overall study period

Source: USDA, 2014.

Productivity of Maize in Major States of India

The productivity rates in seven states of India are higher than that of Indian average of which Tamil Nadu leads with 6040 kg. per hectare (Table 4.10). Tamil Nadu occupies first position in productivity though it ranks eleventh in area (Table 4.7). Karnataka ranks fifth in productivity while ranking first in area. On the yield front, the same trend is observed in India and world.

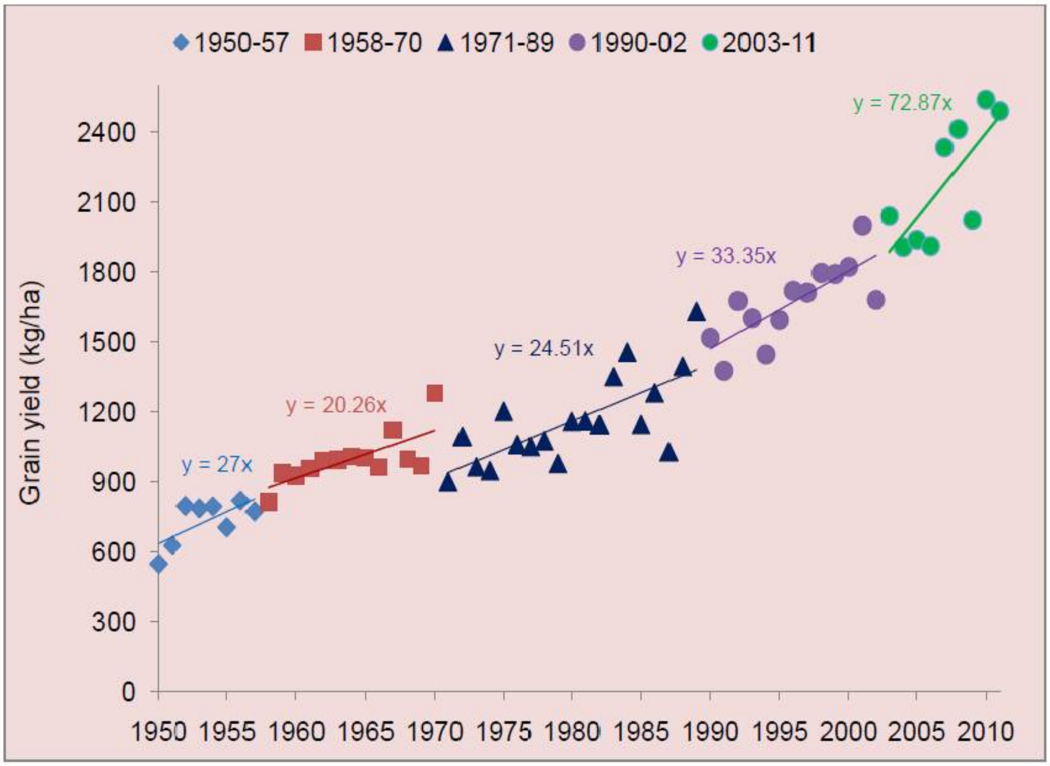
Table 4.10: Productivity of Maize in Major Growing States of India during 2009-2012

(Quintals/ha)

SI.No.	State	2009-10	2010-11	2011-12
1.	Tamil Nadu	46.9	44.6	60.4
2.	Andhra Pradesh	35.3	53.2	42.3
3.	Punjab	34.2	36.9	39.8
4.	West Bengal	39.4	39.8	37.2
5.	Karnataka	24.3	34.5	30.3
6.	Maharashtra	23.0	29.2	27.6
7.	Haryana	22.5	19.0	26.7
8.	Himachal Pradesh	18.4	22.6	24.3
9.	Bihar	23.4	22.3	23.9
10.	Orissa	21.6	25.5	20.6
11.	Sikkim	16.7	16.5	16.6
12.	others	35.5	44.3	43.3
	Total	**20.2**	**25.4**	**24.5**

Source: Statistical Year Book, India 2013.

For improving the productivity, maize improvement research in India has been very dynamic since last six decades. Major emphasis was given from 2000 onwards towards development of single cross hybrids (SCHs). Since then more than 80 SCHs have been developed and released. These hybrids have been widely adopted by farmers with the result that maize productivity attained unprecedented rate of enhancement touching 73 kg/ha/year which is 2-3 times higher than the productivity improvement rate witnessed between 1950 and 2000 (Figure 4.1). This made maize very remunerative crop and its cultivation extended in nontraditional areas in southern India.



Source: Project Director Review 2012-13, DMR, 2013.

Note: The Values Indicated Inside Graph Indicate Annual Rate of Improvement in Maize Yield in kg/ha./year

Fig.4.1. Maize Productivity Trend in India during different Phases (1950 - 2010)

World Maize Production

Maize is widely grown all over the world and a greater weight of maize is produced than the other grains. The worldwide production of maize is more than 989 million tonnes. It is processed and prepared in several form according to the country. The details on production of maize in top ten nations in the world are provided in Table 4.11. World production has been dominated by USA where output peaked to nearly 354 million tonnes during 2013-14, followed by China with 218 million tonnes; the highest output achieved by that country in the past decade, Brazil follows at a distant third with 79.3 million tonnes, European Union with 64 million tonnes, Ukraine with 31 and Argentina with 25 metric tonnes. United States is the leading producer of maize accounting for 35.78 per cent of world production in 2013-14 and its annual productivity was 3,53,715 thousand tonnes which was the greatest production and still United states is the leading country for maize production.

Table 4.11: Production Status of Maize in the Top Ten Producing Countries during 2010-2014

(‘000 MT)

SI.No.	Country	2010-11	2011-12	2012-13	2013-14	Percentage to total
1.	United States	316,165	313,949	273,832	353,715	35.78
2.	China	177,245	192,780	205,614	218,490	22.10
3.	Brazil	57,400	73,000	81,500	79,300	8.02
4.	European Union	58,265	68,118	58,866	64,190	6.49
5.	Ukraine	11,919	22,838	20,922	30,900	3.13
6.	Argentina	25,200	21,000	27,000	25,000	2.53
7.	India	21,730	21,760	22,260	24,190	2.45
8.	Mexico	21,058	18,726	21,591	22,400	2.27
9.	South Africa	10,924	12,759	12,365	14,750	1.49
10.	Canada	12,043	11,359	13,060	14,200	1.44
11.	others	1,23,970	1,33,029	1,31,596	1,41,431	14.31
	World	**8,35,919**	**8,89,318**	**8,68,606**	**988,566**	**100.00**

Source :USDA, 2014.

The maize production of United States is more than 1.6 times that of China, the world's second largest maize producer which accounts for 22.10 per cent of world production. The province of Jilin is the largest maize producing state in China, followed by Shandong the second largest maize producing province.

The production of maize in India as well as world exhibited a significant rise. World production increased by 268.32 per cent during the overall study period, while India’s production enhanced by 223.14 per cent during 1970 to 2013. India’s production has substantially contributed to world production with an increase of more than 3 folds.

The production of maize is increasing ever since 1970 and the estimated all India production in 2013 was about 24 million tonnes. The percentage increase in production during the post liberalization period was (142.09 %) much higher than that of during the post green revolution period (7.67 %). On aggregation the productivity rate has increased around thirty times during the overall study period than that of during the post green revolution period. In absolute terms, India's production in 1970 was around 7.5 million tonnes which increased to 24 million tonnes in 2013. Similarly, the world's production of maize was about 268 million tonnes in 1970 and about 989 million tonnes in 2013. Comparative picture is shown in Table 4.12.

Table 4.12:Comparative Picture of Production of Maize in the Top Ten Producing Countries during 1970-2013

(in '000 MT)

SI.No	Country	1970	1991	PGRP % Increase	1992	2013	PLP % Increase	OSP % Increase
1.	United States	1,05,472	1,89,868	80.02	2,40,719	3,53,715	46.94	235.36
2.	China	33,030	98,770	199.03	95,380	2,18,490	129.07	561.49
3.	Brazil	14,130	30,800	117.98	29,200	79,300	171.58	461.22
4.	Argentina	9,930	10,600	6.75	10,200	25,000	145.10	151.76
5.	India	7,486	8,060	7.67	9,992	24,190	142.09	223.14
6.	Mexico	8,900	14,689	65.04	18,631	22,400	20.23	151.69
7.	South Africa	8,600	3,277	-61.90	9,997	14,750	47.54	71.51
8	Canada	2,634	7,413	181.44	4,883	14,200	190.80	439.10
	World	**2,68,078**	**4,92,950**	**83.88**	**5,35,605**	**9,88,566**	**84.35**	**268.32**

Note :PGR-Post Green Revolution period, PLP-Post Liberalisation period, OSP-Overall study period

Source: USDA, 2014.

Maize Production in Major States of India

India is one of the major producing countries of maize. During 2011-12, more than half of the maize output in India was contributed by the four states viz., Karnataka, Andhra Pradesh, Maharashtra and Tamil Nadu. The details on state-wise production of maize are depicted in Table 4.13 and Figure 4.2. Karnataka contributed 18.8 per cent of total Indian maize production from 14.7 per cent of maize area of the country followed by Andhra Pradesh with a share of 16.8 per cent of total production. Karnataka and Andhra Pradesh have emerged as important producers of maize in India. The yield of maize in these two states was much higher than the traditional producing states as well as average Indian yield (Table 4.13). In both the states, maize is provided with proper irrigation.

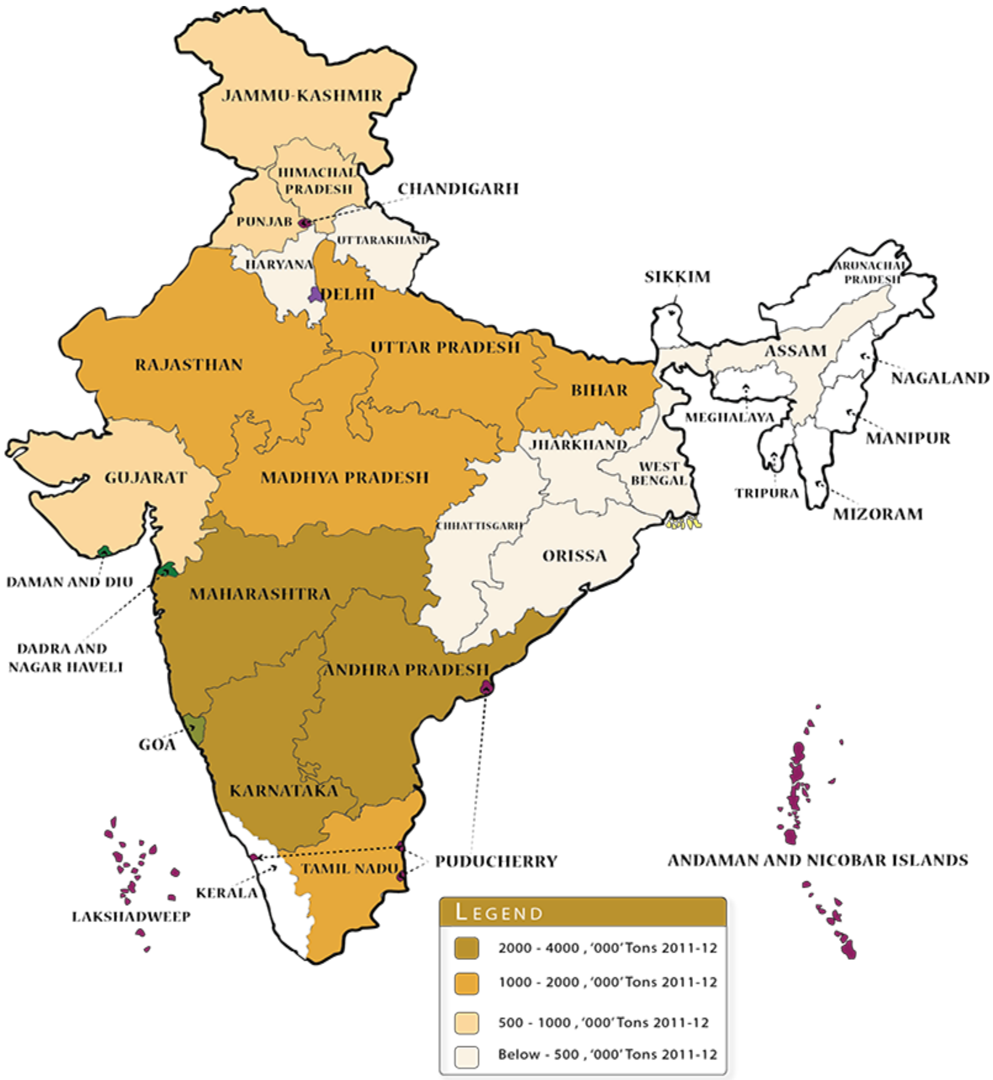
Table 4.13: Production of Maize in the Major Producing States of India during 2009-2012

(‘000 MT)

SI.No.	State	2009-10	2010-11	2011-12	Percentage to the total
1.	Karnataka	3,013	4,444	4,085	18.8
2.	Andhra Pradesh	2,762	3,956	3,658	16.8
3.	Maharashtra	1,828	2,602	2,433	11.2
4.	Tamil Nadu	1,144	1,028	1,696	7.8
5.	Rajasthan	1,146	2,053	1,667	7.7
6.	Bihar	1,479	1,440	1,611	7.4
7.	Uttar Pradesh	1,039	1,114	1,308	6.0
8.	Madhya Pradesh	1,045	1,052	1,287	5.9
9.	Gujarat	533	820	786	3.6
10.	Himachal Pradesh	543	671	715	3.3
11.	Jammu & Kashmir	487	528	505	2.3
12.	Others	1,701	2,014	2,007	9.2
	Total	**16,720**	**21,726**	**21,759**	**100**

Source: Statistical Year Book, India 2013.

During the same period, Maharashtra was the next largest producer of maize in the country contributing 11.2 per cent of total production. Tamil Nadu was the fourth largest producer of maize in India and accounted for 7.8 per cent. Around 1.7 million tonnes of maize has been produced in Tamil Nadu during 2011-12.



Source: Annual Progress Report *Kharif* Maize, 2012.

Fig 4.2. Maize Producing States in India

Rajasthan with a contribution of 7.7 per cent occupies the next position in production among all the major maize producing states of India. It attracts good demand from industries due to good quality output. Southern Rajasthan is the major producing area and the colour of maize here remains red. Bihar, the largest producer of maize, at one stage, lost much of its importance as a major maize producer in the country. During 2011-12 the state accounted only 7.4 per cent of Indian production. Almost all the districts of the north Ganga plain produce maize but the major production comes from Samastipur, Begusarai, Bhagalpur, Purnea, Purbi Champaran and Siwan districts.

The Upper Ganga Plain is an important maize growing region of Uttar Pradesh state. Madhya Pradesh, one of the traditional maize growing states, accounted for 5.9 per cent of the total maize production in the country. In Gujarat, Mahsana, Banaskantha, Rajkot and Kheda districts in the valleys of the Sabarmati and Mahi rivers are the main locations of maize cultivation and contribute over 3.6 per cent of India's production. The hilly areas of Himachal Pradesh are also well suited to maize cultivation. Kangra, Mandi, Sirmaur and Chamba districts occupy an important position in the production of maize.

The area under maize cultivation during both *kharif and rabi* seasons were on the rise since 2000 with an increase of 23 and 125 per cent respectively (Table 4.14). The overall increase in area under maize during the period was to the tune of 33 per cent. Both horizontal and vertical growth of maize has resulted in more than 80 per cent increase in grain production since 2000.

The 2012 crop season was very unique. The onset of rains in the rainy season was delayed by 2-3 weeks. The crop experienced moderate to severe drought during the early season especially in Karnataka, Rajasthan and Gujarat. The distribution of rains improved during mid-season offsetting, up to some extent, effects due to early-season drought. The estimated production of maize during 2012 *kharif* season was 15.59 million tonnes in comparison to 16.49 million tonnes during *kharif* 2011 (5 % lower). However, the *rabi* production was estimated to be slightly higher in 2012-13 (5.46 million tonnes) in comparison to that of *rabi* 2011-12 (5.27 million tonnes). Thus, the total estimated production of 21.06 m tons during 2012-13 was thus only 3 per cent lower of 2011-12 production (21.76 m tons). This situation caused some fluctuations in market rate of maize grain and this varied from -15 per cent to +20 per cent of minimum support price (MSP) of maize.

It could be observed from the table that around 23 per cent increase in area over the years (from 2000-01 to 2011-12) during *kharif* season yielded around 61 per cent increase in production through around 31 per cent increase in productivity due to varietal improvement. Similarly, during the same period about 125 per cent increase in area during *rabi* season yielded about 189 per cent increase in production through about 29 per cent increase in productivity. However, about 81 per cent increase in total Indian maize production during 2011-12 over 2000-01 was achieved due to 33 per cent increase in area and 36 per cent increase in productivity.

Table 4.14: Status in Area, Production and Productivity of Maize during Kharif and Rabi Season in India since 2000

SI.No.	Year	Area ('000 ha.)			Production ('000 tons)			Productivity (Kg/ha.)		
		Kharif	Rabi	Total	Kharif	Rabi	Total	Kharif	Rabi	Total
1.	2000-01	5,987	624	6,611	10,220	1,824	12,043	1,707	2,921	1,822
2.	2001-02	5,934	648	6,582	11,248	1,912	13,160	1,896	2,952	2,000
3.	2002-03	5,976	659	6,635	9,272	1,879	11,152	1,552	2,851	1,681
4.	2003-04	6,590	753	7,343	12,734	2,250	14,984	1,932	2,987	2,041
5.	2004-05	6,594	836	7,430	11,476	2,696	14,172	1,740	3,224	1,907
6.	2005-06	6,758	830	7,588	12,156	2,554	14,710	1,799	3,076	1,938
7.	2006-07	6,960	934	7,894	11,556	3,541	15,097	1,660	3,793	1,912
8.	2007-08	7,119	999	8,117	15,107	3,849	18,955	2,122	3,854	2,335
9.	2008-09	6,895	1,279	8,174	14,121	5,611	19,731	2,048	4,387	2,414
10.	2009-10	7,063	1,198	8,262	12,293	4,426	16,719	1,740	3,964	2,024
11.	2010-11	7,282	1,271	8,553	16,637	5,088	21,726	2,285	4,003	2,540
12.	2011-12	7,381 **(23.28)**	1,401 **(124.52)**	8,782 **(32.84)**	16,486 **(61.31)**	5,273 **(189.09)**	21,759 **(80.68)**	2,234 **(30.87)**	3,765 **(28.89)**	2,478 **(36.0)**
13.	2012-13*	NA	NA	NA	15,590	5,460	21,060	NA	NA	NA

Note: * estimated value, ( ) the figures in parentheses indicate percentage increase since 2000, NA- Not Available
Source: Project Director Review 2012-13, DMR, 2013

As discussed elsewhere it could be inferred that the production in India has increased due to parallel increase in area and productivity but the contribution of area to production had been proportionately greater than by that of productivity. Government initiatives are likely to further push the production of maize in the country. For the first time ever, the government has fixed the MSP of maize for 2013-14 crop season at INR 1,310 per quintal, which is same as that for common paddy with a view to encourage growers to plant more maize replacing paddy, particularly in Punjab and Haryana. The crop has also been included in the government's ambitious crop diversification strategy of INR 500 crore for North Indian states of Punjab, Haryana and western Uttar Pradesh.

Export of Maize

Due to continuous increase in consumer demand and industrial use the maize export is increasing in nature. The total world maize export was around 129 million tonnes during 2013-14. The details on export of maize in top ten nations in the world are provided in Table 4.15.

Table 4.15: Status of Export of Maize in the Top Ten Exporting Countries during 2010-2014

('000 MT)

SI.No.	Country	2010-11	2011-12	2012-13	2013-14	Percentage to world
1.	United States	45,162	38,389	18,262	50,500	39.28
2.	Brazil	11,582	12,674	26,044	22,041	17.14
3.	Ukraine	5,008	15,157	12,726	20,000	15.56
4.	Argentina	15,198	16,501	22,789	12,500	9.72
5.	Russia	37	2,027	1,917	4,100	3.19
6.	India	3,376	4,674	4,768	3,954	3.08
7.	Paraguay	1,201	2,188	2,858	2,400	1.87
8.	European Union	1,096	3,287	2,193	2,300	1.79
9.	South Africa	2,839	1,831	2,398	2,300	1.79
10.	Serbia	2,004	2,331	601	1,800	1.40
	World	**91,709**	**1,03,723**	**1,00,513**	**1,28,566**	**100.00**

Source: USDA, 2014.

The United States has enough excess maize production to have average exports of 50,500 thousand tonnes, making the United States the largest maize exporter in the world. All of this is done while still keeping ending stocks at an average level of 31,388 thousand tonnes, the second highest maize ending stocks in the world. However, there has been a declining trend in maize exports from USA. The reason for decrease in exports from USA is due to maize being consumed locally for production of ethanol. The rising demand for maize and decrease in exports from USA has led to an increase in prices globally.

Brazil ranks second in export with an average export of 17.14 per cent share followed by Ukraine (15.56 %), Argentina (9.72 %), Russia (3.19 %), India (3.08 %), Paraguay (1.87 %), European Union and South Africa (1.79 %) and Serbia (1.40 %).

As of Table 4.16 world maize exports have grown by almost 67 per cent over the last three decades. India exports around 16 per cent of its production and a larger share was utilized for domestic consumption. The overall situation in India is quite different from that of other major producing countries and only USA, India and China have got substantial internal market. While World exports increased by 66.53 per cent, India's exports increased by many folds during the period from 1980 to 2013. India's share in the world exports was 3.08 per cent during 2013-14.

Table 4.16: Comparative Picture of Export of Maize in the Top Ten Exporting Countries during 1970-2013

(in '000 MT)

SI.No.	Country	1980	1991	PGRP % Increase	1992	2013	PLP % Increase	OSP % Increase
1.	United States	59,420	40,686	-32	42,572	50,707	19.11	-14.66
2.	Argentina	9,016	5,888	-35	4,790	12,808	167.39	42.06
3.	India	10	4	-60	28	3,954	14,021.43	39,440
4.	South Africa	4,127	797	-81	23	2,300	9,900.00	-44.27
5.	Canada	1,048	939	-10	190	1,846	871.58	76.15
6.	Thailand	2,113	458	-78	199	1,109	457.29	-47.52
	World	77,820	63,037	-19	62,565	1,29,597	107.14	66.53

Note: PGR-Post Green Revolution period, PLP-Post Liberalisation period, OSP-Overall study period
Source: USDA, 2014.

India occupies sixth position contributing around 4 million tonnes to the total world exports of maize. The Importing country-wise details on value and quantity of maize imports are presented in Table 4.17. So far this year, the total foreign exchange earnings from maize are not less than 59 billion rupees.

Indian maize reaches the consumers of around 67 countries in the world. The top ten importing countries of Indian maize are Indonesia, Malaysia, Vietnam, Bangladesh, Nepal, Taiwan, China, United Arab Emirates, Singapore and Yemen Republic. Indonesia was the largest importer of Indian maize during 2013-14 and its share in Indian exports was 25.36 per cent. There has been continuous increase in the export due to continuously increasing demand from feed and residual sector, food, seed and industrial use and sub-sector requirement like production of ethanol. An encouraging feature of Indian maize exports has been a rise in value added goods. The total value of Indian exports in 2013-14 was about Rs. 598.37 crore.

Utilization Pattern of Maize

Apart from human consumption, maize has diversified utility viz., livestock feed, fermentation base in beverage industry and many industrial uses. Depending on their colour and taste, maize grown around the world is generally categorized into two broad groups: yellow and white. Yellow maize constitutes the bulk of total world maize production and international trade. It is grown in most northern hemisphere countries where it is traditionally used for animal feed. White maize, which requires more favourable climatic conditions for growing, is produced in only a handful of countries, the United States, Mexico and in southern Africa. White maize is generally considered a food crop. Market prices are usually higher for white maize compared to the yellow type but the premium can vary depending on local supply and demand conditions.

The use of maize varies in different countries. In USA, EU, Canada and other developed countries, maize is used mainly to feed animals directly or sold to feed industries and as raw material for extractive/ fermentation industries (Morris, 1998; Galinat, 1988; Shaw, 1988, Mexico, 1994). The United States is the largest consumer of maize in the world, with average consumption of 295,392 thousand tonnes. Since the U.S. produces more than it needs, imports make up only a small portion of the U.S.'s total supply.

Table 4.17: Country-wise Exports of Maize from India (2013-14)

(Qty. in '000 MT and Value in Lakh Rupees)

SI. No.	Country	Qty	Value
1	Indonesia	1,003	1,48,004
2	Malaysia	898	1,31,842
3	Vietnam Soc Rep	857	1,22,908
4	Bangladesh Pr	516	85,976
5	Nepal	198	28,412
6	Taiwan	167	25,898
7	China P Rp	56	8,894
8	U Arab Emts	55	8,422
9	Singapore	45	6,602
10	Yemen Republic	36	6,026
11	Iran	24	4,460
12	Oman	27	4,211
13	Philippines	16	2,669
14	Thailand	2	2,299
15	Pakistan Ir	3	2,231
16	Hong Kong	10	1,641
17	Brunei	9	1,581
18	Japan	6	1,265
19	Canada	4	711
20	Qatar	3	563
21	Belgium	2	443
22	Mozambique	3	422
23	U K	1	373
24	Seychelles	2	307
25	Jordan	1	291
26	Kuwait	2	277
27	U S A	1	202
28	Korea Rp	1	147
29	Norway	1	136
30	France	1	116
31	Lebanon	0	106
32	Saudi Arab	0	88
33	Others	5	1035
	Total	**3,954**	**5,98,366**

Source: DGCIS Annual Export, 2013-14

During 2013-14, in fact, average imports are only 700 thousand tonnes. In developing countries use of maize is variable. In Latin America and Africa the main use of maize is for food while in Asia it is used for food and animal feed. In fact in many countries it is the basic staple food and an important ingredient in the diets of people. Many countries depended on maize as a major part of their diet it would be difficult for any American today to live without maize.

Maize has varied uses in India, varying from feed to industrial products. Recently there has been a splurge in using maize for production of ethanol an additive for petroleum based fuels. As it could be observed from Figure 4.3, only 23 per cent of the maize production was used for human consumption. Among non-food uses, livestock feed accounted for a staggering 63 per cent of the total demands. In India, as the demand for poultry feed is expanding, the demand for maize will also face an upward trend. The current demand from the sector is estimated to grow rapidly in the years to come. For instance, Tamil Nadu which has the largest number of poultry units is one of the major consumers of maize. Since Tamil Nadu's production is not sufficient to meet the demand, poultry firms are procuring the produce from the states of Andhra Pradesh, Karnataka and Bihar (Vetrivel, 2013).

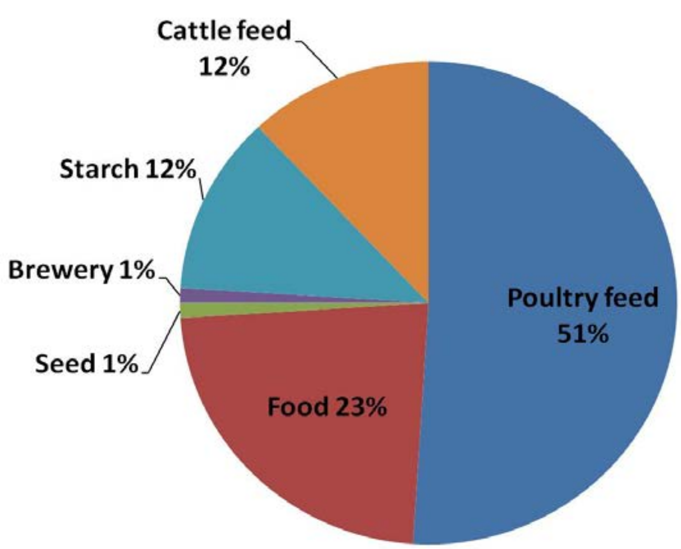


Fig. 4.3. Consumption Pattern of Maize Crop in India during 2012-2013

It is also used as basic raw material for the production of starch, oil and protein, alcoholic beverages, food sweeteners, cosmetic, film, textile, gum, packaging and paper industries, and more recently fuel.

Maize Processing Methods and By products

For more than 150 years, maize refiners have been perfecting the process of separating corn into its component parts to create a myriad of value added products. Maize can be processed in two ways dry milling and wet milling.

Dry Milling

In dry milling, the maize is tempered and cleaned with hot water and steamed for about 2-6 hours to soften the bran and the germ so that it becomes easier for them to be separated from the endosperm. The coarse, granular material is sifted using a sifter machine and then the miller extracts the oil and the maize flour from the kernel.

Wet Milling

The maize refining process is indicated in Figure 4.4. The process begins with the maize kernels being soaked in large tanks called steep tanks in a dilute aqueous sulfur dioxide solution. The softened kernel is then processed to remove the germ which is further processed to remove the high-value corn oil. Maize contains 1.2 to 5.7 per cent edible oil which is extracted from germ of maize. The oil content of maize varieties is as much as 14 per cent which has 98 per cent fat. Corn oil today is used as a cooking medium and it is revealed that consumption of corn oil reduces occurrence of heart attack and other cardiovascular diseases in human and is claimed to be ever healthier than extra virgin olive oil. The corn oil is also a feedstock used for biodiesel. Other uses are in soap, paint industry as well as oil molecules are used as a carrier for drug molecules in pharmaceutical preparations. The germ meal remaining after the oil is extracted and marketed for animal feed use.

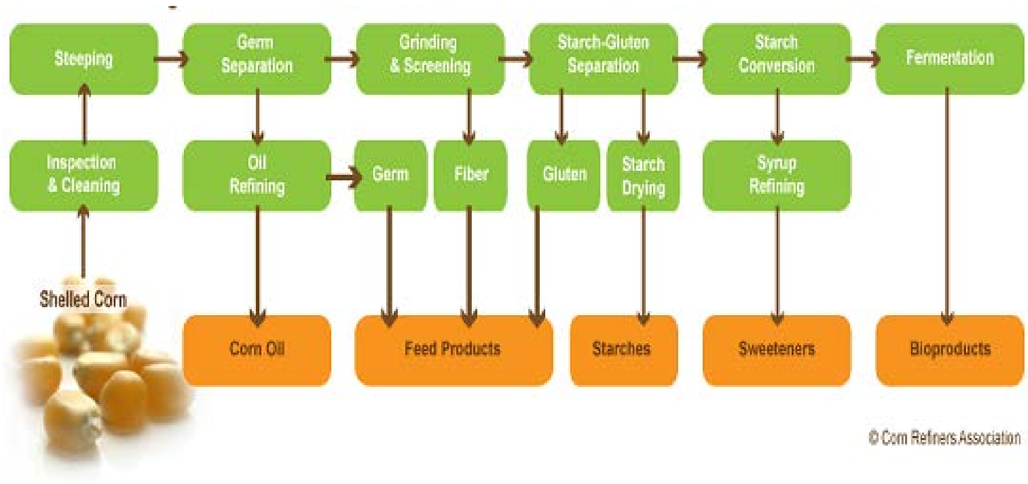


Fig 4.4. The Flow Chart of Maize Refining Process

Following germ removal, the remaining kernel components are screened to remove the fiber. The fiber is combined with the evaporated, concentrated and dried steep liquor and other co-product streams to produce corn gluten feed. The starch and gluten protein subsequently pass through the screens and the starch-gluten slurry is sent to centrifugal separators where the lighter gluten protein and the heavier starch are separated, the gluten protein is then concentrated and dried to produce corn gluten meal, a 60 per cent protein feed. Feed industry consumes gluten as a feed meal. Gluten is a byproduct of maize processing and is rich in protein content. Maize gluten is rich in amino acids and vitamins and is consumed as a cattle feed and poultry feed.

Some of the starch is then washed and dried or modified and dried. These starch products are marketed to the food, paper, and textile industries. The remaining starch can be processed into products such as sweeteners or ethanol. Starch and Gluten have good export potential as well. India exports these products to Sri Lanka, South East Asian countries, Bangladesh and South Africa. While the wet milling process is capital intensive with higher operating costs, the ability to produce a variety of products can be valuable in dealing with volatile markets. The wet milling process results in slightly lower ethanol yields than a traditional dry milling process since some of the fermentable starch exits the process attached to the saleable co-products.

Another trend catching up in the maize processing industry is the emergence of value added products from Maize. Maize is being used in innovative ways to reduce plastic usage now a days. Companies are pushing the boundaries in an endeavor to go green. Almost all parts of the maize plant are used. The silk threads of maize are used as a filter; husks could be braided and woven to make masks, moccasins, sleeping mats, baskets, corn pipes or cornhusk dolls. Corncobs could be used for fuel, for game darts or for ceremonial use. The stalks and cobs are made use of for the preparation of furfural. Oil is also extracted from maize which is used for cooking and glucose and dextrin are also extracted from maize. Maize provides huge quantities of fodder to the cattle in the state.

Further more, fabrics used to make clothing are strengthened by cornstarch. Many of the soft drinks are sweetened with corn syrup. The textbooks are bound with cornstarch. The ink used to print them contains corn oil. Maize is also used in such products as glue, shoe polish, aspirin, ink, marshmallows, ice cream and cosmetics. New ways of using maize are being developed every day. Our only limitation is our own imagination.

Processed Food Products from Maize

Most commonly used forms are (i) Chapattis (ii) porridges of various forms (iii) boiled or roasted green ears (iv) breakfast foods like corn flakes and (v) pop corn. For the (iii) and (v) category sweet and Pop corn varieties are especially grown in USA and Europe.

Corn Flakes

The breakfast cereal technology emerged which has gained popularity in higher and higher middle income group people. The flakes are mainly manufactured from maize plant and many MNCs, Indian companies and now a day's local companies as well entered in the corn flakes manufacturing activity. There is a good opportunity in the agro processing sector wherein cost competitive cornflakes products can be manufactured and marketed under Indian brand. This product may get the market due to its cost competitive factor. The corn flakes manufacturing unit of 200 tons capacity will cost somewhat higher than corn flakes due to the improved technology involved in the process. The machinery cost is around 2 lakh and the total cost including investment in asset, working capital etc is around 7.8 lakh. Around 10 per cent profit is observed at the end of first year including all costs including running costs involved in it.

Baby Corn

Baby corn is nothing but the tender cobs harvested from maize. The baby corn is used as a vegetable and also as a special gourmet touch to dishes and salads. Baby corn can be grown as a market crop as it is gaining good amount of share in corn market. Small and medium entrepreneurs can enter in baby corn business by marketing the crop to hotels and restaurants. Equally the crop has good opportunity in export business. The baby corn market is attractive and has good scope to grow in the international market. In the domestic market it has potential to capture the consumers in the metro cities as well as hotels, restaurant industry as well. In India, Mumbai, Delhi, Ahmedabad and Kolkata are the major markets for processed maize products.

Forage and Feed

The next important field where maize finds extensive use is for livestock feeds viz. cattle, poultry and piggery both in the form of seeds and fodder. The green fodder can be fed to milch cattle to boost the milk production to a considerable extent. The digest ability of maize fodder is higher than sorghum, bajra and other non-leguminous forage crops. Gluten has great demand in animal feed industry because of its high protein content (60 %) and fiber, mainly the husk, is used by animal feed manufacturers. Maize plant does not have any problem of hydrogenic acid or prussic acid production, hence of necessary crop can be harvested and fed to cattle at any stage of its growth, of course ideal stage of harvest for green fodder mid dough stage, when the dry matter content and digestibility are more desirable. The high carotene content of yellow maize is considered to be very useful in importing yellow colour to egg yolk and yellow tinge to the milk. No other concentrate is yet to known to substitute maize in this respect.

Maize Starch –New Applications

Maize which is not used for feed or human consumption is processed to obtain its by-products which acts as a raw material for different industries. Of lately maize processing has gathered momentum in India and is gaining importance in the associated industries. The most common industrial by product of maize is starch or corn starch or corn flour.

Corn starch is the starch derived from the maize grain. The starch is obtained from the endosperm of the maize kernel. Indian pharma industry uses maize starch as a binder and filler for tablets and capsules, coating and dusting media for various types of coatings.

Food Industry

Maize starch is avidly used in processed food industry in the bakery products, beverages and confectionary. With rising share of packed/processed food in the total food consumption, the demand for starch from food processing sector is rising. In select food processing sector, it is used as thickener in sauces and soups, gel former in puddings, suspension stabilizer and also as bodying agent in bakeries. Indian food industry consumes other maize by products like corn meal, grits, flour etc.

Bags

Maize starch is being essentially used in making bags in India. After gaining popularity in Europe and America, maize starch bags are making its way in India and are all set to replace bags made of plastic and oxy degradable materials. Maize starch bags are gaining popularity because they are biodegradable and decompose completely without causing any pollution in the environment. Rising awareness about environment protection is providing base for sustainability to maize starch bags.

Car Parts

Another revolutionary property of corn starch is its ability to handle tremendous pressure which is helping it in finding a place in the automobile industry. Automobile companies now a days are increasing their focus on car safety and are looking for alternative materials other than the conventional ones, to serve the purpose. Maize starch fortunately fits the bill and it set to emerge as a wonder material. Recently Tata Motors, the country's largest automobile producer, announced that it is using cornstarch in the making body parts for cars to improve safety aspects. Qualities like non-flammable, non-toxic, ability to stand high pressures and high elasticity makes it the preferred choice for improving safety in vehicle. Thus maize starch can increase the crash resistance of cars and reduce the effects of an accident on occupants. It can also be used in many other products, such as making body armour, helmets (for soldiers, construction workers and others) and impact-proof gear.

Maize to Ethanol

Maize is the most important and economical source of starch, comprising about 68-72 per cent of kernel weight, which is easily converted into glucose and fermented into ethanol. In the USA, ethanol production tripled in last few years from 2.8 billion gallons in 2003 to over 9 billion gallons in 2008 (Ling Tao and Andy Aden, 2009). Under the Energy Independence and Security Act of 2007 (EISA, 2007), 36 billion gallons of renewable fuel is required by 2022. Out of which, 15 billion gallons will be maize based ethanol. According to World Agricultural supply and Demand Estimates (WASDE, 2014), during 2012-13 the maize utilized for ethanol was about 4,641 million bushels out of production of 10,755 million bushels (one bushel maize equals 25.40 kilograms). World fuel ethanol production by country or region is presented in Table 4.18. The leading producer of maize, USA has produced 13,300 million gallons of ethanol during 2013 with a share of 56.77 per cent to the global production followed by Brazil, Europe, China and Canada with a share of 26.75, 5.85, 2.97 and 2.23 per cent respectively.

Table 4.18: Status of Ethanol Production in Major Ethanol Producing Countries during 2008-2013

(Million Gallons)

SI.No.	Country	2008	2011	2012	2013	Percentage to the total
1.	USA	9,309.00	13,948.00	13,300.00	13,300.00	56.77
2.	Brazil	6,472.20	5,573.24	5,577.00	6,267.00	26.75
3.	Europe	733.60	1,167.64	1,179.00	1,371.00	5.85
4.	China	501.90	554.76	555.00	696.00	2.97
5.	Canada	237.70	462.30	449.00	523.00	2.23
6.	Rest of World	389.40	698.15	752.00	1,272.00	5.43
	World	**17,643.80**	**22,404.09**	**21,812.00**	**23,429.00**	**100.00**

Source: Ethanol Industry Outlook 2008-2013 reports.

India now has a surplus of maize that can be economically processed into ethanol so as to meet the emerging energy demands of the nation and the world (India and Ethanol Production.mht). The increasing focus of Indian government on increasing ethanol usage in car fuel will help maize in making its mark in Indian ethanol industry. India introduced its National Policy on Biofuels in 2009, to ensure mitigation of pollutants emitted by locomotives - it involved directing the state government to implement the blending of 5 per cent biofuel with conventional ones, increasing it to 10 per cent by 2012 and 20 per cent by 2017.

International-Planners are planning the construction of 20 regional grain to ethanol conversion facilities in India. They could produce 6 million gallons of ethanol a month, ending India’s reliance upon fossil fuel and doubling the income of the average farm workers family so as to make them economically independent. These ethanol production centers will be built in the 20 different states. India now has to import 15 million barrels of ethanol a year. The Indian government has recently offered to underwrite 75 per cent of the development costs of ethanol bio-mass production centers in order to stimulate National ethanol production. The ethanol production centers will produce those 15 million barrels of ethanol for India’s needs, which will save India each year more than Rs. 900 crore ~ 760 million US$ (Sapna, 2011).Global demand for maize in ethanol production is strong and growing rapidly which will soon experienced in India.

Further, a recent study by National Centre for Agricultural Economics and Policy Research (NCAP) has showed that there is an increasing demand for maize in the industry sector which caters to consumer needs like textiles, paper, glue, alcohol, confectionery, food processing and pharmaceutical industry etc., of which the demand keeps on increasing with population pressure.

Results and Discussion

CHAPTER V

RESULTS AND DISCUSSION

The data and information collected from secondary sources were analysed keeping in view the stated objectives of the present study. The results of the analysis are presented and discussed under three major sections. The focus of the first section is on the past trends of the maize crop and the discussion mainly draws on time series analysis of the relevant data. The rate of increase in area, production, and yield of maize should be stable and steady. But in reality, instability exists in area, production, and yield of maize. Therefore, it is very important to know the pattern of change and relationship between area, production, productivity, consumption, price and export of maize crop in India. The second part investigates the effect of maize exports through an estimation of a system of maize export demand equations. The third part is organized around the results of the market integration model.

Area under Maize Cultivation

On the global front, in the recent past, maize gained tremendous importance due to rising demand from diversified sectors like food, feed and ethanol production**.** Moreover, in the last decade, acreage under maize cultivation has been continuously on an increasing trend to meet rising demand. New technologies were first confined to wheat and rice alone and only over time they were extended to all major crops including maize. The mean, coefficient of variation, linear and compound growth rate of area under maize crop in India during the period 1970 to 2013 are presented in Table 5.1 and Figure 5.1. A negligible amount of 0.14 per cent increase in area during the post green revolution period (1970-1991) was observed. This may be due to considerable interstate variation, as most states were unable to share the gains of the green revolution (Bhalla, 2009). But, during the post liberalization period (1992-2013) the scenario entirely changed as area under maize increased to a large extent of 58 per cent and increase in area was found to be 61 per cent during the overall study period (1970-2013).

Table 5.1: Comparative Picture of Mean, C.V, Linear and Compound Growth Rate of Area under Maize in India during 1970-2013

(in '000 ha.)

SI.No.	Growth Parameters	Post Green Revolution (1970-1991)	Post Liberalization (1992-2013)	Overall Study Period (1970-2013)
1.	Area in Percentage	0.14	57.64	60.63
2.	Mean Area	5844	7248	6546
3.	Coefficient of Variation (%)	2.09	15.38	16.16
4.	Linear Growth Rate	-1.2	165.7	68.43*
5.	Compound Growth Rate (%)	-0.02	2.29*	0.98*

Note: *Significant at 1 % level.

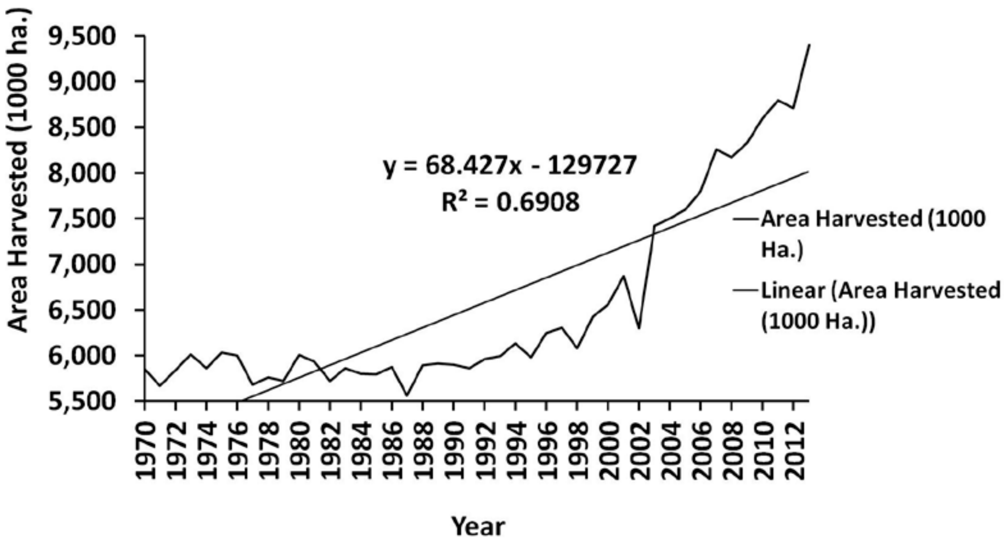


Fig. 5.1. Trend in Area of Maize during the Overall Study Period (1970-2013)

During the post green revolution, post liberalization and the overall study periods the average area under maize crop was 5844, 7248 and 6546 thousand hectares respectively. Similarly the fluctuations in terms of area during all the three periods viz., post green revolution, post liberalization and the overall study periods were also found to be 2.09, 15.38 and 16.16 per cent respectively. This implies that the growth in terms of area secured to be stable.

The compound growth rate of area during the overall study period, as seen from table was 0.98 per cent per annum increasing in absolute terms from 5852 thousand hectares in 1970 to 9400 thousand hectares in 2013. Though the larger issues of geo-environmental limitations coupled with socio-economic forces might have contributed for this trend, for the moment the significant observation was that the growth rate during the post liberalization period (2.29 %) far exceeded that of during the post green revolution and the overall study periods. During the post green revolution period, the compound growth rate was negative and insignificant resulting almost static. In fact, with its size, during the post liberalization period due to opening up of economy and steps taken to attain self sufficiency in food grain production contributed for the total area expansion by inducting more area under maize crop in non-traditional areas of southern India and Punjab. In absolute terms, as evident from the linear trends in the table, during the post liberalization period the area added was about 165.7 thousand hectare annually while the area added during the overall study period was about 68.43 thousand hectare annually which is less than two and a half times of the addition during the post liberalization period. The rapid expansion in area under this crop was mainly due to its important features like short duration and its adaption to a wide range of soil and climatic conditions.

Since, yearly data was used, seasonal movements (S_t) could not be identified. The discussion so far, had abstracted of the random fluctuations and relied mainly upon the secular trends. The results of harmonic analysis of the area under maize would provide evidence on the existence of cyclical fluctuations. The Schuster's 'k' values of Table 5.2 indicated that no significant cyclical fluctuations existed in the maize area during all the three periods. Some erratic fluctuations occurred and the pattern was not consistent and stable.

Combining the discussion of the secular trend with these observations, it would be evident that the area under maize in India had been increasing at a greater phase during the post liberalization period predicting no structural changes during the post green revolution period and response to market forces during the post liberalization period and the overall study period. The classical postulates of causal relationships seem to be perceptibly very weak during the post green revolution and the overall study periods.

Table 5.2:Results of Fourier Analysis of Area under Maize during 1970-2013

Post Green Revolution (1970-1991)					
Cycle Length	**Fourier Coefficient**		**Rp2**	**Rm2**	**K**
	Ap	**Bp**			
3	-12.5665	-76.8463	6,063.2702	3,282.1101	1.8474
4	62.2169	4.8680	3,894.6383	3,626.1953	1.0740
5	37.8893	-68.4996	6,127.7865	3,626.1953	1.6899
6	-17.5460	-40.0738	1,913.7761	4,500.7533	0.4252
7	33.9528	-36.8501	2,510.7235	3,282.1101	0.7650
8	5.6371	-85.7999	7,393.3921	3,939.7647	1.8766
9	7.2875	-34.5560	1,247.2259	4,500.7533	0.2771
10	14.2484	-83.7588	7,218.5514	3,626.1953	1.9907
Post Liberalization (1992-2013)					
Cycle Length	**Fourier Coefficient**		**Rp2**	**Rm2**	**K**
	Ap	**Bp**			
3	8.6088	-16.2491	338.1435	9,884.5527	0.0342
4	-111.6231	62.5282	16,369.5022	9,454.9204	1.7313
5	-0.7070	34.3321	1,179.1962	9,454.9204	0.1247
6	3.5872	119.2733	14,238.9904	11,722.8385	1.2146
7	26.9603	41.0162	2,409.1843	9,884.5527	0.2437
8	45.8939	-30.6688	2,106.3299	14,903.9500	0.1413
9	33.4154	93.7452	9,904.7482	11,722.8385	0.8449
10	-73.5826	89.3104	13,390.7431	9,454.9204	1.4163
Overall Study Period (1970-2013)					
Cycle Length	**Fourier Coefficient**		**Rp2**	**Rm2**	**K**
	Ap	**Bp**			
3	19.2373	-7.6217	428.1645	4,917.5807	0.0871
4	27.8810	-15.2276	1,009.2289	4,708.8738	0.2143
5	42.6802	-34.2502	2,994.6736	5,360.7798	0.5586
6	19.8926	34.7377	1,602.4244	4,917.5807	0.3259
7	-13.9734	-1.8664	198.7396	4,917.5807	0.0404
8	-12.7606	-41.0723	3,984.9268	5,360.7798	0.7433
9	-14.3727	-41.0723	1,893.5114	6,119.0127	0.3094
10	27.9897	-34.8489	1,997.8659	5,360.7798	0.3727

To explore the above hypothesis, OLS estimates of different specifications of the behavioural relationship were attempted and the most promising among them are presented below.

$$PGRPA_t = -48.6032 + 0.0076\ IP_t + 43.0311\ DP_t/SP_t + 0.5222\ KRF_t + 0.0233\ FR_t + 0.0054\ A_{t-1}$$

(-1.2088) (0.6747) (0.5568) (1.6037) (0.5280) (0.2289)

$R^2 = 0.24$ D.W = 1.60

$$PLPA_t = 12.0697^{**} - 0.0118\ IP_t + 373.86\ DP_t/SP_t + 1.7523\ KRF_t^{*} + 0.2099\ FR_t^{*} + 0.0046\ A_{t-1}$$

(2.1434) (-0.3953) (1.0172) (3.6815) (2.9257) (1.6058)

$R^2 = 0.96$ D.W = 1.54

$$OSPA_t = 402.84^{**} + 0.0182\ IP_t^{**} + 90.6692\ DP_t/SP_t^{*} + 0.7422\ KRF_t^{*} + 0.0849\ FR_t^{*} + 0.6921 A_{t-1}^{*}$$

(2.0586) (2.4155) (4.5024) (2.8784) (2.7371) (3.6323)

$R^2 = 0.94$ D.W = 1.36

Note: *significant at 1% level, **significant at 5% level

Broadly, the signs of all the coefficients confirmed with a priori expectations during the post green revolution period but they were not significant. The explanatory power of the independent variables (24 %) was comparatively very low during the post green revolution period, implying that the fluctuations during the period distorted the specified casual relationships, atleast in the models tried. During the post liberalization period the sign of the coefficient was negative with respect to the impact of international prices (IP_t) on the area under maize but the coefficient with respect to the impact of the domestic price relative to the price of the substitute crop sorghum (DP_t/SP_t) was positive. However, they were not significant. But the signs of the coefficients of *kharif* rainfall and consumption for feed and residuals (FR_t) were positive and have a significant impact on the area under maize. The explanatory power of the independent variables (96 %) was comparatively very high during the post liberalization period.

The signs of all the coefficients confirmed with a priori expectations during the overall study period and they were all significant. The signs were positive with respect to the impact of international prices and the domestic price relative to the price of the substitute crop sorghum. The increase in domestic price increases the relative price ratio high and there by influencing more on the area expansion while the increase in the price of the substitute crop sorghum increases the relative price ratio relatively low and there by influencing less on the area expansion. The signs of the coefficients of *kharif* rainfall and consumption for feed and residuals were positive and have a significant impact on the area under maize. The explanatory power of the independent variables (94 %) was high during the overall study period, implying that the fluctuations during the period have not distorted the specified casual relationships, atleast in the models tried.

In the Nerlovian partial adjustment framework, the domestic price relative to the price of the substitute crop sorghum (DP_t / SP_t) i.e. the relative price movement to capture the short run effects included in the model had positive impacts during all the three periods. However, in the short run the responsiveness of area was only marginal and it was not surprising that the coefficients did not pass the confidence tests during the post green revolution and the post liberalization periods. During the overall study period, the area under maize had significantly responded to market forces in the long run as indicated by the significance of lagged dependent variable (A_{t-1}), but the contribution seemed to be marginally high.

To summarize, the past trends were of indication that the market forces seem to appreciably influence the maize areas in the short run.

Productivity

Productivity is the vehicle through which improvements in the science and art of cultivation are transformed into improved production of any crop. The improvements accumulate over years and subsume both the short and long run effects. Over the past two decades, much of the increases in Indian maize production came about by parallel improvements in productivity and area expansion (refer Tables 4.9 and 4.6).

The mean, coefficient of variation, linear and compound growth rate of productivity of maize crop in India during the period 1970 to 2013 are presented in Table 5.3 and Figure 5.2. In India, the average productivity of maize increased from 1280 kilogram per hectare in 1970 to 2450 kilogram per hectare in 2013, an improvement of about 91 per cent. During the post green revolution period the increase in productivity of maize crop accounted for only 7.81 per cent, but during the post liberalization period the scenario entirely changed as productivity of maize increased by 46 per cent. The percentage (91.41) change in productivity of maize during the overall study period was phenomenal.

The average productivity improved from 1191 kilogram per hectare during the post green revolution period to 1970 kilogram per hectare during the post liberalization period but it was only 1580 kilogram per hectare during the overall study period. The fluctuation in terms of productivity was found to be lower during both the post green revolution (16.64 %) and the post liberalization (16.99 %) periods and was higher (30.28 %) during the overall study period. As far as the average productivity of maize in India is concerned the highest productivity recorded was 2450 kilogram per ha. in 2013 which is still more than 50 per cent lower than global average of 5500 kilogram per ha. (refer Table 4.9) and this warrants the need for further improvement in the productivity of maize.

Table 5.3: Comparative Picture of Mean, C.V, Linear and Compound Growth Rate of Productivity of Maize in India during 1970-2013

(in kg. / ha.)

SI.No.	Growth Parameters	Post Green Revolution (1970-1991)	Post Liberalization (1992-2013)	Overall Study Period (1970-2013)
1.	Productivity in Percentage	7.81	45.83	91.41
2.	Mean Productivity	1191	1970	1580
3.	Coefficient of Variation (%)	16.64	16.99	30.28
4.	Linear Growth Rate	19.3*	47.3*	35.1*
5.	Compound Growth Rate (%)	1.61*	2.40*	2.25*

Note: *Significant at 1 % level.

The growth rate in productivity was significant both in absolute and compound terms during the post liberalization and the overall study periods. The productivity during the post liberalization period was higher and it had much impact on the productivity during the overall study period since the average productivity of maize in Tamil Nadu of non-traditional area was found to be 6040 kg. / ha. (refer Table 4.10).

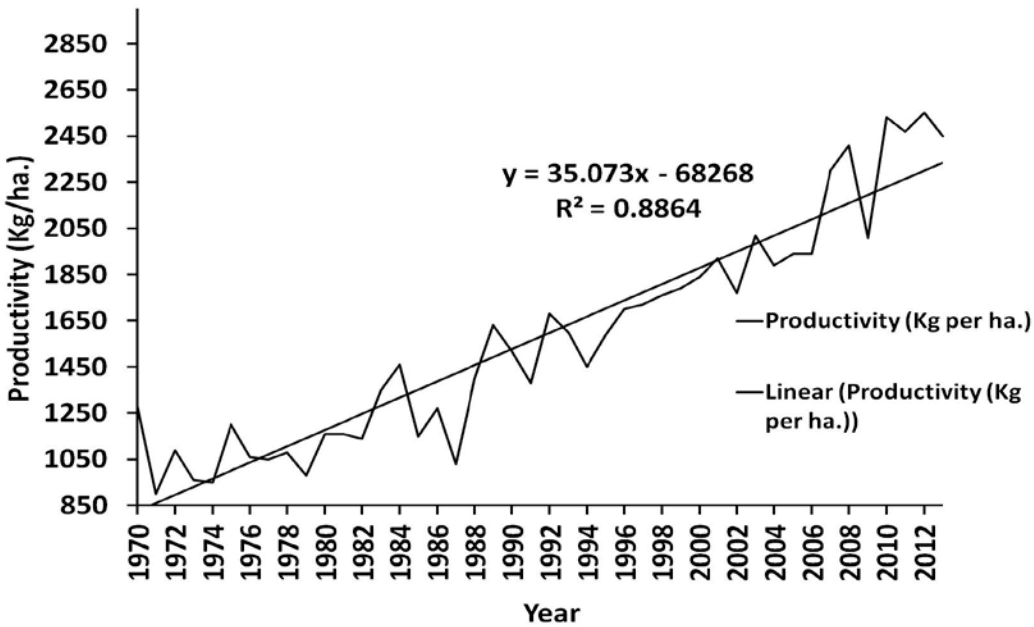


Fig.5.2. Trend in Productivity of Maize during the Overall Study Period (1970-2013)

In absolute terms, as could be seen from the linear trends in the table, the yield added was about 47.3 kilogram per hectare annually during the post liberalization period which is more than two and a half times than that of during the post green revolution period (19.3 kilogram per hectare) while during the overall study period the same was about 35.1 kilogram per hectare annually which is almost double than that of during the post green revolution period. Similarly, the same trend was recorded in the compound growth rate. The compound growth rate of productivity during the post green revolution, the post liberalization and the overall study periods were 1.61, 2.40 and 2.25 per cent per annum respectively. The growth rate of productivity was found to be significant in both absolute and compound terms. The compound growth rate of productivity of 2.25 per cent during the overall study period was far higher than that of area growth (0.98 %) and was the most important component of the two in determining the production levels.

While productivity by itself is determined by technological improvements and management internalised in the production process, their adoption, to a greater extent, is conditioned by the socio-economic backgrounds of the growers. Economically, while big farmers were able to better utilise most of the management and capital based resources, the small farmers were traditionally supposed to better utilise the government support.

On an average, the productivity was on the higher side during the post liberalization period due to relatively considerable share of adoption of improved cultivation practises and high yielding / hybrid varieties. Obviously, in these circumstances, a casual reading of the variables at the macro-level was misleading.

There were considerable variations in productivity among different producing states as evident from Table 4.10. From the eighties onwards, the non traditional areas had overtaken the traditional areas in productivity. It might perhaps be due to the relatively more suitable nature of the southern states, cultivation of high yielding / hybrid varieties and better management and cultivation practices. If the yield differentials were narrowed, and the productivity of the traditional areas was raised to that of the non traditional areas, by its size, then traditional areas would be able to add substantially to total production.

Input management is an important component of efforts to improve productivity. The predominant inputs in maize production are cultivation of high yielding / hybrid varieties, better management and cultivation practices, labour, application of recommended doses of fertilizers, irrigation, plant protection measures etc. The cost on these inputs is alleged to affect the international competitiveness of Indian maize. However, the productivity of these inputs must be increased quite seriously to attain the desired result. The information about all the inputs utilised were generally lacking and additional information like expenditure on research and development would be required to make a confident assertion. These observations were further supported by the following trend results.

Since yearly data was used, seasonal movements (S_t) could not be identified. The trends apart, cyclical fluctuations were discernible as evident from the Fourier results. The results of the harmonic analysis employed to test statistically the existence and length of cycles are presented in Table 5.4. The evaluated 'K' values indicated significant seven year cycle for the post green revolution period and also a significant ten year cycle for the overall study period at 5 per cent level. No cyclical fluctuation was found for the post liberalization period. The fluctuations might be due to fluctuation in the rainfall. A five year rainfall cycle during the post green revolution period and a five and a ten year rainfall cycle during the overall study period has been identified and observed but no fluctuation in rainfall was observed during the post liberalization period.

Table 5.4:Results of Fourier Analysis of Productivity of Maize during 1970-2013

Post Green Revolution (1970-1991)					
Cycle Length	**Fourier Coefficient**		**Rp2**	**Rm2**	**K**
	Ap	**Bp**			
3	-0.0090	0.0265	0.0008	0.0035	0.2243
4	0.0473	0.0242	0.0028	0.0038	0.7411
5	-0.0221	0.0091	0.0006	0.0038	0.1505
6	-0.0465	-0.0697	0.0070	0.0040	1.7489
7	0.0602	0.0990	0.0134	0.0035	3.8546*
8	0.0813	0.0137	0.0068	0.0037	1.8326
9	0.0458	0.0310	0.0031	0.0040	0.7606
10	-0.0185	-0.0607	0.0040	0.0038	1.0598
Post Liberalization (1992-2013)					
Cycle Length	**Fourier Coefficient**		**Rp2**	**Rm2**	**K**
	Ap	**Bp**			
3	0.0473	0.0066	0.0023	0.0027	0.8331
4	-0.0267	0.0774	0.0067	0.0030	2.2389
5	0.0511	-0.0504	0.0052	0.0030	1.7228
6	0.0185	0.0095	0.0004	0.0032	0.1356
7	0.0049	0.0368	0.0014	0.0027	0.5031
8	0.0101	0.0373	0.0015	0.0022	0.6640
9	-0.0005	-0.0306	0.0009	0.0032	0.2945
10	-0.0563	0.0061	0.0032	0.0030	1.0706
Overall Study Period (1970-2013)					
Cycle Length	**Fourier Coefficient**		**Rp2**	**Rm2**	**K**
	Ap	**Bp**			
3	-0.0367	-0.0308	0.0023	0.0017	1.3491
4	0.0460	-0.0334	0.0032	0.0016	2.0328
5	-0.0021	-0.0314	0.0010	0.0018	0.5409
6	0.0028	-0.0523	0.0027	0.0017	1.6139
7	0.0058	0.0389	0.0015	0.0017	0.9100
8	0.0404	-0.0130	0.0023	0.0018	1.2541
9	0.0294	-0.0130	0.0010	0.0017	0.6058
10	0.0090	-0.0620	0.0039	0.0018	2.1459*

Note: * significant at 5% level.

In India, it is being estimated that maize demand will continue to increase in view of increasing demand in poultry and livestock sectors in the country and growing non-vegetarian population and changing food habits. To meet the growing demand, enhancement of maize productivity in coming years across all the growing locations in India is the big challenge in the era of climate change like rise in temperature of the earth surface and in atmosphere, fluctuation in rainfall, declining ground water and so on.

Attempts made to capture the fluctuations in productivity through behavioural equations were not generally successful on statistical grounds. The result obtained by regressing for the post green revolution period; productivity ($PGRPY_t$) on domestic (DP_t) and international (IP_t) prices, changes in maize area (ΔA_t), average *kharif* season rainfall (KRF_t) and the trend variable (T) is presented below. Similarly, the result obtained by regressing productivity ($PGRPY_t$) for the post liberalization and productivity ($OSPY_t$) for the overall study periods on the same variables are also presented below.

$$PGRPY_t = \underset{(1.5817)}{789.705} + \underset{(1.6932)}{0.2128\, DP_t} + \underset{(1.9612)}{0.3056\, IP_t} - \underset{(1.2184)}{0.1915\, \Delta A_t} + \underset{(0.4513)}{0.1424\, KRF_t} + \underset{(1.1067)}{25.4496\, T}$$

$R^2 = 0.78$ D.W = 1.48

$$PLPY_t = \underset{(0.0374)}{18.897} + \underset{(0.4549)}{0.0163 DP_t} + \underset{(1.1528)}{0.0342\, IP_t} + \underset{(0.0064)}{0.0006\, \Delta A_t} + \underset{(2.4957)}{0.6797\, KRF_t^{**}} + \underset{(4.2533)}{40.5427\, T^{*}}$$

$R^2 = 0.89$ D.W = 1.67

$$OSPY_t = \underset{(2.2355)}{490.971^{**}} + \underset{(2.0560)}{0.0013\, DP_t^{**}} + \underset{(2.7830)}{0.0376\, IP_t^{*}} + \underset{(3.1812)}{0.0837\, \Delta A_t^{*}} + \underset{(2.3436)}{0.4119\, KRF_t^{**}} + \underset{(8.6345)}{27.6449\, T^{*}}$$

$R^2 = 0.94$ D.W = 1.93

Note: *significant at 1% level, **significant at 5% level

All the coefficients had expected signs with the exception of changes in maize area which had a negative impact in the short run, as specified in the model. The variable ΔA_t was included in the model to proxy government measures for green revolution like use of chemical fertilizer, more area under irrigation and improved infrastructure facilities for attaining food security and self sufficiency in food grain production. As discussed elsewhere, productivity during the post green revolution period did not improve due to green revolution measures and that seemed to be properly accounted by the coefficient of the variable ΔA_t. Both domestic and external prices had a positive impact on productivity as also the average *kharif* rainfall and the trend variable. Trend variable was included in the model to capture the impact of adoption of improved crop production technologies and varietal improvements. Unfortunately, none of the coefficients were significant but overall the regression had a satisfactory explanatory power.

As regards to the post liberalization period, all the coefficients also had expected signs. As discussed elsewhere, productivity, increased due to the developments in the poultry sector, industrial and residual use and trade liberalization; and that seemed to be properly accounted by the coefficient of the variable ΔA_t. Improved explanatory power was exhibited by the regression coupled with the insignificance of all the coefficients except that of average *kharif* rainfall and trend variables significance at 5 and 1 per cent level respectively. The trend variable which was highly significant exhibited that the productivity has increased due to adoption of improved crop production technologies and varietal improvements and that seemed to be properly accounted by the coefficient of the trend variable.

During the overall study period, on aggregation, all the coefficients had expected signs. As discussed elsewhere, productivity, increased due to the developments in the poultry sector, industrial and residual use and trade liberalization; and that seemed to be properly accounted by the coefficient of the variable ΔA_t. Both domestic (DP_t) and external prices (IP_t) had significant positive impact on productivity and also the average *kharif* rainfall. Explanatory power exhibited by the regression had improved to 94 per cent coupled with the significance of all the coefficients and the trend variable which was highly significant exhibited that the productivity has increased due to adoption of improved crop production technologies and varietal improvements and that seemed to be properly accounted by the coefficient of the trend variable.

In the absence of reliable data on the extent and nature of adoption of improved crop production technologies or practices of maize, area under high yielding and hybrid varieties and extent of maize area brought under irrigation through green revolution measures altering the yield profile and consequently productivity, it might naturally pose difficulties to relate improvements in productivity to market forces without some qualification. In any case, trend variable and changes in maize area by themselves seemed to capture most of the variations that these variables could explain.

Production

The mechanics of production, being determined by area and productivity, follows them closely. The results of mean, coefficient of variation, linear and compound growth rate of production of maize crop in India during the period 1970 to 2013 are presented in Table 5.5.

Table 5.5: Comparative Picture of Mean, C.V, Linear and Compound Growth Rate of Production of Maize in India during 1970-2013

(in '000 MT)

Growth Parameters	Post Green Revolution (1970-1991)	Post Liberalization (1992-2013)	Overall Study Period (1970-2013)
Production in Percentage	7.67	142.06	223.14
Mean Production	6965	14598	10780
Coefficient of Variation (%)	17.29	32.11	47.60
Linear Growth Rate	120.2*	684.3*	360.7*
Compound Growth Rate (%)	1.69*	4.75*	3.25*

Note: *Significant at 1 % level.

In India the average production of maize increased from 7486 thousand tonnes in 1970 to 24,190 thousand tonnes in 2013, thus registering an increase of about 223 per cent. During the post green revolution period (1970-1991), the increase in the production of maize accounted for only 7.67 per cent, but during the post liberalization period the scenario entirely changed as production of maize increased to a large extent of 142 per cent. The percentage (223.14) change in production of maize during the overall study period was astonishing and phenomenal.

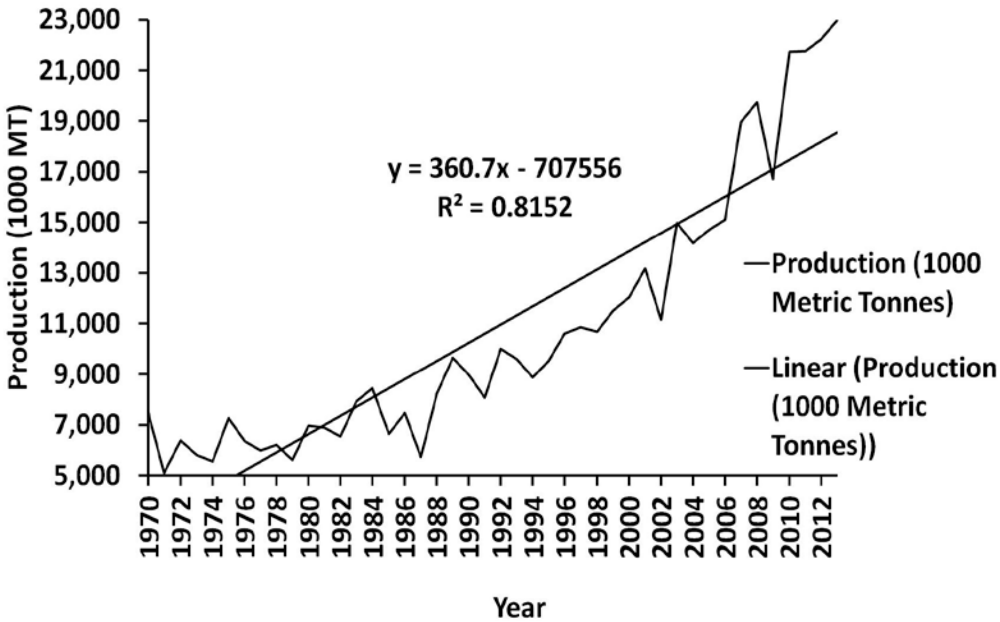


Fig. 5.3 Trend in Producion of Maize during the Overall Study Period (1970-2013)

It could also be seen that average production of maize has doubled from 6965 thousand tonnes during the post green revolution period to 14598 thousand tonnes during the post liberalization period and to 10780 thousand tonnes during the overall study period which accounted for one and a half fold increase. As discussed earlier, it is to be noted that the important determining components of increased production were area and productivity. While comparing these two components, the most important determining component was found to be area because the area expansion was proportionately far higher than that of productivity contributing substantially to total production. The fluctuation in terms of production was also observed. The coefficient of variation of production was found to be lower during the post green revolution period (17.29 %) but was higher during the post liberalization (32.11 %) and the overall study periods (47.60 %). This trend confirms that the growth in production was not stable.

The growth rate in production was significant both in absolute and compound terms during the post liberalization and the overall study periods. The production during the post liberalization period was higher and it had much impact on the production during the overall study period since the area expansion and productivity of maize in the non traditional areas were found to be significant (refer Table 4.10).

In absolute terms, as could be seen from the linear trends in the table, the output added was about 684.3 thousand tonnes annually during the post liberalization period which is more than five and a half times than that of during the post green revolution period (120.2 thousand tonnes / annum) while during the overall study period the same was about 360.7 thousand tonnes annually which is almost thrice that of during the post green revolution period. Similarly, the same trend was recorded in the compound growth rate. The compound growth rate of production during the post green revolution, the post liberalization and the overall study periods were 1.69, 4.75 and 3.25 per cent per annum respectively.

Productivity wise, the performance of the crop during the post liberalisation period (2.40 %) was better and hence the contribution to output growth was high during the same period (4.75 %). Of these two components, the contribution of productivity to production had been almost equal to that of the area growth (2.29 %). For the past two decades, therefore, emphasis seemed to have been on productivity and area expansion to increase total production and land resources had almost been exploited and further expansion possibilities were limited. Already considerable area under the crops like cotton, paddy etc., has been replaced over this period of time exerting tremendous pressure on several other crops also. This augments the findings of Bathla (2008), who while studying the extent of shift in area within the cropping sector in India reported that the growth in productivity has led to the growth in production.

Since yearly data was used, seasonal movements (S_t) could not be identified. The discussion so far, had abstracted of the random fluctuations and relied mainly upon the secular trends. The results of harmonic analysis of production of maize to test statistically the existence and length of cycles are presented in Table 5.6. Only during the post green revolution period production showed evidence of a seven year cycle for reasons discussed earlier, which lost its significance when aggregated with the post liberalization period. No cyclical fluctuation was found during the post liberalisation period as well as the overall study period. A seven year rainfall cycle has been observed in India and this augments with the production cycle. However, fluctuations did occur within a year, largely influenced by monsoons and climate. Thus the peak production coincided with the monsoon periods associated with rainfall.

Table 5.6: Results of Fourier Analysis for Production of Maize during 1970-2013

Cycle Length	Fourier Coefficient		Rp2	Rm2	K
	Ap	**Bp**			
Post Green Revolution (1970-1991)					
3	-62.6295	94.7122	12,892.8592	1,42,143.8012	0.0907
4	333.7359	145.9055	1,32,668.0599	1,55,448.4770	0.8535
5	-90.4324	-16.0145	8,434.4833	1,55,448.4770	0.0543
6	-287.0107	-435.5344	2,72,065.3787	1,66,083.5237	1.6381
7	393.9211	542.9533	4,49,972.2073	1,42,143.8012	3.1656*
8	478.0649	23.0809	2,29,078.8124	1,42,881.8156	1.6033
9	281.3875	143.4004	99,742.6131	1,66,083.5237	0.6006
10	-90.2348	-421.6065	1,85,894.3392	1,55,448.4770	1.1959
Post Liberalization (1992-2013)					
Cycle Length	**Fourier Coefficient**		**Rp2**	**Rm2**	**K**
	Ap	**Bp**			
3	365.2800	-62.2179	1,37,300.5130	2,23,334.0987	0.6148
4	-336.5517	722.9021	6,35,854.5361	2,45,759.3681	2.5873
5	423.9167	-365.3858	3,13,212.1966	2,45,759.3681	1.2745
6	187.7051	248.6599	97,064.9540	2,71,211.1880	0.3579
7	67.4883	289.7930	88,534.6667	2,23,334.0987	0.3964
8	68.2421	160.6771	4,657.0635	2,06,649.5211	0.0225
9	88.9965	-135.9933	26,414.5378	2,71,211.1880	0.0974
10	-544.5593	220.6875	3,45,247.8212	2,45,759.3681	1.4048
Overall Study Period (1970-2013)					
Cycle Length	**Fourier Coefficient**		**Rp2**	**Rm2**	**K**
	Ap	**Bp**			
3	-338.7504	-506.6822	3,71,478.7457	1,28,176.0229	2.8982
4	346.5062	-395.1494	2,76,209.6304	1,16,732.9195	2.3662
5	115.7751	-325.7372	1,19,508.6020	1,36,108.9110	0.8780
6	133.5517	-282.6602	97,732.8551	1,28,176.0229	0.7625
7	-29.2640	139.4918	20,314.3428	1,28,176.0229	0.1585
8	234.2327	-193.2098	1,52,971.5149	1,36,108.9110	1.1239
9	153.8059	-193.2098	60,986.2787	1,24,422.5328	0.4902
10	146.4147	-507.6572	2,79,153.1359	1,36,108.9110	2.0510

Note: * significant at 5% level.

The results implied that maize production was sensitive to climate and weather factors, market forces and it would be worthy to explore whether these were abnormalities and would adversely affect production. To account these fluctuations, OLS estimates of different specifications of the behavioural relationship were attempted and the most promising among them are presented below.

$$PGRQt = 6452.5 + 2.0667\ At - 0.9567\ TDCt + 814.449\ DPt/\ IPt + 995.522\ DPt/SP_t + 2.7898\ KRFt$$

(0.5302) (1.2098) (-1.0808) (1.21385) (1.3938) (1.3337)

$R^2 = 0.68$ D.W = 2.37

$$PLPQ_t = 2495.44 + 3.3994\ A_t^{**} + 0.1601\ TDC_t + 1239.13\ DP_t/IP_t + 1655.749\ DPt/SP_t^{**} + 1.4435\ KRF_t^{*}$$

(1.1988) (8.0968) (1.0531) (1.2898) (2.09826) (3.4313)

$R^2 = 0.97$ D.W = 2.32

$$OSPQ_t = 10180.05^{*} + 3.0618\ A_t^{*} + 0.4568\ TDC_t + 936.151 DP_t/IP_t^{**} + 1365.891\ DPt/SP_t^{*} + 2.1178\ KRF_t^{**}$$

(3.4978) (8.0481) (4.2161) (1.6846) (3.3040) (2.1595)

$R^2 = 0.97$ D.W = 1.91

Note: *significant at 1% level, **significant at 5% level

All the coefficients had expected signs with the exception of total domestic consumption of maize (TDC_t) which had a negative impact, as specified in the model during the post green revolution period. The domestic, external and substitute crop sorghum prices were included in the model as domestic price of maize relative to external price (DP_t/IP_t) and substitute crop sorghum price (DPt/SP_t) to capture the relative price movements and their impact on Indian maize production. The average *kharif* rainfall (KRF_t) was also included in the model as more of the area under the maize crop in the southern states was rainfed areas.

During the post liberalization period all the coefficients had expected signs and the coefficients of the variables area, domestic price relative to the price of substitute crop sorghum and the average *kharif* rainfall were significant. The regression had a satisfactory explanatory power. As regards to the overall study period, all the coefficients had expected signs with a positive impact on production. The relative price movements were very well captured in the model and all the domestic, external and substitute crop sorghum prices had positive impact on the production of maize. The average *kharif* rainfall was also positively contributing for the production as most of the area under maize was rainfed. Strong explanatory power was exhibited by the regression coupled with the significance of all the coefficients.

Domestic Consumption

The demand for maize is rising rapidly with increase in population and per caput income and growing demand from poultry and industry sector. Though the increase in domestic consumption of maize started relatively late in India, the growth in consumption had been relatively fast. The Total Domestic Consumption (TDC) here includes consumption of maize for Feed and Residual (FR), and for Food, Seed and Industrial use (FSI). The analyses were done separately on FR and FSI for all the three periods. The estimated mean, coefficient of variation, linear and compound growth rates for consumption of maize crop in India during the study period 1970 to 2013 are presented in Table 5.7.

The increase in consumption of maize for FR were positive and found to be 7.75 and 48.5 folds during the post green revolution and the overall study periods respectively, whereas during the post liberalization period it was 241.38 per cent. Similarly the increase in consumption of maize for FSI exhibited a negative growth of -12.25 per cent during the post green revolution period but was positive and found 27.39 and 23.29 per cent during the post liberalization and the overall study periods respectively. However, the increase in TDC of maize was positive and found to be 8.75, 89.66 and 152 per cent during the post green revolution, the post liberalization and the overall study periods respectively.

Table 5.7: Comparative Picture of Mean, C.V, Linear and Compound Growth Rate of Consumption of Maize in India during 1970-2013

(in '000 MT)

SI.No.	Growth Parameters		Post Green Revolution (1970-1991)	Post Liberalization (1992-2013)	Overall Study Period (1970-2013)
1.	Consumption in Percentage	FR	7.75#	241.38	48.5#
		FSI	-12.25	27.39	23.29
		TDC	8.75	89.66	152.00
2.	Mean Consumption	FR	810	5677	3244
		FSI	6196	7568	6882
		TDC	7007	13245	10126
3.	Coefficient of Variation (%)	FR	73.81	40.81	91.74
		FSI	12.00	11.17	15.24
		TDC	16.36	22.89	38.36
4.	Linear Growth Rate	FR	79.4*	348.7*	65.6*
		FSI	47.4	103.3*	219.4*
		TDC	126.8*	452.1*	285.0*
5.	Compound Growth Rate (%)	FR	10.62*	7.03*	0.95*
		FSI	0.77	1.33*	9.62*
		TDC	1.77*	3.48*	2.81*

Note: # the figures in no. of times, *Significant at 1 % level.
FR- Feed & Residual, FSI- Food, Seed & Industrial Use, TDC- Total Domestic Consumption.

At the same time the average consumption of maize for FR has increased from 810 thousand tonnes to 5677 thousand tonnes per annum which is seven folds but when aggregated, the same has increased to 3244 thousand tonnes per annum during the overall study period which is nearly four folds. But the average consumption of maize for FSI showed marginal increase and was 6196, 7568 and 6882 thousand tonnes per annum during the post green revolution, the post liberalization and the overall study periods respectively. However, the TDC almost doubled from 7007 thousand tonnes during the post green revolution period to 13245 thousand tonnes during the post liberalization period and to 10126 thousand tonnes during the overall study period which is one and a half folds more.

The fluctuations were found to be lower in the consumption of maize for FSI during all the three periods viz., the post green revolution (12 %), the post liberalization (11.17 %) and the overall study periods (15.24 %). This implies that the consumption of maize for FSI was secured and found to be stable in all the three periods. The fluctuation in the consumption of maize for TDC was lower only during the post green revolution period (16.36 %) but was higher during the post liberalization (22.89 %) and the overall study periods (38.36 %). In the consumption of maize for FR, the fluctuations were higher during all the three periods viz., the post green revolution (73.81 %), the post liberalization (40.81 %) and the overall study periods (91.74 %). This might be due to the increasing demand for maize for Feed and Residuals (FR) i.e., other than Food, Seed and Industrial use (FSI). This demand is increasing at an increasing pace since the beginning of liberalization era and hence the fluctuations are quite visible. If the same trend in consumption continues for a fairly long time in future, the fluctuations would be smoothening out.

The growth rates of consumption of maize for FR, FSI and TDC were significant both in absolute and compound terms during all the three periods. It could be seen from the table and Figure 5.4, the linear trend during the post green revolution period was high for TDC with an additional consumption of 126.8 thousand tonnes annually, followed by FR with an additional consumption of 79.4 thousand tonnes annually and FSI with an additional consumption of 47.4 thousand tonnes annually. The same trend was observed in consumption during the post liberalization period with an additional consumption of 452.1 thousand tonnes annually for TDC, 348.7 thousand tonnes for FR and 103.3 thousand tonnes for FSI. But during the overall study period the trend changed slightly and the high additional consumption of 285.0 thousand tonnes annually was observed for TDC, followed by FSI with 219.4 thousand tonnes annually and for FR with 65.6 thousand tonnes annually.

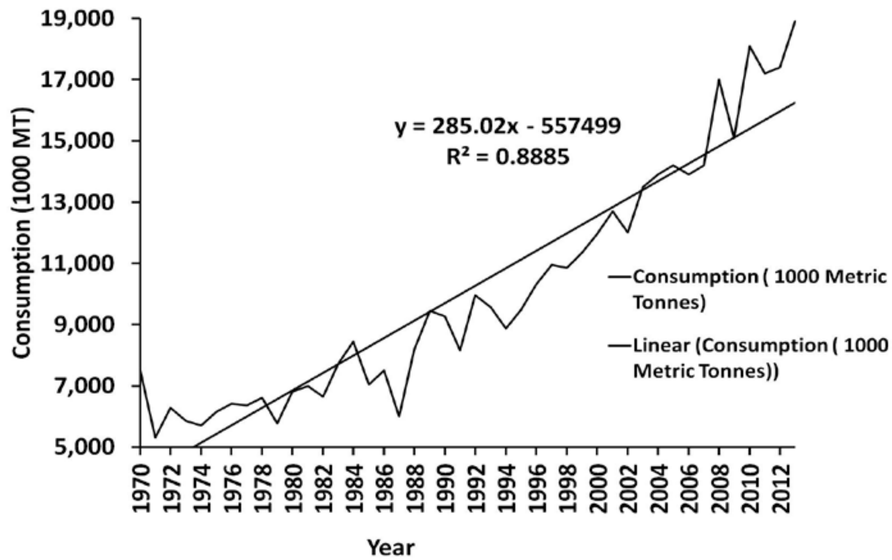


Fig. 5.4. Trend in Consumption of Maize during the Overall Study Period (1970-2013)

The compound growth rates of consumption for FR, FSI and TDC during the post green revolution period were 10.62, 0.77 and 1.77 per cent per annum respectively. The growth rate for FR was around fourteen times more than that of FSI and six times more than that of TDC indicating the phenomenal increase in the demand for feed and residuals even before the start of liberalization. The same trend was also observed during the post liberalization and the overall study periods. The growth rate of productivity was found to be significant in both absolute and compound terms. The compound growth rate of TDC of 2.81 per cent during the overall study period was far higher than that of area growth (0.98 %) and productivity growth (2.25 %).

The increased consumption in the FR sector of maize is the major reason for this growth rate in consumption. Though maize is consumed directly as food in most of the developing countries, in India it is directed for human consumption mostly in North-Eastern states alone. But in the other parts the crop is mainly used as live-stock feed, industrial raw materials and food processing (DMR, 2014).

Since yearly data was used, seasonal movements (S_t) could not be identified. The discussion so far, had abstracted of the random fluctuations and relied mainly upon the secular trends. The results of harmonic analysis of the consumption of maize would provide some evidence on the existence of cyclical fluctuations and results are presented in Table 5.8.

Table 5.8: Results of Fourier Analysis of Domestic Consumption of Maize during 1970-2013

Post Green Revolution (1970-1991)					
Cycle Length	**Fourier Coefficient**		**Rp2**	**Rm2**	**K**
	Ap	**Bp**			
3	-12.3366	78.1796	6,264.2355	1,00,676.5907	0.0622
4	297.5983	321.7378	1,92,079.9606	1,07,559.4821	1.7858
5	-11.1433	-27.0615	856.4981	1,07,559.4821	0.0080
6	-237.9397	-468.0305	2,75,667.8934	1,17,249.5769	2.3511
7	251.4770	542.8648	3,57,942.8696	1,00,676.5907	3.5554*
8	324.6114	136.7799	1,24,081.2766	92,040.7230	1.3481
9	183.7443	70.5379	38,737.5659	1,17,249.5769	0.3304
10	-68.9494	-425.3561	1,85,681.8248	10,7559.4821	1.7263
Post Liberalization (1992-2013)					
Cycle Length	**Fourier Coefficient**		**Rp2**	**Rm2**	**K**
	Ap	**Bp**			
3	194.4194	-68.6692	42,514.3491	87,344.6730	0.4867
4	-178.3117	139.1545	51,159.0375	92,042.9633	0.5558
5	381.2757	-341.4442	2,61,955.3109	92,042.9633	2.8460
6	-13.6737	-114.1347	13,213.6888	91,381.5369	0.1446
7	157.2568	42.0912	26,501.3718	87,344.6730	0.3034
8	254.4928	-69.7244	64,766.6775	64,439.7049	1.0051
9	155.9282	-39.1329	25,844.9984	91,381.5369	0.2828
10	-129.9370	-79.8898	23,266.0085	92,042.9633	0.2528
Overall Study Period (1970-2013)					
Cycle Length	**Fourier Coefficient**		**Rp2**	**Rm2**	**K**
	Ap	**Bp**			
3	-96.8305	55.4265	12,448.2467	47,182.2332	0.2638
4	285.9280	197.1650	1,20,628.8570	43,816.9310	2.7530
5	19.4798	-156.0965	24,745.5752	47,355.5788	0.5225
6	-95.2943	-386.9388	1,58,802.6377	47,182.2332	3.3657*
7	92.7430	325.9236	1,14,827.4382	47,182.2332	2.4337*
8	66.2746	-59.6792	10,042.0929	47,355.5788	0.2121
9	166.5883	-59.6792	31,313.2739	44,703.4428	0.7005
10	-54.1426	-389.2014	1,54,409.1327	47,355.5788	3.2606*

Note: * significant at 5% level.

The evaluated ‘K’ values for the post green revolution period indicated significant seven year cycle at 5 per cent level and no fluctuations were observed during the post liberalization period. But during the overall study period six to seven years and ten year cycles were identified. During the post green revolution period, seven year productivity and production cycles were observed and this arguments with the consumption pattern.

The explanatory power of the trend variable (about 89 per cent) was crucial in that, changes in the tastes and preferences of the population that determined consumption levels were by and large qualitative and needed to be proxied for empirical scrutiny. Though income per capita, prices of the commodity and its substitutes did provide some predictable relationships, the role of subjective factors that too in a time span of about three decades could not be underestimated. And trend variable often came out to be the simple effective proxy to represent them. Keeping in view the above factors, OLS estimates of different specifications of the consumption relationship were attempted and the most promising among them is presented below.

PGRPDCt = 5656.279 – 1246.1 DPt/IP_t – 237.888 DPt/ SPt + 0.40677 PCIt + 0.0101 ANLAt
(1.4461) (-1.5108) (-0.5146) (1.2547) (1.7182)

$R^2 = 0.76$ D.W = 2.71

PLPDCt = 8331.831 – 1588.055 DPt/IP_t** – 1161.11 DPt/ SPt*** + 0.1546 PCIt***+ 0.0016 ANLAt**
(1.6914) (-2.5932) (1.7519) (1.8342) (2.2187)

$R^2 = 0.93$ D.W = 2.02

OSPDCt = 4478.422** – 1078.78 DPt/IP_t* – 1173.286 DPt/ SPt* + 0.0098 PCIt* + 0.0152ANLAt*
(2.0635) (-2.8364) (3.2686) (2.9253) (3.3353)

$R^2 = 0.96$ D.W = 2.17

Note: *significant at 1% level, **significant at 5% level,***significant at 10% level.

All the coefficients had expected signs as specified in the model during the post green revolution period. The domestic, external and substitute crop sorghum prices were included in the model as domestic price of maize relative to external price (DPt/IP_t) and substitute crop sorghum price (DPt/SP_t) to capture the relative price movements and their impact on domestic consumption of maize. The explanatory power of the above specification was 76 per cent, with a negative sign of the relative price coefficients. The lack of confidence of the relative price coefficients would go to indicate that the effect of prices on consumption was obscured. The coefficients of income per capita (PCI_t) and number of live animals in India ($ANLA_t$) were positive but insignificant.

All the coefficients had expected signs as specified in the model during the post liberalization and the overall study periods and they were highly significant. The relative prices were highly significant with negative impact on domestic consumption of maize. However, growing per capita income definitely and positively contributed to the domestic consumption. The income elasticity indicated that every one per cent addition to net per capita income raised domestic consumption i.e. irrespective of the increase in domestic price the consumption increased if per capita income increased.

Though, from the consumer point of view, the impact of causal factors appeared to be little, one could note plausibly that the producers could have a strong reason to turn to domestic market. In terms of prices, they received for their produce; domestic market offered them an irresistible outlet.

Over the last decade, the domestic prices were higher than the unit value realised, on exports. Domestic market offered the producers better profits with lesser risk. In contrast, exports involved severe international competition, strict quality control enforcement atleast by the importing countries and associated formalities; the captive domestic market, with its vastness coupled with the lack of consumer awareness, proved a strong disincentive for the producers to export maize.

The indications were that, consumption would grow unchecked due to changing food habits, increase in non vegetarian population, exorbitant growth of poultry sector and increasing inclination towards intensification in the industrial use of maize and in ethanol production. The government seemed to aid the domestic consumers as it occasionally placed restrictions on interstate movements and exports to ensure food security as well as protect producers through minimum support price by which they had all the advantages to turn to the domestic market.

Price

Economic theory asserts that in a free market economy the market price reflects interaction between supply and demand. As the Indian economy is growing steadily over the years, this generally exerts an upward pressure on prices. For the study, the annual average producer price, that proxied the domestic price, had been steadily growing over the decades. The growth rate of prices was significant both in absolute and compound terms during the post liberalization and the overall study periods. The prices during the post liberalization period were higher and it had much impact on the prices during the overall study period.

In absolute terms, as could be seen from the linear trends in the Table 5.9 and Figure 5.5, during the post liberalization period the price increase was about rupees 497.40 per tonne annually while the increase in price during the post green revolution period was about rupees 79.09 per tonne annually which is around six and half times less than the increase during the post liberalization period. During the overall study period the increase in price was rupees 253.66 per tonne annually which is around two times less than the increase during the post liberalization period. Similarly, the same trend was recorded in the compound growth rate. The compound growth rate of price during the post green revolution, the post liberalization and the overall study periods were 5.95, 7.15 and 7.00 per cent per annum respectively.

Table 5.9: Linear and Compound Growth Rate for Maize Price in India during 1970-2013

(Rupees per Tonne)

SI.No.	Period	Linear Growth Rate	Compound Growth Rate (%)
1.	Post Green Revolution (1970-1991)	79.09*	5.95*
2.	Post Liberalization (1992-2013)	497.40*	7.15*
3.	Overall Study Period (1970-2013)	253.66*	7.00*

Note: *Significant at 1 % level.

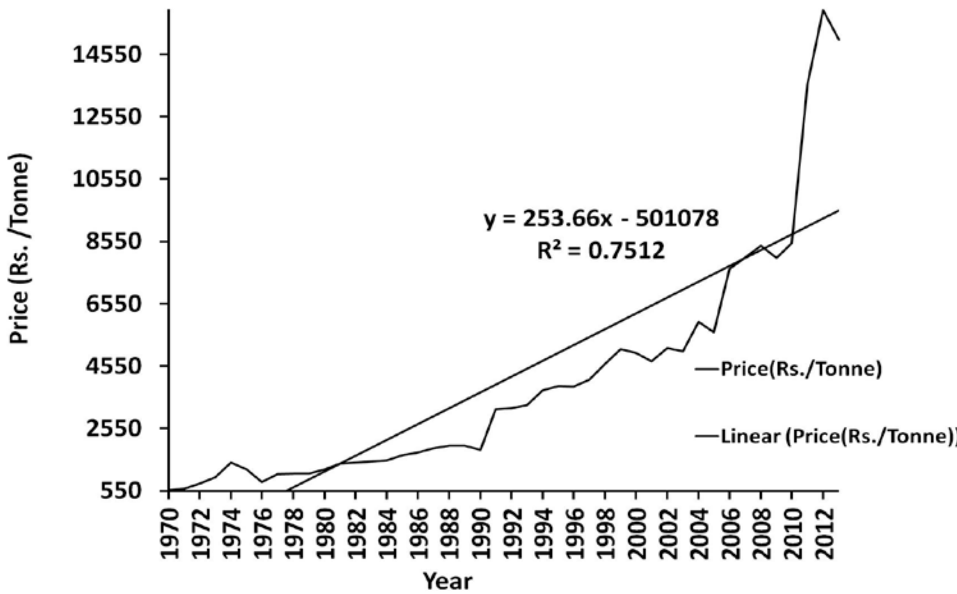


Fig. 5.5. Trend in Domestic Price of Maize during the Overall Study Period (1970-2013)

It is to be expected that, in a predominantly outward looking industry, increases in domestic prices, by suppressing consumption, would lead to increased exports. But the reverse had happened in the present case. The increase in domestic consumption, irrespective of prices, seemed to have exerted an upward pressure on prices, which consequently made the domestic market more profitable. Alternatively, the inbuilt inflationary pressures of the economy could have caused the economy to be a high cost one, thereby placing the Indian maize exports at a disadvantageous position and, at the same time, raising the domestic prices.

The results of harmonic analysis of domestic price of maize would provide some evidence on the existence of cyclical fluctuations and the results are presented in Table 5.10. The evaluated ‘K’ values of the post green revolution period indicated the existence of significant seven to eight year cycle at 5 per cent level. The trends apart, fluctuations in price occurred, which lost its identity when aggregated and no cyclical fluctuations found during the post liberalization and the overall study periods. The results showed that during the post green revolution period once in seven years period, the maize price attained the maximum. The producers obtained maximum profit in the peak years than in other years.

Table 5.10: Results of Fourier Analysis of Price of Maize during 1970-2013

Post Green Revolution (1970-1991)					
Cycle Length	**Fourier Coefficient**		**Rp2**	**Rm2**	**K**
	Ap	**Bp**			
3	-24.2945	-49.2682	3,017.5759	7,307.2062	0.4130
4	-48.4626	33.5007	3,470.9221	6,048.9556	0.5738
5	-32.1806	29.3341	1,896.0819	6,048.9556	0.3135
6	21.1207	1.7503	449.1486	6,983.1681	0.0643
7	96.1062	-119.4998	23,516.6118	7,307.2062	3.2183*
8	32.7313	-174.5197	31,528.4531	8,832.1637	3.5697*
9	63.5782	-21.8690	4,520.4457	6,983.1681	0.6473
10	-26.7499	-42.5961	2,529.9854	6,048.9556	0.4183
Post Liberalization (1992-2013)					
Cycle Length	**Fourier Coefficient**		**Rp2**	**Rm2**	**K**
	Ap	**Bp**			
3	-223.836	62.738	54,038.715	2,47,744.572	0.218
4	28.026	418.101	1,75,593.614	2,01,970.007	0.869
5	-149.677	388.663	1,73,462.426	2,01,970.007	0.859
6	-23.971	-278.326	78,039.843	1,40,865.857	0.554
7	-92.860	645.010	4,24,661.403	2,47,744.572	1.714
8	5.324	145.466	28.429	1,02,480.242	0.000
9	13.023	-74.485	5,717.604	1,40,865.857	0.041
10	84.057	220.509	55,689.812	2,01,970.007	0.276
Overall Study Period (1970-2013)					
Cycle Length	**Fourier Coefficient**		**Rp2**	**Rm2**	**K**
	Ap	**Bp**			
3	-146.1183	-158.5274	46,481.5074	64,049.6121	0.7257
4	136.3958	-228.7447	70,927.9666	1,20,857.7993	0.5869
5	84.8235	-34.8040	8,406.3504	42,708.0030	0.1968
6	-35.4629	119.4458	15,524.9189	64,049.6121	0.2424
7	-177.7056	0.1985	31,579.3090	64,049.6121	0.4930
8	178.7469	-72.2248	54,625.6436	42,708.0030	1.2790
9	33.2812	-72.2248	6,324.0648	43,699.0971	0.1447
10	27.2753	-44.6805	2,740.2891	42,708.0030	0.0642

Note: * significant at 5% level.

While the prices exhibited cyclical fluctuations, seasonally they were quite stabilized (Table 5.11). The seasonal indices were calculated for the monthly average prices of maize in the selected five different domestic markets; two markets viz. Chhindwara (CH) and Kota (KO) from the traditional maize growing states of Madhya Pradesh and Rajasthan and three markets viz. Davangere (DAV), Nizamabad (NZ) and Udumalpet (UDU) from the non-traditional areas of Karnataka, Andhra Pradesh and Tamil Nadu respectively for the period from January 2003 to December 2013. There were no much variations found in seasonal indices of different domestic maize markets. The seasonal index 109.17 of Udumalpet market for the month of August indicated that the price in the month of August was nine percent above the monthly average and the price in the month of March was six percent less than the monthly average. Similarly in all other markets seasonal indices were above the monthly average during the months of July and August and below the average during October and November. That is, the price was above average at the time of harvest (*rabi* season) and below average at the time of harvest (*kharif* season). These fluctuations may be due to environmental factors, underlying market adjustments, though seasonally stabilized due to the organized nature of its markets.

Table 5.11. Seasonal Indices of Prices of Maize in Different Domestic Markets

	DAV	**NZ**	**UDU**	**CH**	**KO**
January	99.4154	97.2317	94.3340	98.3758	101.2639
February	98.8773	98.0728	94.6997	98.3025	100.7710
March	99.6034	98.1340	93.7706	99.2895	101.3898
April	100.6400	100.0723	97.4222	100.2364	100.9133
May	100.1547	97.5789	97.4697	98.5049	99.0809
June	103.6733	103.2860	103.9171	102.9115	99.9281
July	107.5371	105.1871	105.5400	106.1595	101.9573
August	103.1335	104.1884	109.1691	108.7005	104.0475
September	97.3130	103.6936	105.9954	102.1584	99.3994
October	93.4839	97.2752	101.0203	95.8247	94.1477
November	96.9222	97.4000	99.3335	93.7473	97.5610
December	99.2608	97.9888	97.6420	95.9738	99.9876

Note: Computations pertain to the time period 2003 to 2013

NZ-Nizamabad, DAV-Davangere, CH- Chhindwara, KO-Kota,UDU- Udumalpet

The OLS results, of the basic version of the domestic prices specification depict the perspective of the price formation process, are presented below:

$$PGRDP_t = 363.966 + 2469.903\ S_t/DC_t + 5089.358\ S_t/Q_t + 0.8211\ IP_t + 0.3355\ DP_{t-1}$$
$$(1.6895) \quad (0.3359) \quad (0.6456) \quad (1.1536) \quad (1.7009)$$

$R^2 = 0.88$ D.W = 1.81

$$PLPDP_t = 915.44^{***} + 3948.398\ S_t/DC_t^{**} + 6762.321\ S_t/Q_t^{**} + 0.6889\ IP_t + 0.31332\ DP_{t-1}$$
$$(1.9786) \quad (2.0849) \quad (2.5083) \quad (1.5973) \quad (1.3761)$$

$R^2 = 0.94$ D.W = 1.74

$$OSDP_t = 622.83^{*} - 2225.03\ S_t/DC_t^{*} + 6188.77\ S_t/Q_t^{**} + 0.6602\ IP_t^{*} + 0.3822\ DP_{t-1}^{*}$$
$$(2.7852) \quad (3.1069) \quad (2.2814) \quad (5.6674) \quad (3.0739)$$

$R^2 = 0.97$ D.W = 1.77

Note:*significant at 1% level, **significant at 5% level, ***significant at 10% level.

The stock-flow adjustment process had a determined role in the price formation process, as also the international market forces as proxied by the international prices (IP_t). None of the variables during the post green revolution period in the stock-flow adjustment process were significant with an unexpected sign for stocks relative to consumption (S_t/DC_t). Similarly both the price variables were insignificant with unexpected positive sign for stocks relative to consumption during the post liberalization period. All the variables in the domestic prices specification during the overall study period were significant with expected signs. Both the domestic (DP_{t-1}) and international prices (IP_t) were significant at one per cent level with an expected negative sign for stocks relative to consumption. Stocks, which had grown significantly in the recent years, apparently had a decisive role in price formation. Rising stocks relative to consumption, by excess accumulation had a price-suppressing effect, whereas when moved upward relative to production (S_t/Q_t), the prices tended to rise due to limited release for consumption. Similarly, the international market, through its competition transmitted an upward pressure on domestic prices. The futures market in India is in primitive stage as maize is included in the commodities market quite recently and expectations, in a commodity that involved commitments over decades, seemed to be very conservative. While domestic prices were positively influenced by the international prices, the later too had been growing over time.

International Price

The growth rate of international price was significant both in absolute and compound terms during the post green revolution, the post liberalization and the overall study periods. The prices during the post liberalization period were higher and it had much impact on the prices during the overall study period.

In absolute terms, as could be seen from the linear trends in the Table 5.12 and Figure 5.6, during the post liberalization period the price increase was about rupees 475.48 per tonne annually while the increase in price during the post green revolution period was about rupees 53.33 per tonne annually which is almost nine times less than the increase during the post liberalization period. During the overall study period the increase in price was rupees 229.49 per tonne annually which is two times less than the increase during the post liberalization period. Similarly, the same trend was recorded in the compound growth rate. The growth rate of international prices 5.92, 7.70 and 7.77 per cent during the post green revolution, the post liberalization and the overall study periods respectively came closer to that of domestic prices 5.95, 7.15 and 7.00 per cent during the post green revolution, the post liberalization and the overall study periods, respectively implying that the domestic market was closely responding to international conditions. The unit value realised on exports by the principal exporting countries, takes into account the spatial distribution of exports, prices and exchange rate fluctuations.

Table 5.12: Comparative Picture of Mean, C.V, Linear and Compound Growth Rate of International Price of Maize in India during 1970-2013

(Rs./Tonne)

Period	Linear Growth Rate	Compound Growth Rate (%)
Post-Green Revolution (1970-1991)	53.33*	5.92*
Post-Liberalization (1992-2013)	475.48*	7.70*
Overall Study Period (1970-2013)	229.49*	7.77*

Note: *Significant at 1 % level.

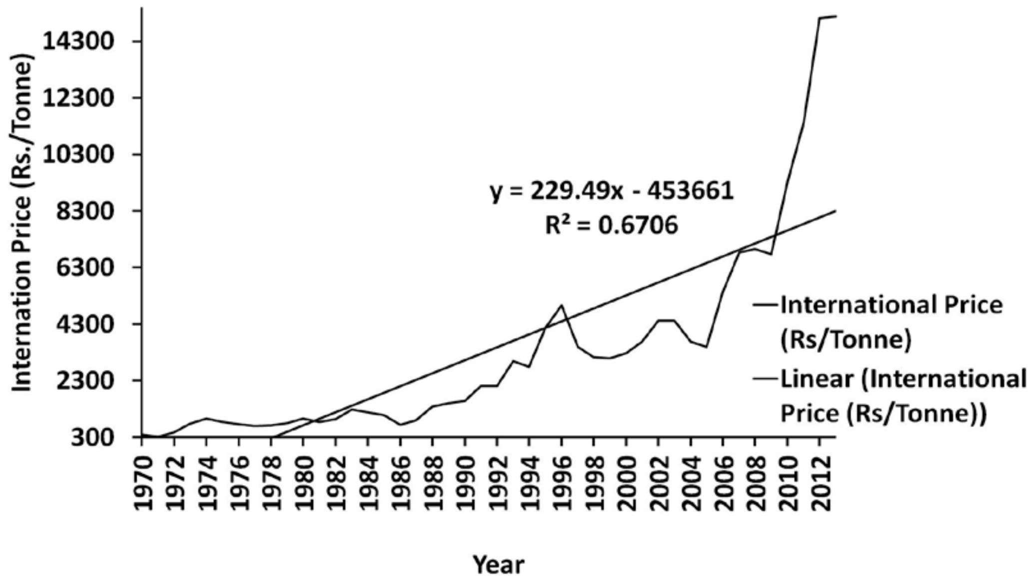


Fig. 5.6. Trend in International Price of Maize Crop during the Overall Study Period (1970-2013)

Stock

The level of stockholding which was only 500 thousand tonnes in 1970 increased to 1320 thousand tonnes in 2013, which was greater than the total exports in 2003. The results of mean, coefficient of variation, linear and compound growth rate of ending stock of maize in India during the period 1970 to 2013 are presented in Table 5.13 and Figure 5.7.

Table 5.13: Comparative Picture of Mean, C.V, Linear and Compound Growth Rate of Ending Stock of Maize in India during 1970-2013

(‘000 MT)

SI.No.	Growth Parameters	Post Green Revolution (1970-1991)	Post Liberalization (1992-2013)	Overall Study Period (1970-2013)
1.	Mean Stock	436	488.59	462.48
2.	Coefficient of Variation (%)	78	66.54	71.41
3.	Linear Growth Rate	-21.965**	30.388*	2.833
4.	Compound Growth Rate (%)	-6.64*	9.01*	0.836

Note: *Significant at 1 % level, ** Significant at 5 % level.

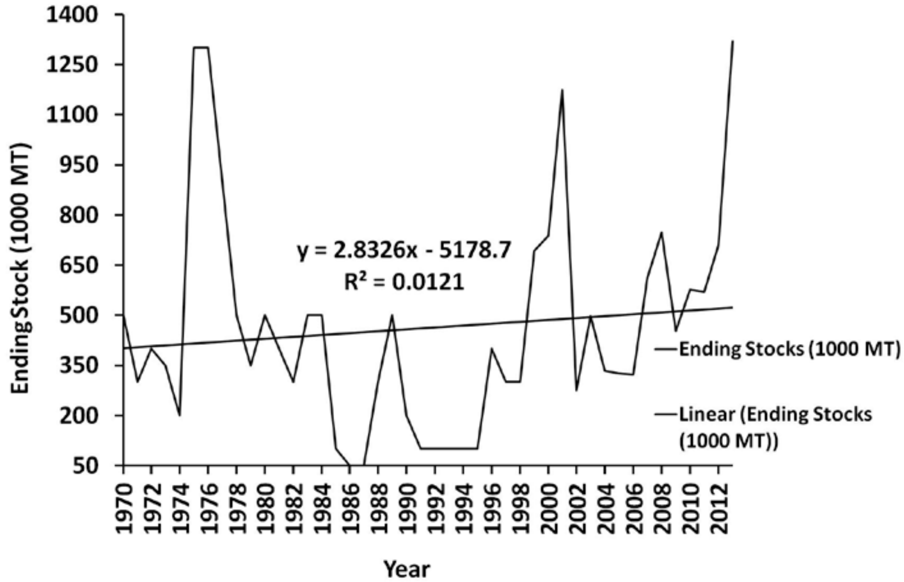


Fig. 5.7 Trend in Maize Stocks during the Overall Study Period (1970-2013)

During the post green revolution, the post liberalization and the overall study periods the average stock of maize were 436, 488.59 and 462.48 thousand tonnes respectively and the average stock position was hovering around 400 to 500 thousand tonnes. The fluctuation in the stock position was high and unstable and was about 78, 66.54 and 71.41 per cent during the post green revolution, the post liberalisation and the overall study periods respectively.

Due to this volatility the growth rate of Indian maize stock position exhibited the same trend both in absolute and compound terms during the post green revolution, the post liberalization and the overall study periods. The compound growth rate of stock during the post green revolution period was negative (-6.64 % per annum) and increased to 9.01 per cent per annum during the post liberalisation period and further on aggregation stabilized at 0.836 per cent per annum during the overall study period. In absolute terms, as evident from the linear trends in the table, during the post liberalization period the stocks registered the negative trend (about -21.965 thousand tonnes annually) and increased to 30.388 thousand tonnes annually during the post liberalisation period which on aggregation showed an increase of 2.833 thousand tonnes annually during the overall study period.

However, except the consolidated figures of stock held, no further details and break up of stocks held by different categories were available; the seasonal movements (S_t) could not be identified. The discussion so far, had abstracted of the random fluctuations and relied mainly upon the secular trends. The results of harmonic analysis of the stock of maize would provide some evidence on the existence of cyclical fluctuations. The Schuster's 'k' values of Table 5.14 indicated that no significant cyclical fluctuations existed in the maize stocks during the post liberalisation and the overall study period but seven year cyclical fluctuation was observed during the post green revolution period may be due to fluctuations in production and productivity. As discussed earlier, seven year cyclical changes were found in production and productivity.

The growth in stocks might imply that there had been a perpetuating gap between supply and demand, the former outstripping the latter and the existence of cycles would imply that the gap was to some extent market influenced. Since the supply side had been stable and growing, the fluctuations appeared to have originated from the demand side. The stable growth of supply in India had occasionally resulted in price slumps which had been attributed to the excess world supply. While in the long run supply management was also important, demand management was clearly the deserving parameter in the short run. Tangible efforts had been undertaken so far in domestic demand management. Efforts had to be made to stimulate international demand.

Export

Maize exports have emerged as one of the most important price influencing factors. Export of maize started in the year 1980 with 10 thousand tonnes and reached all time high close to 3954 thousand tonnes in 2013-14 which accounted for around 17 per cent of the total production. India has witnessed a boom in maize exports from the year 2007-08 onwards. The increase in export volumes is attributed to increased production, higher realization of price and substantial demand from international markets. Export volume declined during the period 2009-2011 due to drought conditions leading to low production. Increased local demand for maize from poultry and starch industries, within India, and application in diversified industries such as alcoholic beverages, bio-fuel, processed food, maize oil, etc., has kept maize prices relatively steady. Drought in USA

Table 5.14: Results of Fourier Analysis of Stock of Maize in India during 1970-2013

Post Green Revolution Period (1970-1991)					
Cycle Length	**Fourier Coefficient**		**Rp2**	**Rm2**	**K**
	Ap	**Bp**			
3	-25.1965	-1.2272	636.3679	17,550.8457	0.0363
4	101.7161	-98.8881	20,125.0237	19,295.2060	1.0430
5	-16.2946	-14.3042	470.1261	19,295.2060	0.0244
6	-69.0041	46.0026	6,877.8016	22,291.1279	0.3085
7	116.5872	209.7087	57,570.3083	17,550.8457	3.2802*
8	199.6896	102.2932	50,339.8420	26,353.6948	1.9102
9	17.7724	47.8230	2,602.8945	22,291.1279	0.1168
10	27.6597	72.3662	6,001.9338	19,295.2060	0.3111
Post Liberalization Period (1992-2013)					
Cycle Length	**Fourier Coefficient**		**Rp2**	**Rm2**	**K**
	Ap	**Bp**			
3	11.7332	-51.5324	2,793.2556	10,514.3412	0.2657
4	-96.7573	21.0562	9,805.3375	11,612.1585	0.8444
5	19.4464	33.2907	1,486.4357	11,612.1585	0.1280
6	65.1332	45.8997	6,349.1093	13,935.1888	0.4556
7	-96.6630	-8.7659	9,420.5801	10,514.3412	0.8960
8	-40.3758	133.3960	1,630.2889	16,758.9390	0.0973
9	7.3010	45.1048	2,087.7476	13,935.1888	0.1498
10	-47.1351	77.4136	8,214.5776	11,612.1585	0.7074
Overall Study Period (1970-2013)					
Cycle Length	**Fourier Coefficient**		**Rp2**	**Rm2**	**K**
	Ap	**Bp**			
3	-24.4776	-9.1268	682.4500	7,928.4114	0.0861
4	66.7630	-44.3659	6,425.6270	7,736.2443	0.8306
5	31.4448	-37.8890	2,424.3513	8,643.0898	0.2805
6	3.2411	44.3399	1,976.5293	7,928.4114	0.2493
7	-22.6377	-85.6818	7,853.8392	8,561.0894	0.9174
8	89.0441	-16.3129	9,300.5266	8,643.0898	1.0761
9	15.7392	-16.3129	513.8340	10,338.5253	0.0497
10	-13.0171	27.4803	924.6094	8,643.0898	0.1070

Note: * significant at 5% level.

also left a major gap in the world markets; Indian exporters took the advantage of the same. Together Indonesia, Malaysia and Vietnam imported 70 per cent of the total Indian maize exports (Figure 5.8). Globally India has emerged as one of the top five maize supplying countries since 2010-11 and slightly slipped down to sixth place in 2013-14.

An attempt has been made with the available limited data set, since the export of maize started from the year 1980 onwards, to study the trend and other growth parameters during the post green revolution and the post liberalisation periods.

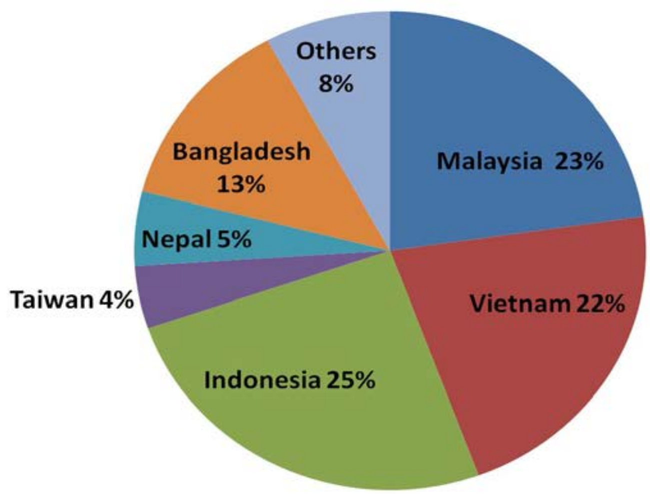


Fig. 5.8. Percentage Share of Indian Maize Export during 2013-14

However trend and other parameters were studied for the overall study period to capture the underlying characteristics of the time series data on Indian exports of maize and the results are given in the Table 5.15. Initially 10 thousand tonnes of maize was exported in the year 1980 which declined to 4 thousand tonnes in the year 1991, the post green revolution period. But during the post liberalization period the export increased to 140 times and the same was observed during the overall study period with an increase of 394 times.

Table 5.15: Comparative Picture of Mean, C.V, Linear and Compound Growth Rate of Export of Maize from India during 1980-2013

(Export '000 MT)

SI.No.	Growth Parameters	Post Green Revolution (1980-1991)	Post Liberalization (1992-2013)	Overall Study Period (1980-2013)
1.	Mean Export (million tonnes)	4.402	1293.86	838.87
2.	Coefficient of Variation (%)	122.14	137.47	184.84
3.	Linear Growth Rate	-0.9766**	219.38*	111.32*
4.	Compound Growth Rate (%)	-23.03	40.81*	32.55*

Note: *Significant at 1 % level, ** Significant at 5 % level.

It could also be seen that the average export of maize was 4.402 thousand tonnes during the post green revolution period which increased significantly to 1293.86 thousand tonnes during the post liberalization period and on aggregation averaged to 838.87 thousand tonnes during the overall study period. High fluctuations in growth dimensions were also observed. The coefficient of variation for export was comparatively lower during the post green revolution period (122.14 %) than that of during the post liberalization period (137.47 %). On aggregation, the coefficient of variation for export was higher (184.84 %) during the overall study period. This trend confirmed that the growth in export was not stable. In absolute terms, as evident from the linear trends in the table, during the post green revolution period the exports registered the negative trend (about – 0.9766 thousand tonnes annually) and increased to 219.38 thousand tonnes annually during the post liberalisation period which on aggregation showed an increase of 111.32 thousand tonnes annually during the overall study period.

Due to this volatility the growth rate of Indian maize export exhibited the same trend both in absolute and compound terms during the post green revolution, the post liberalization and the overall study periods. The compound growth rate of exports during the post green revolution period was negative (- 23.03 % per annum) then increased to 40.81 per cent per annum during the post liberalisation period which further on aggregation stabilized at 32.55 per cent per annum during the overall study period. The findings of the study, clearly show that because of removal of barriers to exports, the export of maize was improved during the post liberalisation period and it was significant at 1 per cent level.

In absolute terms, as evident from the linear trends in the Table 5.16, during the post green revolution period the Indian share of maize exports to the world export registered the negative trend and increased to 2.2 metric tonnes annually during the post liberalisation period which on aggregation showed an increase of 1.1 metric tonnes annually during the overall study period.

The compound growth rate of Indian share of world exports during the post green revolution period was negative (-0.22 % per annum) then increased to 3.71 per cent per annum during the post liberalisation period which further on aggregation stabilized at 2.01 per cent per annum during the overall study period. The Indian exports found to be widely fluctuating with no apparent trend pattern and the Indian Share (IS), declined sharply at almost 1.77 per cent per annum during the overall study period even as the total world maize trade was expanding at about 1.55 per cent per year. The value realised on exports on the other hand, had been significantly growing on account of increased prices.

Table 5.16: Comparative Picture of Linear and Compound Growth Rate of Indian Share of World Maize Export during 1980-2013

(in '000 MT)

Period	Linear Growth Rate	Compound Growth Rate (%)
Post Green Revolution (1980-1991)	-0.00001**	- 0.22
Post Liberalization (1992-2013)	0.0022*	3.71*
Overall Study Period (1980-2013)	0.0011*	2.01*

Note: *Significant at 1 % level, ** Significant at 5 % level.

It could also be seen from the Table 5.17 that the average world export of maize was 63869 thousand tonnes with a negative increase (- 22.73 %) during the post green revolution period which increased significantly to 80171 thousand tonnes with an increase of 87.96 per cent during the post liberalization period and on aggregation averaged to 74417 thousand tonnes with an increase of 48.02 per cent during the overall study period. No fluctuations in growth dimensions were observed and the world export was stable. This trend confirmed that the growth in world export was stable.

In absolute terms, as evident from the linear trends in the table, during the post green revolution period the exports registered the negative trend (about – 649.33 thousand tonnes annually) and increased to 2137.95 thousand tonnes annually during the post liberalisation period which on aggregation showed an increase of 1207.7 thousand tonnes annually during the overall study period.

Table 5.17: Comparative Picture of Mean, C.V, Linear and Compound Growth Rate of World Export of Maize during 1970-2013

(in '000 MT)

SI.No.	Period	Post Green Revolution (1970-1991)	Post Liberalization (1992-2013)	Overall Study Period (1970-2013)
1.	Percentage Export	-22.73	87.96	48.02
2.	Mean Export	63869.08	80171.32	74417.59
3.	Coefficient of Variation (%)	11.78	19.39	20.61
4.	Linear Growth Rate	-649.33	2137.949*	1207.70*
5.	Compound Growth Rate (%)	-0.93	2.64*	1.55*

Note: *significance at 1 % level.

The compound growth rate of world exports during the post green revolution period was negative (- 0.93 % per annum) then increased to 2.64 per cent per annum during the post liberalisation period which further on aggregation stabilized at 1.55 per cent per annum during the overall study period. The findings of the study clearly show that because of removal of barriers to exports, the world export of maize was improved during the post liberalisation period and it was significant at 1 per cent level.

Since yearly data was used, seasonal movements (S_t) could not be identified. The discussion so far, had abstracted of the random fluctuations and relied mainly upon secular trends. The harmonic analysis was used to test statistically the existence and length of cycles. Due to unavailability of data, the Fourier analysis was carried out only for the overall study period. The results of harmonic analysis of the Indian maize export would provide evidence on the existence of cyclical fluctuations are presented in Table 5.18. The Schuster's 'k' values indicated that no significant cyclical fluctuations existed in the maize export during the overall study period.

Day by day, demand for maize is increasing in the world as well as in India due to its diversified uses. With an increase in yield in the past five years, India is in a position to ship the exportable surplus to the global markets. India shipped a record 4.77 million tonnes of maize in the year 2012. As per USDA report, due to sluggish global prices India's exports of maize is expected to drop sharply by 29 per cent in 2014-15.

Table 5.18: Results of Fourier Analysis of Indian Export of Maize during 1980-2013

Cycle Length	Fourier Coefficient		Rp2	Rm2	K
	Ap	Bp			
3	108.3879	23.5510	12,302.5984	68,624.1469	0.1793
4	-63.3930	357.0599	1,31,510.4098	4,150.6310	1.8892
5	-80.2466	22.5149	6,946.4388	4,727.6410	0.0967
6	-26.5269	-188.6843	36,305.4556	68,252.6289	0.5319
7	-183.0490	146.5604	54,986.8625	79,143.8506	0.6948
8	161.3890	355.2654	1,52,259.8797	69,609.9632	2.1873
9	28.1658	16.3454	1,060.4832	33,259.2765	0.0319
10	167.5853	-312.8613	1,25,967.0016	71,867.7406	1.7528

As in the other cases, the OLS regression corresponding to the specification in the model was attempted with some modifications and the results are presented below**:**

$$PGRPE_t = \underset{(0.0153)}{1.9221} + \underset{(0.8742)}{0.01085\ DP_t} + \underset{(0.6341)}{0.0147\ IP_t} + \underset{(0.6788)}{0.0001MDE_t} + \underset{(0.5274)}{0.02157MRWE_t}$$

$$+ \underset{(2.0848)}{0.0023\ MCRW_t^{***}} + \underset{(2.0921)}{0.0019\ ANLARW_t^{**}} + \underset{(0.2370)}{1.5437\ T}$$

$R^2 = 0.52$ D.W = 2.46

$$PLPE_t = \underset{(0.0858)}{494.59} + \underset{(0.4054)}{0.1196\ DP_t} + \underset{(0.4360)}{0.1259IP_t} + \underset{(2.4224)}{0.0175MDE_t^{**}} + \underset{(0.1736)}{0.04931MRWE_t}$$

$$+ \underset{(2.5394)}{0.0233\ MCRW_t^{**}} + \underset{(2.7704)}{0.0006\ ANLARW_t^{**}} + \underset{(0.2459)}{71.754\ T}$$

$R^2 = 0.78$ D.W = 2.05

$$OSPE_t = \underset{(2.0378)}{3764.846^{**}} - \underset{(0.6084)}{0.1371\ DP_t} + \underset{(2.4663)}{0.0728IP_t^{**}} + \underset{(2.8947)}{0.00475MDE_t^{*}} + \underset{(4.1689)}{0.0023MRWE_t^{*}}$$

$$+ \underset{(3.3433)}{0.0137\ MCRW_t^{*}} + \underset{(4.2131)}{0.0001\ ANLARW_t^{*}} + \underset{(2.7419)}{114.5257\ T^{*}}$$

$R^2 = 0.79$ D.W = 1.89

Note: *significant at 1% level, **significant at 5% level, ***significant at 10% level.

The trend variable was included to capture the expectation formation hypothesis. According to Hallam (1990), in the model of expectations formation, expectations are assumed to be based upon the simple extrapolation of a variable's past behaviour and this is found to be positive and significant at 1 per cent level for the overall study period while it is insignificant for both the post green revolution and post liberalization periods. Direct exports through private sales and forward contracts was included to capture the effects of future trading, if any. Direct export (MDE_t) was positive and significant in the post liberalization period whereas it was insignificant in the post green revolution period. The results indicated that domestic price (DP_t) had no significant impact on exports while international price (IP_t) had significant impact on exports. Both the rest of the world consumption ($MCRW_t$) and number of live animals in the rest of the world ($ANLARW_t$) had positive significant effects on exports, indicating that the overall international market conditions were atleast partially responsible for the wide fluctuations in Indian exports in the overall study period. The international market was treated exogenously in the present model, with the inclination to treat the equation as an export demand equation, under which assumption the signs of the price variables were as expected. When the overall demand for maize improved, the demand for Indian maize also improved but only partly, as indicated by the coefficient of the rest of the world export ($MRWE_t$). The fact that the equation explained only about 79 per cent of the variations in exports implied that there were additional factors not accounted for in this study. Perhaps quality differences in exports, external competitiveness, future trading and other factors could have improved the results when added, but their inclusion was not possible for want of data.

Export Demand Model

Food problems are among the most important problems facing countries and may affect the political and economic relations between countries. Modern production techniques are used to increase production of various agricultural crops, including maize, but natural and climate factors also affect the productivity of agricultural crops and lead to random fluctuations. Maize is one of the most important goods that human beings depend on for both food and manufacturing; and it gains importance as population increases. Maize currently accounts for 22 per cent of total cereal exports from the country. Declining exports from USA and price parity offered by Indian maize provides an opportunity to supply maize to importing countries within Asia. Maize exports are therefore likely to continue, and researching the factors that affect those exports is therefore important. Therefore, analysing export demand is important for policy and planning at the country level.

So an attempt was made to analyse the relationship between the dependent variable Indian maize exports (M_{IE}) and the following independent variables viz., ending stocks in India (M_{ES}), number of live animals in India (A_{NLA}), total domestic consumption in India (M_{DC}), ending stocks in the rest of the world (M_{RWES}), number of live animals in the rest of the world (A_{NLARW}), rest of world maize exports (M_{RWE}), total consumption in the rest of the world (M_{CRW}), Indian annual maize trade weighted exchange rate (ER_{INR}), Indian maize price (MP), price of substitute crop sorghum (SP), Indian average annual rainfall (RF) and Indian population relative to the rest of the world population (RPO = IPO/WPO).

The correlations between the variables are given in the Table 5.19. This table determines the existence of multicollinearity between independent variables. The diagonal elements in the table are equal to one because each variable is perfectly correlated with itself. There were a strong positive correlation between some of these variables (about 0.8 to 0.9 in absolute value) such as between (M_{RWE} and M_{DC}), (M_{CRW} and M_{DC}, M_{RWE}) , (A_{NLA} and M_{DC}, M_{CRW}), (A_{NLARW} and A_{NLA}), (ER_{INR} and M_{DC}, M_{CRW}), (MP and M_{DC}, M_{RWE}, M_{CRW}, ER_{INR}), (SP and M_{DC}, M_{RWE}, M_{CRW}, ER_{INR}, MP) , (RPO and M_{DC}, M_{CRW}, A_{NLA}, A_{NLARW}, ER_{INR}, MP, SP). These high correlations might arise because of the general upward trends due to growth over time in many of the series, such as RPO, A_{NLA} and A_{NLARW}, where RPO is the Indian Population relative to the rest of the world population, A_{NLA} is the number of live animals in India and A_{NLARW} is the number of live animals in the rest of the world, and fluctuations because of economic crises of various sorts. Most of the variables were correlated with each other and only the variables with more than 80 per cent correlation were discussed here.

Factors in Indian Maize Exports

There are many variables that affect maize export model, and those included in the study are reviewed below.

Domestic Consumption

Table 5.19 and Figure 5.9, shows the correlation coefficients between the variables used in this analysis and it is evident that the relationship between Indian maize exports and domestic consumption is negative: if Indian maize exports increase, Indian domestic maize consumption decreases as expected by theory. The maize exports and consumption in India increased from 10 and 6807 thousand tonnes during 1980s to 3954 and 19100 thousand tonnes respectively during 2013. The increases that happened in the final years may have been because maize used not only for food and feed, but also for ethanol and in the beverage industry. It could be seen from the table that a 78 per cent

Table 5.19: Correlation Matrix on Twelve Parameters of Maize Export

	MIE	MDC	MES	MRWE	MCRW	MRWES	ANLA	ANLARW	ERINR	MP	SP	RF	RPO
MIE	1.000												
MDC	0.777*	1.000											
	6.992												
MES	0.456*	0.618*	1.000										
	2.900	4.451											
MRWE	0.770*	0.840*	0.680*	1.000									
	6.837	8.759	5.245										
MCRW	0.814*	0.979*	0.574*	0.874*	1.000								
	7.924	26.854	3.968	10.167									
MRWES	-0.158	-0.131	-0.066	-0.228	-0.065	1.000							
	-0.903	-0.747	-0.375	-1.322	-0.368								
ANLA	0.819*	0.823*	0.250	0.669*	0.838*	-0.174	1.000						
	8.077	8.182	1.459	5.086	8.688	-0.997							
ANLARW	0.643*	0.782*	0.163	0.545*	0.788*	-0.144	0.925*	1.000					
	4.747	7.087	0.935	3.680	7.250	-0.826	13.736						
ERINR	0.545*	0.887*	0.514*	0.698*	0.891*	0.021	0.684*	0.786	1.000				
	3.677	10.860	3.386	5.512	11.078	0.121	5.303	7.185					
MP	0.849*	0.911*	0.582*	0.866*	0.941*	-0.036	0.794*	0.673*	0.803*	1.000			
	9.092	12.493	4.051	9.801	15.774	-0.203	7.393	5.153	7.634				
SP	0.758*	0.924*	0.610*	0.823*	0.951*	0.009	0.722*	0.676*	0.877*	0.948*	1.000		
	6.580	13.644	4.357	8.186	17.361	0.049	5.905	5.193	10.319	16.819			
RF	-0.240	-0.364*	-0.356*	-0.416*	-0.418*	-0.241	-0.273	-0.251	-0.433*	-0.419*	-0.429*	1.000	
	-1.396	-2.210	-2.158	-2.588	-2.604	-1.408	-1.604	-1.470	-2.717	-2.612	-2.688		
RPO	0.706*	0.957*	0.495*	0.779*	0.967*	-0.028	0.815*	0.854*	0.960*	0.878*	0.924*	-0.383*	1.000
	5.647	18.613	3.218	7.018	21.445	-0.157	7.971	9.275	19.435	10.370	13.694	-2.347	

Note: *Significant at 5 % level.

correlation for the data between M_{IE} and M_{DC}, with an unexpected positive sign. This is probably due to upward trend in both series after 1992 and positive shocks found in export during 2003, 2007 and 2011.

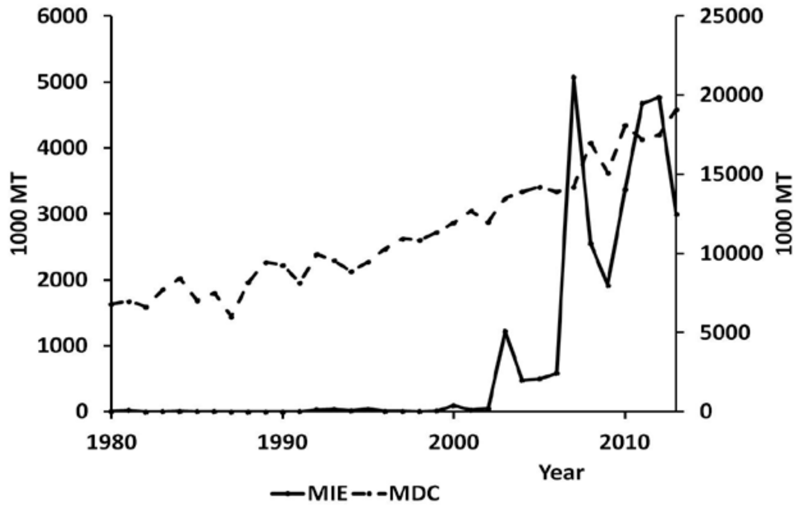


Fig. 5.9. Indian Export and Domestic Consumption of Maize during 1980-2013

Ending Stocks in India

From Figure 5.10, it could be observed that both Indian maize exports and ending stock in India were increasing in nature. But during 2013 the ending stock increased to 1561 thousand tonnes while exports decreased to 3954 thousand tonnes. This was due to increase in the production of maize and high demand in India from poultry industry and human consumption in the form of value added products. It was observed that the highest ending stock were 1174 and 1561 thousand tonnes during 2001 and 2013 respectively. From Table 5.19 it could be seen that there was only 46 per cent correlation between ending stocks in India and Indian export of maize with positive sign as expected by theory.

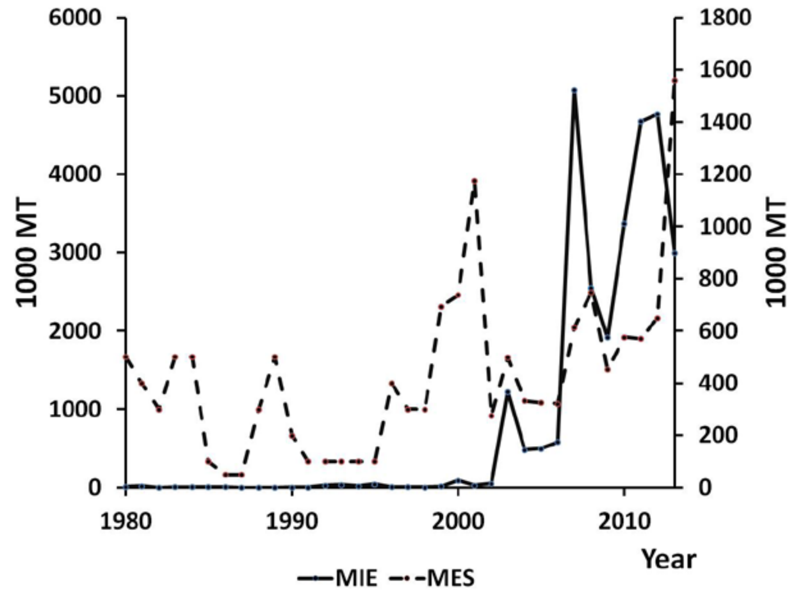


Fig. 5.10. Indian Export and Ending Stock of Maize during 1980-2013

Rest of the World Consumption

From Figure 5.11, it could be seen that consumption in the rest of the world has increased over time, which suggests growing opportunities for Indian exports. From theory, if the world increases their consumption, the maize demand curve will shift to the right because of this consumption increase. Export increased because of increasing ethanol consumption, feed consumption in the importing countries. One of the reasons for increased maize exports was increased consumption of maize in uses such as ethanol. High positive correlations (Table 5.19) were observed between M_{CRW} and M_{DC}, M_{RWE}.

Rest of the World Ending Stock

Maize ending stocks the inventories at the end of the previous year, so if ending stocks increase, maize exports in the following year would decrease. The rest of the world stocks were small, as would be expected, so the relationship between Indian maize exports and rest of the world ending stocks should be inverse. As expected (Table 5.19), the sign between M_{IE} and M_{RWES} was negative.

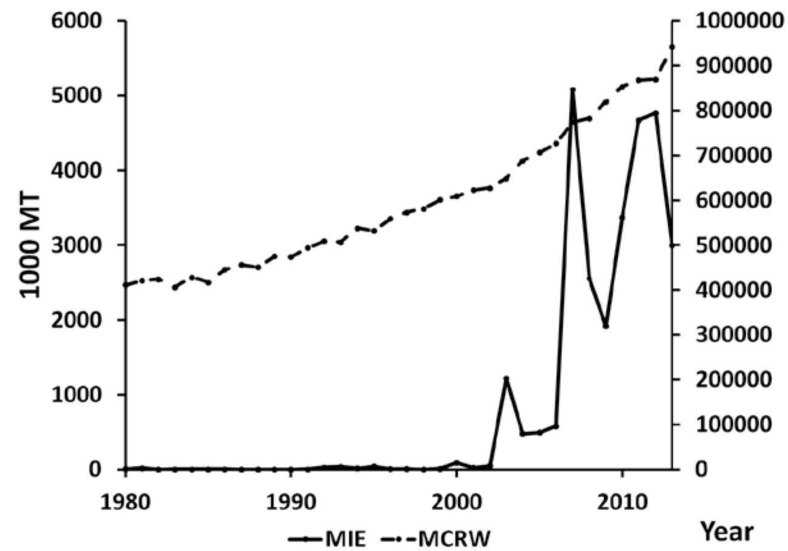


Fig. 5.11. Indian Export and Rest of the World Consumption of Maize during 1980-2013

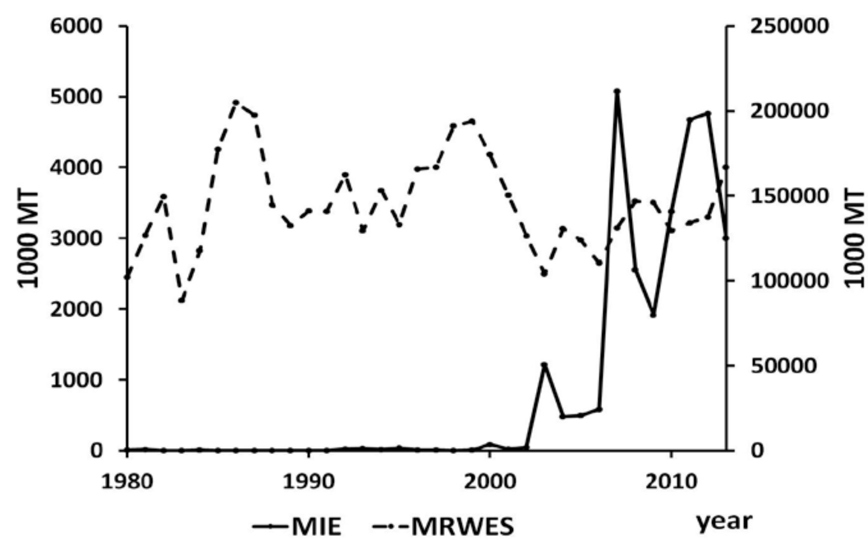


Fig. 5.12. Indian Export and Rest of World Ending Stocks of Maize during 1980- 2013

Number of Live Animals in India

Figure 5.13 and Table 5.19 shows a positive relationship between Indian maize exports and the number of live animals in India. This relationship makes sense if these animals are exported live for other countries. The structural change in this graph occurs at the end of each year. The increase in maize exports might be caused by an increase in live animals exports.

If that number of animals exported alive, and were not slaughtered, more feed might be needed in the importer countries and thus there could be an increase in maize exports. On the other hand, if the number of live animals in India increases then the consumption of maize as feed will increase and so automatically export of maize from India will decrease. It could be observed that (Table 5.19) 82 per cent correlation prevails between Indian export and number of live animals in India.

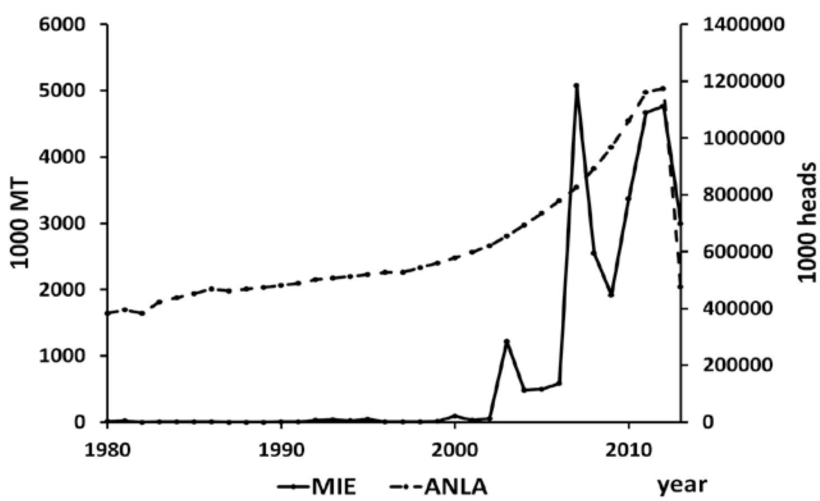


Fig. 5.13. Indian Maize Export and No. of Live Animals during 1980-2013

Rest of the World Number of Animals

From Figure 5.14 and Table 5.19, it could be seen that there existed 64 per correlation between export and number of live animals in the rest of the world. If the number of live animals in the rest of the world increases, then the consumption of maize as feed will also increase so as the export. This was confirmed by Pena (2007) who found that the number of animals in the rest of the world would affect the maize market. The Livestock Marketing Information Center (2008) also found this same result. Also in this study a strong positive correlation has been found between A_{NLARW} and A_{NLA}.

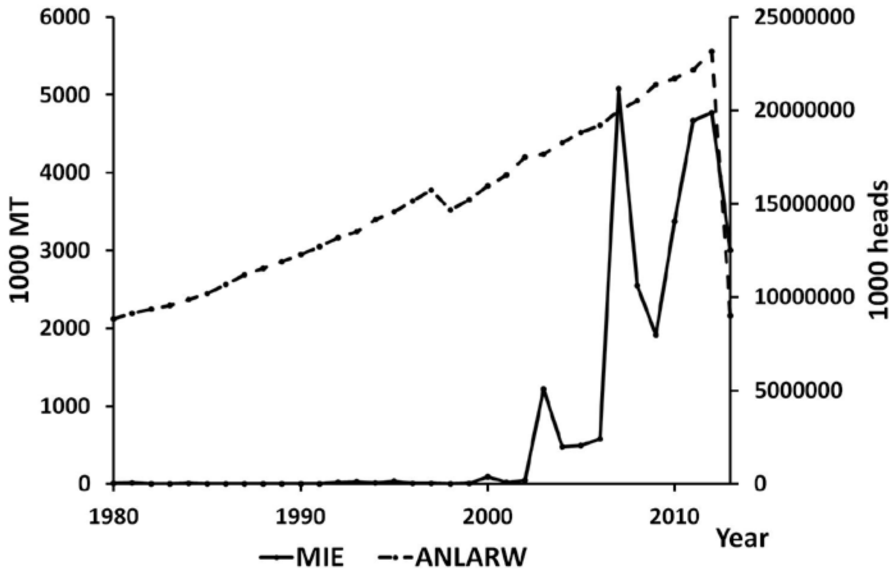


Fig. 5.14. Indian Maize Export and Rest of the World Animals during 1980-2013

Rest of World Maize Exports

As of theory, the export of maize form India and rest of the world export should be of negative relation. That is, if the rest of the world export increases then the maize export from India will decrease. India is one of the major contributors in maize export. Figure 5.15 and Table 5.19 shows that there was 77 per cent positive correlation between export of maize form India and Rest of the world export. Also it was evident that there was 84 per cent correlation between M_{RWE} and M_{DC}.

Annual Maize Trade Weighted Exchange Rates

Figure 5.16 shows that annual maize trade weighted exchange rates have a negative relationship with Indian maize exports. When the exchange rate increases the Indian export will decrease because Indian maize has been priced high in the international market relative to other exporters. Thus, maize demand shifts left as the exchange rate increases. Batten *et al.*, (1984) found that real exchange rates were negatively related to exports. As per Table 5.19, there was 54 per cent correlation between exchange rate and maize exports with an unexpected positive sign.

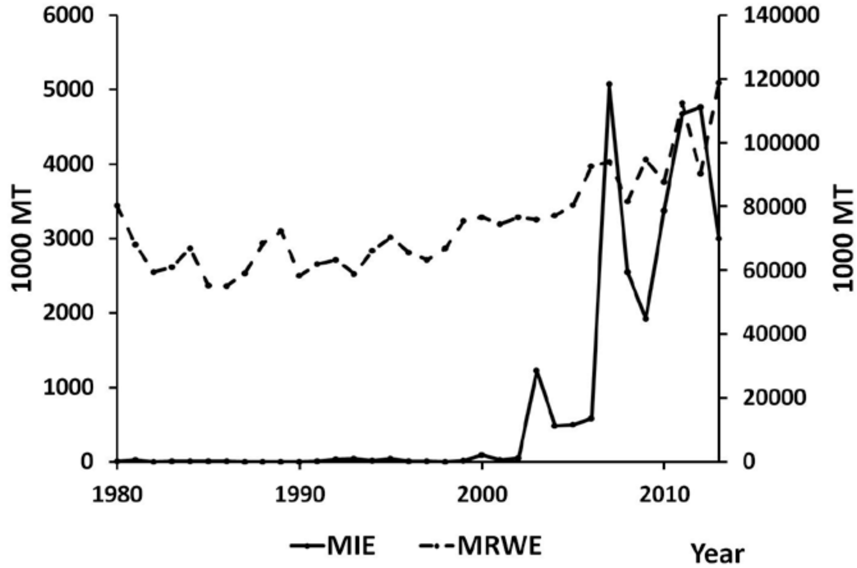


Fig. 5.15. Indian Export and Rest of the World Export of Maize during 1980-2013

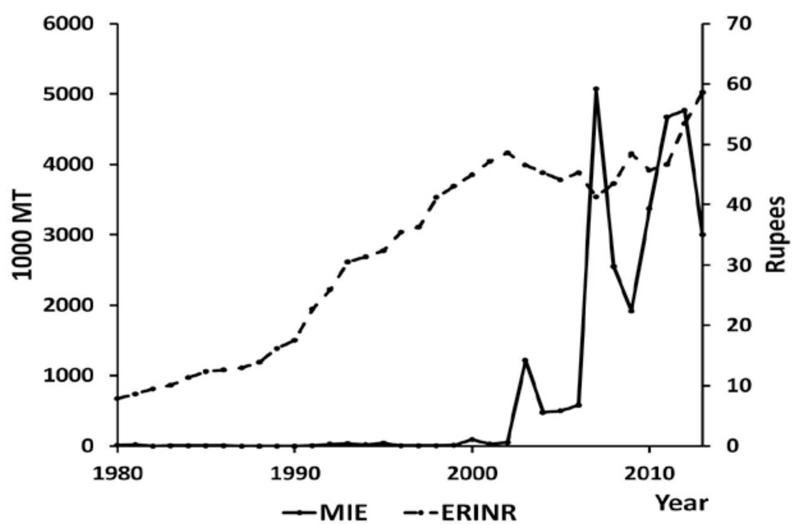


Fig. 5.16. Indian Maize Export and Exchange Rates during 1980-2013

Maize Price in India

Figure 5.17 shows the direct impact of maize price on maize exports. As theory says there is an indirect relationship between maize price and exports. But logically if the price of maize increases the export will also increase because the domestic consumer will prefer the substitute commodity sorghum rather than maize. The USDA ERS (2008), Wilson *et al.,* (2004), and Liu *et al.*, (2008) showed that increase in the maize price were due to the increase in the price of products, such as ethanol, that use maize. Table 5.19 shows there was 85 per cent correlation between maize export and maize price with a logically expected but theoretically unexpected positive sign.

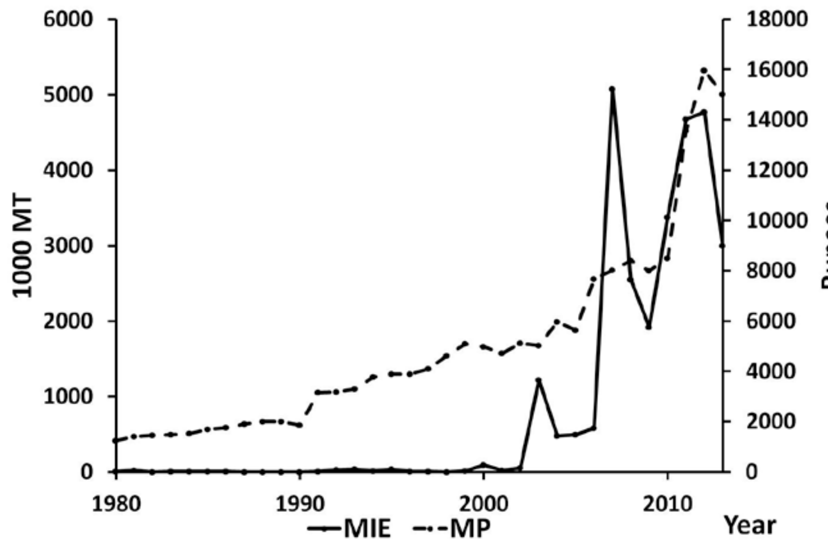


Fig. 5.17. Indian Export and Domestic Price of Maize 1980-2013

Sorghum Price in India

As per theory there is an inverse relationship between sorghum price and maize export. Sorghum is the substitute commodity for maize. If the price of maize decreases the consumer demand for the substitute commodity sorghum decreases and if the price of maize increases the consumer demand for the substitute commodity sorghum increases automatically leading to an increase in the export of maize. Figure 5.18 shows that there was an inverse relationship between maize export and sorghum price. Also Table 5.19 shows that there was 76 per cent correlation between export and sorghum with an unexpected positive sign.

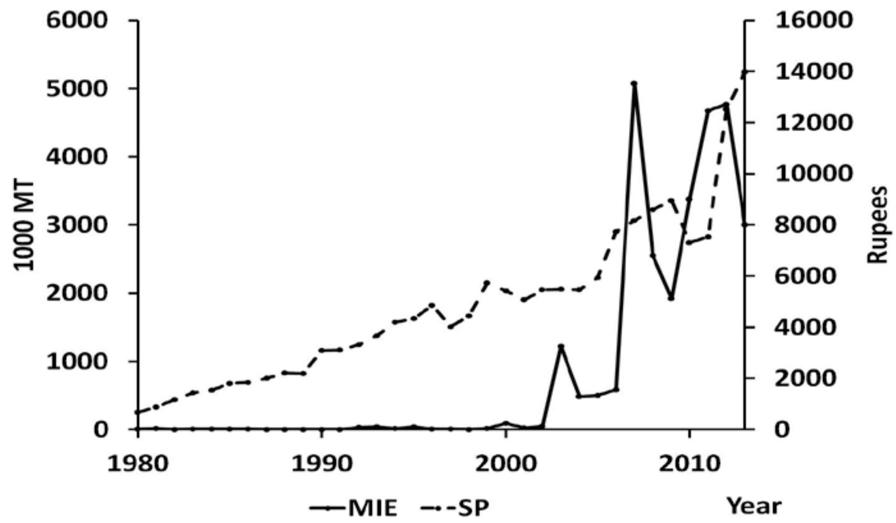


Fig. 5.18. Indian Maize Export and Domestic Price of Sorghum during 1980-2013

Rainfall in India

In India maize is cultivated as a rainfed crop in most of the states of traditional area and non-traditional area. Hence good rainfall triggers significantly the productivity and in turn healthy production levels. The increased production leads to surplus which in turn leads to exports. From Figure 5.19 it could be noticed that the export of maize has increased after 2003 with a negative sign between export and rainfall with no correlation, which is not expected.

Indian Population Relative to the Rest of the World population

If the population in India increases the consumption of maize will also increase leading to a decrease in exports. The increase in the rest of the world population influences the demand for maize leading to increased imports by the importers. In the present study, the variable Indian population relative to the rest of the world population is expected with a negative sign. Increase in Indian population results in increased ratio leading to a reduction in the incremental increase in exports and increase in the rest of the world population results in reduced ratio leading to a decrease in the incremental reduction in exports. There is an inverse relation between export and population. Table 5.19 and Figure 5.20 show that there was 71 per cent correlation between population and export with an unexpected positive sign.

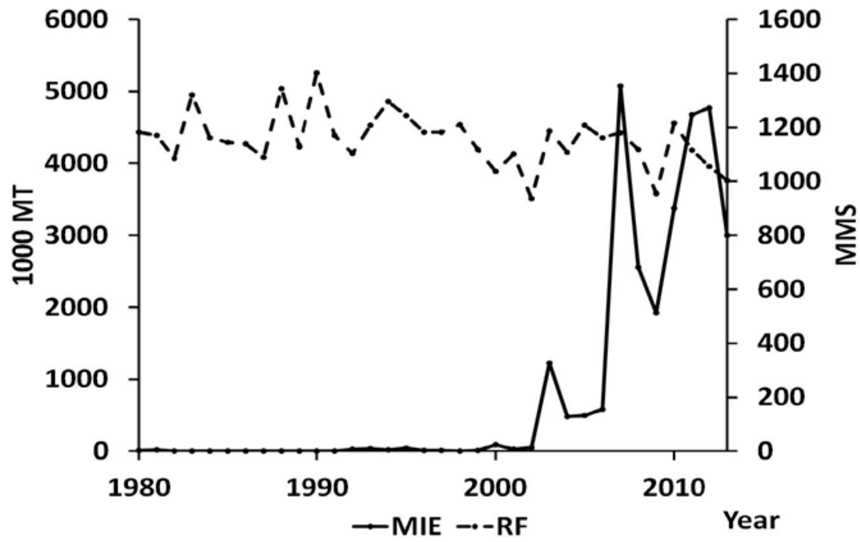


Fig. 5.19. Indian Maize Export and Annual Average Indian Rainfall during 1980-2013

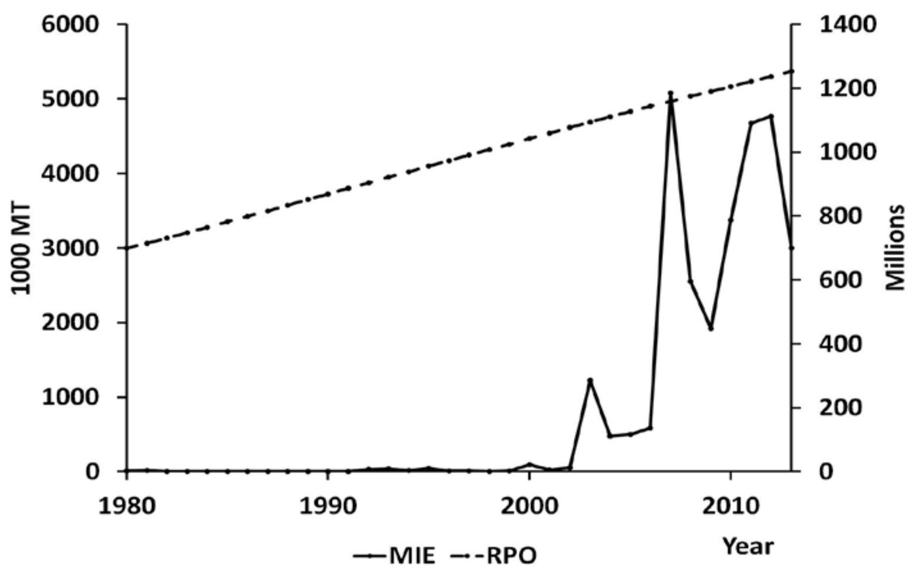


Fig. 5.20. Indian Maize Export and Relative Population of India to Rest of the World Population during 1980-2013

Empirical results

The Ordinary Least Squares (OLS) approach was used to estimate the export demand. The OLS regression was insignificant for almost all of the variables as shown, where t-statistics are presented in the parentheses.

$$M_{IE} = 47909.8 + 1.1295\ M_{ES} - 0.002\ A_{NLA} - 0.342\ M_{DC} - 0.01\ M_{RWES}$$
$$\quad (1.610) \quad (1.413) \quad (-0.406) \quad (-1.457) \quad (-1.621)$$

$$+ 0.002\ A_{NLARW} - 0.043\ M_{RWE} + 0.028\ M_{CRW}^{**} - 129.20\ ER_{INR}^{*}$$
$$(-0.458) \quad (0.113) \quad (2.000) \quad (-2.886)$$

$$+ 0.477\ MP^{**} - 0.229\ SP + 0.251\ RF + 302515\ RPO$$
$$(2.605) \quad (-1.285) \quad (0.166) \quad (1.460)$$

$$R^2 = 0.834 \qquad F = 10.57 \qquad D.W = 2.246$$

Note: * significance at 1 % level, ** significance at 5 % level

High R^2 value indicates that 83 per cent of the variations in Indian maize exports were explained by these independent variables. Those variables that were significant generally had the correct signs, although this was less than half of the total explanatory effects in the model. The Durbin Watson (DW) statistic (2.246) and the Table 5.19 reveal the presence of auto correlation. If Indian domestic consumption were to increase (M_{DC}), then the Indian export would decline, as found in the model. If rest of world exports (M_{RWE}) rise, then there would be less need for the Indian product and Indian exports of maize would decline, but if rest of world consumption were to rise, then India could export more, and so the coefficient would be positive, as found.

To correct the auto correlation, the insignificant variables and improve the model, the following measures can be adopted: i) add observations, ii) change variables iii) increase or decrease the number of variables. In the present study there is no possibility of adding the observations since Indian export of maize started only from 1980 onwards. Hence alternatively to correct this problem some of the variables were dropped (RF and RPO). Further to improve the model two year lagged values of ending stock of maize in India (M_{ES-2}), one year lagged values of number of live animals in India (A_{NLA-1}), rest of the world ending stock of maize (M_{RWES-1}) and maize price in India (MP_{-1}) were used instead of original variables and then tested for auto correlation. This following equation shows the ordinary least squares results using lagged instead of current values for the right hand side influences. As can be seen in the statistical output, the model has performed very well. The resultant F-statistic was good, the signs were as expected, the coefficients were significantly different from zero at the 95 percent level, and the equation was significant. The Durbin Watson Statistic was 1.98 and the model did not find any autocorrelation. Also R^2 was 89 per cent, meaning that 89 per cent of variation in the Indian maize export was explained by these independent variables. The result of the improved model is as follows.

$$M_{IE} = \underset{(2.369)}{4327.16^{**}} + \underset{(2.830)}{0.2953\, M_{ES-2}^{*}} - \underset{(-2.096)}{0.0101\, A_{NLA-1}^{**}} - \underset{(-3.817)}{0.141\, M_{DC}^{*}}$$

$$- \underset{(-2.161)}{0.007\, M_{RWES-1}^{**}} + \underset{(2.056)}{0.002\, A_{NLARW}^{**}} - \underset{(-2.169)}{0.005\, M_{RWE}^{**}}$$

$$+ \underset{(4.502)}{0.009\, M_{CRW}^{*}} - \underset{(-2.405)}{78.577\, ER_{INR}^{**}} + \underset{(3.542)}{0.197\, MP_{-1}^{*}} - \underset{(-2.835)}{0.199\, SP^{*}}$$

$R^2 = 0.886$ $F = 13.58$ $D.W = 1.98$

Note: * significance at 1 % level, ** significance at 5 % level,

The positive coefficient of intercept was significant at 5 per cent level indicating that the export would be 4327 thousand tonnes while all the variables were kept constant. The coefficient of M_{ES-2} at two year lag period was about 0.2953. This indicates that if the ending stock of maize in India change by 1000 MT in a given year, Indian maize export would increase by 295.3 MT after two years, while other factors held constant. The coefficient was significant at one per cent level with an expected positive sign, as higher stocks allow more exports.

The coefficient of A_{NAL-1} was – 0.0101 indicating that if the number of live animals in India changes by 1000 head in a given year, Indian maize export decreases by 10 MT after one year while other factors held constant. The coefficient was significant at 5 per cent level with theoretically unexpected sign. But this result was also meaningful, when the number of live animals in India increases the consumption of maize in India will also increase so that the export will decrease.

The coefficient of M_{DC} was – 0.141 which indicates that if the Indian consumption changes by 1000 MT, Indian maize exports decrease by 141 MT while other factors held constant. The coefficient was significant at one per cent level with the expected sign as we cannot export as much as with less domestic consumption.

The coefficient of M_{RWES-1} was – 0.007 which indicates that if rest of the world maize ending stocks change by 1000 MT in a given year, Indian maize exports decrease by 7 MT after one year while other factors held constant. The coefficient was significant at 5 per cent level with an expected positive sign. If there are greater stocks in rest of the world, then there will be less opportunity for Indian maize export.

The coefficient of A_{NLARW} was 0.002 indicates that if the rest of world number of animals changes by 1000 head in a given year, Indian maize export increases by 2 MT while other factors held constant. The coefficient was significant at 5 per cent level with the expected positive sign. If the number of animals in the rest of the world increases the rest of the world consumption will also increase and so as the Indian maize export.

The coefficient of M_{RWE} was – 0.005 indicates that if rest of world maize exports change by 1000 MT, Indian maize exports decrease by 5 MT while other factors held constant. The coefficient was significant at 5 per cent level and the sign was negative as expected. This implies that there exists immense competition as rest of the world exports increase and thereby decreasing Indian maize exports.

The coefficient of M_{CRW} was 0.009 which indicates that if rest of world consumption changes by 1000 MT, Indian maize exports increase by 9 MT while other factors held constant. The coefficient was significant at 1 per cent level and the sign was positive as expected.

The coefficient of ER_{INR} was – 78.577 indicates that if the annual maize trade weighted exchange rates increase by one rupee, Indian maize exports decrease by 78.6 thousand MT while other factors held constant. The coefficient was significant at 5 per cent level and the sign was negative as expected, as India becomes less competitive compared to other countries, less is exported.

The coefficient of MP_{-1} was 0.197 indicates that if the price of maize in India changes by one rupee in a given year, Indian maize export increases by 197 MT after one year while other factors held constant. The coefficient was significant at 1 per cent level with theoretically unexpected positive sign. But this result was also meaningful; when the maize price in India increases the domestic consumer will prefer the substitute commodity sorghum so that surplus will be available for exports and finally an increase in the ending stock.

The coefficient of SP was – 0.199 indicates that if the price of sorghum in India changes by one rupee in a given year, Indian maize export decreases by 199 MT while other factors held constant. The coefficient was significant and the sign was negative as expected. If the price of substitute crop sorghum increases the domestic consumption of maize will increase resulting in decrease in export.

Market Integration

Market integration implies that the changes in price of one market would immediately be transmitted to the other market. Integration of markets is a good indicator of efficiency in the marketing system. Cointegration analysis was used to test the integration of maize prices. The issue of price volatility has assumed critical importance in the context of agricultural trade liberalisation. One of the major arguments advanced against agricultural trade liberalisation is that it would lead to transmission of international price volatility into domestic markets. Thereby both domestic and international maize markets were considered for the study. In the case of domestic markets, two markets viz. Chhindwara and Kota from the traditional maize growing states of Madhya Pradesh and Rajasthan along with three markets viz. Davangere, Nizamabad and Udumalpet from the non-traditional areas of Karnataka, Andhra Pradesh and Tamil Nadu were selected respectively for the period from January 2003 to December 2013 for the present study on the basis of volume of transactions, experts' opinion and availability of data. The maize markets of Argentina and United States were also included to study the impact of international prices for the same period.

Successful risk management requires real understanding of nature of correlations between markets. For price integration, simple bivariate correlation coefficients measure the price movements of a commodity in different markets. This is the simplest way to measure the spatial price relationships between two markets. Early inquiries on spatial market integration, for example Lele (1967) and Jones (1968) used this method. Price correlation coefficients between the domestic and international markets of maize were estimated to examine the strength of price linkages across markets. The degree of linear association between the markets can be measured by the sign and magnitude of the correlation coefficient, *r*. The correlation between different markets was calculated and the results were presented in Table 5.20.

Table 5.20: Correlation Matrix between Domestic and International Maize Markets during 2003 - 2013

	DAV	NZ	UDU	CH	KO	ARG	US
DAV	1						
NZ	0.977	1					
UDU	0.979	0.982	1				
CH	0.970	0.975	0.978	1			
KO	0.957	0.962	0.955	0.977	1		
ARG	0.939	0.943	0.941	0.931	0.912	1	
US	0.945	0.939	0.938	0.925	0.905	0.991	1

Note: all the ‘r’ values are significant at 1 % level.

NZ – Nizamabad, ARG – Argentina, DAV – Davangere, CH – Chhindwara, KO – Kota,

UDU - Udumalpet, US – United States market.

The correlation coefficient value indicates that all the markets were significantly related with each other at 1 per cent level and the degree of association was more than 90 per cent. The positive correlation showed that an increase in the price in one market would follow the price increase in the other market. This could be possible due to the transmission of market information by market players through various means, particularly via the use of mobile phones, coupled with the short distance between markets. This could also suggest the possible existence of relative price elasticities in these markets. However, this method clearly has some limitations, as it cannot measure the direction of price integration between two markets, as it allows for the identification of integration between markets.

Price variability is an important component of profit variability and therefore it is very important to quantify price variability of agricultural products. The differences between the variability in the prices among commodities were important for private investment decisions in farming and farm product marketing (Heifner and Kinoshita, 1994). In the present study the price volatility for maize in the domestic markets was estimated through ARCH and GARCH models. The price volatility for the maize markets during the study period was given in Table 5.21.

Table 5.21: Results of Volatility between Domestic and International Markets

Market	α value	β value	α + β value
DAV	0.9556**	0.0000	0.9556
NZ	0.9787	0.0000	0.9787
UDU	0.9748*	0.0252	1.0000
CH	0.8674*	0.1178	0.9852
KO	1.0000*	0.0000	1.0000
ARG	0.9918*	0.0000	0.9918
US	0.9636*	0.0000	0.9636

Note : * Significant at 1 % level ,** Significant at 5 % level.

NZ – Nizamabad, ARG – Argentina, DAV – Davangere, CH – Chhindwara, KO – Kota,

UDU - Udumalpet, US – United States market.

It was observed that Udumalpet market in Tamil Nadu and Kota market in Rajasthan were highly volatile as indicated by the sum of coefficients of ARCH (α) and GARCH (β) values which were one, significant at 1 per cent level when compared to other markets. Equally other domestic markets were also highly volatile as indicated by the sum of coefficients of ARCH (α) and GARCH (β) values which were nearer to one. The sum of coefficients of

ARCH and GARCH term for the time series of international maize market prices were 0.9918 and 0.9636 indicating that volatility shocks were persistent in the study period. Hence it is concluded that all the markets were highly volatile.

The first step in cointegration is to find the order of lag for the variables which are included in the model. According to Enders (2003), the model will be misspecified when lag length is too small. The more lags, the more parameters need to be estimated and the less bias in the results. The model will be over parameterized if the number of lags is too large. There are different approaches: lag order selection based on the LR test; lag order selection based on Information criteria such as AIC (Akaike's Information Criterion), FPE (Final Prediction Error), SC (Schwarz Criterion), HQ (the Hannan & Quinn (1979) criterion) (See Lutkepohl 2005, p. 142 -149). Different lag lengths were applied in order to evaluate the behaviour so as to ascertain the most appropriate lag length and the results were presented in Table 5.22. Upon the different methods the orders of lag for the variables were chosen by the smallest AIC (Akaike 1973). In the present study, all the variables were found to have minimum AIC values at the second lag. Hence throughout the analyses, second lag of the variables were used wherever necessary.

Table 5.22: Results of Lag Order Indication

Lag	**LogL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	-5148.674	NA	2.28e+26	80.55740	80.71337	80.62077
1	-4604.840	1019.689	1.00e+23	72.82562	74.07338*	73.33259*
2	-4551.203	94.70282	9.38e+22*	72.75317*	75.09272	73.70374
3	-4504.361	77.58189*	9.87e+22	72.78689	76.21824	74.18106
4	-4472.126	49.86300	1.32e+23	73.04885	77.57199	74.88662

Note:* indicates lag order selected by the criterion at 5 % level.

Cointegration test starts with the pre-condition that if two time series variables could be integrated, only when they should be of the same order of integration. To have the same order of integration, these variables should be stationary when they are differenced the same number of times. Hence, the test of cointegration starts with a test of stationarity at different differenced levels. To verify whether the level and first differenced price series were indeed stationary, Augmented Dickey-Fuller (ADF) unit root test was used. The equations were estimated with an intercept and no time trend for each price series.

The null hypothesis of non stationarity was tested based on the critical values reported by MacKinnon (1996). The estimated test statistics from the ADF test for the maize market prices in levels and first differences are reported in Table 5.23. All the price series were transformed in natural logarithm. The lag length was selected using the Akaike Information Criterion (AIC). It can be seen that the null hypothesis of non-stationarity cannot be rejected for the prices in levels but can be rejected for all the prices in first differences. The prices are therefore non-stationary in their levels but stationary in first differences. This implies that the price series of Davangere, Nizamabad, Udumalpet, Chhindwara, Kota, Argentina and United States were non-stationary in the level itself, but it became stationary once it was first differenced. Hence, the value of *d* is 1 i.e. I (1) for all the markets respectively.

Table 5.23: Results of Unit Root Test for Maize Prices in both International and Domestic Markets

Maize Market	Augmented Dickey-Fuller (ADF)		
	Level	1st difference	Critical Value
Davangere	-0.900184 (0.7855)	-7.052686* (0.0000)	-3.482035 (0.01 level) -2.884109 (0.05 level)
Nizamabad	-0.668083 (0.8499)	-6.726628* (0.0000)	
Udumalpet	-1.133241 (0.7013)	-7.205017*(0.0000)	
Chhindwara	-0.825315 (0.8083)	-7.862378* (0.0000)	
Kota	-0.257636 (0.9267)	-8.196888* (0.0000)	
Argentina	-0.764263 (0.8253)	-6.836085* (0.0000)	
United States	-1.024356 (0.7433)	-5.813276* (0.0000)	

Note: *Significant at 1 % level, Values in parenthesis indicate MacKinnon (1996) p-values

Having confirmed that the price series were stationary in their first differences, cointegration between the markets was tested using Johansen-Juselius maximum likelihood procedure for the presence of short run and long run relationship between the domestic and international maize markets and associated price transmission and resultant price volatility in the domestic markets for maize.

The procedure consisted of two tests *viz.* trace statistic and maximum Eigen-value statistic and the results of which were shown in Table 5.24 and 5.25 respectively. As it could be seen from the Table 5.24, the trace test procedure indicated that the domestic maize markets of Nizamabad, Davangere and the international market of Argentina were integrated with other markets each with three cointegrating equations. At the same time, cointegration between the markets was also confirmed with Maximum-Eigen value test. It was found that Nizamabad and Argentinean maize markets were integrated with other markets each with two cointegrating equations (Table 5.25). The existence of cointegration between markets confirms that there was a long run relationship between markets.

Table 5.24: Unrestricted Cointegration Rank Test (Trace) between International and Domestic Maize Markets

Maize Markets	Eigen value	Trace Statistic	Critical Value	Prob.**	Hypothesized No. of CE(s)
NZ	0.390122	182.7769	125.6154	0.0000	None *
ARG	0.312805	118.9869	95.75366	0.0005	At most 1 *
DAV	0.221324	70.59417	69.81889	0.0433	At most 2 *
CH	0.160811	38.32357	47.85613	0.2881	At most 3
KO	0.069565	15.70731	29.79707	0.7327	At most 4
UDU	0.047117	6.406011	15.49471	0.6475	At most 5
US	0.001395	0.180077	3.841466	0.6713	At most 6

Note: * Significant at 5 % level.

NZ-Nizamabad , ARG- Argentina, DAV-Davangere , CH- Chhindwara, KO-Kota,

UDU- Udumalpet, US- United States market

Table 5.25: Unrestricted Cointegration Rank Test (Maximum Eigen-value) between International and Domestic Maize Markets

Maize Markets	Eigen value	Max-Eigen Statistic	Critical Value	Prob.**	Hypothesized No. of CE(s)
NZ	0.390122	63.79001	46.23142	0.0003	None *
ARG	0.312805	48.39270	40.07757	0.0047	At most 1 *
DAV	0.221324	32.27059	33.87687	0.0768	At most 2
CH	0.160811	22.61626	27.58434	0.1905	At most 3
KO	0.069565	9.301303	21.13162	0.8074	At most 4
UDU	0.047117	6.225934	14.26460	0.5844	At most 5
US	0.001395	0.180077	3.841466	0.6713	At most 6

Note:* Significant at 5 % level.

NZ-Nizamabad , ARG- Argentina, DAV-Davangere , CH- Chhindwara, KO-Kota,

UDU- Udumalpet, US- United States market

Since, cointegration tests indicate only the existence of long run relationship among the markets, Granger Causality tests were used to analyse the direction of relationship among different maize market price series. The causality test results for the domestic and international markets are presented in Table 5.26. The null hypothesis of the granger causality test is that there is no granger cause which means there is no direction of causality. Significance indicates that rejecting the null hypothesis i.e. there is a Granger cause. The results revealed that in two cases Chhindwara, Nizamabad and United States, Udumalpet, there exists bidirectional causality. In cases of other markets unidirectional causality of prices was observed. For easy understanding, the directions of causality between the market prices were presented in Table 5.27. Davangere market prices had unidirectional causality with Nizamabad, Chhindwara and Udumalpet markets. Nizamabad and Chhindwara had unidirectional causality with Udumalpet market. Also Kota market had unidirectional causality with Udumalpet and Chhindwara market. The causality of two international markets was also found. Argentina market was one

Table 5.26: Results of Granger Causality Test for Selected Markets

Null Hypothesis	F-Statistic	Prob.	Direction
ARGENTINA does not Granger Cause NIZAMABAD	11.5282	3.E-05*	unidirectional
NIZAMABAD does not Granger Cause ARGENTINA	0.69264	0.5022	
DAVANGERE does not Granger Cause NIZAMABAD	9.01653	0.0002*	unidirectional
NIZAMABAD does not Granger Cause DAVANGERE	1.96614	0.1443	
CHHINDWARA does not Granger Cause NIZAMABAD	3.95084	0.0217**	bidirectional
NIZAMABAD does not Granger Cause CHHINDWARA	14.0726	3.E-06*	
KOTA does not Granger Cause NIZAMABAD	2.73493	0.0688	
NIZAMABAD does not Granger Cause KOTA	1.27200	0.2839	
UDUMALPET does not Granger Cause NIZAMABAD	2.19468	0.1157	
NIZAMABAD does not Granger Cause UDUMALPET	13.7629	4.E-06*	unidirectional
UNITEDSTATES does not Granger Cause NIZAMABAD	11.8323	2.E-05*	unidirectional
NIZAMABAD does not Granger Cause UNITEDSTATES	0.91992	0.4012	
DAVANGERE does not Granger Cause ARGENTINA	0.29183	0.7474	
ARGENTINA does not Granger Cause DAVANGERE	18.2292	1.E-07*	unidirectional

Table 5.26:(Contd...)

Null Hypothesis	F-Statistic	Prob.	Direction
CHHINDWARA does not Granger Cause ARGENTINA	1.39131	0.2526	
ARGENTINA does not Granger Cause CHHINDWARA	7.69657	0.0007*	unidirectional
KOTA does not Granger Cause ARGENTINA	1.20990	0.3017	
ARGENTINA does not Granger Cause KOTA	6.31729	0.0024*	unidirectional
UDUMALPET does not Granger Cause ARGENTINA	2.73027	0.0691	
ARGENTINA does not Granger Cause UDUMALPET	15.5554	9.E-07*	unidirectional
UNITEDSTATES does not Granger Cause ARGENTINA	0.97157	0.3813	
ARGENTINA does not Granger Cause UNITEDSTATES	1.46649	0.2347	
CHHINDWARA does not Granger Cause DAVANGERE	1.34032	0.2655	
DAVANGERE does not Granger Cause CHHINDWARA	20.3217	2.E-08*	unidirectional
KOTA does not Granger Cause DAVANGERE	1.30410	0.2751	
DAVANGERE does not Granger Cause KOTA	2.24638	0.1100	
UDUMALPET does not Granger Cause DAVANGERE	0.84676	0.4312	
DAVANGERE does not Granger Cause UDUMALPET	15.2417	1.E-06*	unidirectional

Table 5.26:(Contd...)

Null Hypothesis	F-Statistic	Prob.	Direction
UNITEDSTATES does not Granger Cause DAVANGERE	21.0900	1.E-08*	unidirectional
DAVANGERE does not Granger Cause UNITEDSTATES	0.86069	0.4254	
KOTA does not Granger Cause CHHINDWARA	7.00452	0.0013*	unidirectional
CHHINDWARA does not Granger Cause KOTA	1.85944	0.1600	
UDUMALPET does not Granger Cause CHHINDWARA	1.80828	0.1682	
CHHINDWARA does not Granger Cause UDUMALPET	4.31960	0.0153**	unidirectional
UNITEDSTATES does not Granger Cause CHHINDWARA	9.18319	0.0002*	unidirectional
CHHINDWARA does not Granger Cause UNITEDSTATES	0.82691	0.4398	
UDUMALPET does not Granger Cause KOTA	0.54953	0.5786	
KOTA does not Granger Cause UDUMALPET	6.16281	0.0028*	unidirectional
UNITEDSTATES does not Granger Cause KOTA	6.74835	0.0016*	unidirectional
KOTA does not Granger Cause UNITEDSTATES	1.85925	0.1601	
UNITEDSTATES does not Granger Cause UDUMALPET	17.9364	1.E-07*	bidirectional
UDUMALPET does not Granger Cause UNITEDSTATES	3.02399	0.0522**	

Note: * Significant at 1 % level, ** Significant at 5 % level .

way related with domestic markets like Davangere, Nizamabad, Udumalpet, Chhindwara, and Kota respectively whereas United States market had unidirectional causality with Davangere, Nizamabad, Chhindwara and Kota.

Table 5.27: Categorisation of Markets Based on Cointegration and Causality Tests

Davangere → Nizamabad, Chhindwara, Udumalpet
Nizamabad → Udumalpet
Chhindwara ↔ Nizamabad
Chhindwara → Udumalpet
Kota → Udumalpet, Chhindwara
Argentina → Davangere, Nizamabad, Udumalpet, Chhindwara, Kota
United States → Davangere , Nizamabad, Chhindwara, Kota
United States ↔ Udumalpet

The last step in cointegration analysis involves the application of Vector Error Correction Mechanism (VECM) for the domestic maize markets which have long run association with the global markets. Accordingly, the VECM results were presented in Table 5.28. The findings revealed the existence of short run disequilibrium. It was also found that how much the short run disequilibrium in a given market got corrected by changes in its own prices and with changes in prices of other markets. The coefficients of the error correction term indicated the speed of convergence to the long run growth path as a result of shock in their own prices and shock in the prices of other domestic and international markets.

As it could be seen from the table, the estimated error term coefficients revealed that in the domestic Udumalpet maize market 28 per cent disequilibrium got corrected within a month by changes in its own prices and the remaining was influenced by other internal and external market forces. The coefficients of the error correction term also indicated the speed of convergence to the long run growth path as a result of shock in its own prices. Moreover the coefficient of own lagged price of Udumalpet market was also

Table 5.28: Reduced Form Vector Error Correction Estimates of International and Domestic Maize Markets

Error Correction	D(NZ)	D(ARG)	D(DAV)	D(CH)	D(KO)	D(UDU)	D(US)
ECM	-0.116018	0.020430	-0.096484	0.033090	0.045943	**0.282008***	-0.178431
	[-1.50987]	[0.22009]	[-1.79856]	[0.46415]	[0.67494]	**[3.77237]**	[-1.87256]
D(NZ (-1))	**-0.358865***	-0.105896	0.158191	0.189580	-0.018258	0.020068	0.123207
	[-2.84173]	[-0.69415]	[1.79428]	[1.61805]	[-0.16320]	[0.16334]	[0.78675]
D(NZ (-2))	-0.189666	-0.119190	0.057365	-0.134701	0.014813	**-0.286886***	-0.024723
	[-1.53165]	[-0.79677]	[0.66355]	[-1.17244]	[0.13503]	**[-2.38131]**	[-0.16100]
D(ARG (-1))	0.178708	-0.280092	0.087146	-0.012224	0.096344	0.241490	-0.143821
	[1.20835]	[-1.56773]	[0.84402]	[-0.08909]	[0.73536]	[1.67836]	[-0.78419]
D(ARG (-2))	**-0.572029***	-0.321621	**-0.346235***	-0.233121	-0.075809	-0.182184	-0.306208
	[-3.85086]	[-1.79228]	**[-3.33862]**	[-1.69150]	[-0.57609]	[-1.26063]	[-1.66229]
D(DAV (-1))	**0.534794***	0.110992	**0.287681***	**0.539613***	0.152849	**0.382607***	0.143007
	[3.47586]	[0.59716]	**[2.67820]**	**[3.78014]**	[1.12142]	**[2.55603]**	[0.74952]
D(DAV (-2))	0.145795	0.023085	-0.093038	0.147659	0.133190	-0.053107	0.233313
	[0.91613]	[0.12008]	[-0.83739]	[1.00005]	[0.94474]	[-0.34301]	[1.18223]
D(CH (-1))	0.045276	-0.048772	0.044940	**-0.261793***	-0.022405	-0.192248	0.172042
	[0.33212]	[-0.29615]	[0.47219]	**[-2.06982]**	[-0.18552]	[-1.44952]	[1.01768]
D(CH (-2))	**0.312059***	0.024054	0.101750	-0.171078	0.062702	0.021678	0.063251
	[2.35975]	[0.15057]	[1.10209]	[-1.39435]	[0.53523]	[0.16849]	[0.38570]
D(KO (-1))	-0.134115	-0.120100	-0.149125	0.004616	-0.027393	0.097973	-0.311174
	[-0.98869]	[-0.73290]	[-1.57466]	[0.03668]	[-0.22795]	[0.74238]	[-1.84984]
D(KO (-2))	-0.223239	-0.302710	**-0.204508***	-0.219295	**-0.268951***	-0.174698	**-0.424726***
	[-1.55967]	[-1.75071]	**[-2.04659]**	[-1.65135]	**[-2.12111]**	[-1.25455]	**[-2.39289]**
D(UDU (-1))	-0.009687	-0.078972	-0.110834	-0.004636	-0.025468	-0.073626	-0.307276
	[-0.07473]	[-0.50428]	[-1.22463]	[-0.03855]	[-0.22177]	[-0.58377]	[-1.91142]
D(UDU (-2))	-0.037359	0.259749	0.030136	0.112755	-0.121674	**0.304596***	0.070451
	[-0.29442]	[1.69452]	[0.34018]	[0.95775]	[-1.08242]	**[2.46736]**	[0.44772]
D(US(-1))	-0.010866	0.328279	0.101852	0.042569	0.043267	0.157370	0.171897
	[-0.07561]	[1.89082]	[1.01510]	[0.31925]	[0.33984]	[1.12550]	[0.96450]
D(US(-2))	**0.564704***	0.307973	**0.352758***	**0.296196***	0.164846	**0.330758***	0.307227
	[3.94131]	[1.77932]	**[3.52657]**	**[2.22816]**	[1.29875]	**[2.37283]**	[1.72913]
C	3.978724	7.875690	2.465892	3.063165	5.330545	0.998076	7.472780
	[0.81798]	[1.34032]	[0.72615]	[0.67876]	[1.23707]	[0.21091]	[1.23888]

Note: Figures in brackets indicate t-ratio. * Significant at 5 % level.
NZ-Nizamabad , ARG- Argentina, DAV-Davangere , CH- Chhindwara, KO-Kota, UDU- Udumalpet, US- United States market, C – Constant

found significant and revealed that the impact of its own price gets corrected within two months lag period. In this case, the speed of convergence was at 30 per cent with short run price movements along the long run equilibrium path. The coefficients of own lagged price of Nizamabad maize market was also found significant and revealed that the impact of its own price gets corrected within one month lag indicating the short run price movements along the long run equilibrium path was stable. At the same time with relation to Udumalpet market the speed of convergence of prices in Nizamabad market was marginal at 29 per cent with short run price movements along the long run equilibrium path getting stable after two months lag period.

Findings also show that the price movements of Davangere market were heavily influenced by the price changes in other domestic markets. The effect of all the domestic markets except that of Kota market was observed causing short run disequilibrium in the prices of Davangere market. The coefficient of its own lagged price was significant with the impact taking one month lag period. The speed of convergence of the short run price movements along the long run equilibrium path was also found to be at 29 per cent. At the same time it was also observed that more than 53, 54 and 38 per cent of short run disequilibria got corrected with one month lag in the Davangere market with relation to Nizamabad, Chhindwara and Udumalpet markets respectively. In the case of Chhindwara market, the coefficient of its own lagged price was found significant at one month lag period. The speed of convergence for the short run disequilibrium to get corrected was at the marginal (26 %). On the other hand, with relation to Nizamabad market about 31 per cent of short run disequilibrium in Chhindwara market got corrected with two months lag period. For the Kota maize market the short run disequilibrium was found to exist at two months lag period with the speed of convergence at 20, 27 and 42 per cent with relation to Davangere, Kota and United States markets respectively. Further the error correction estimates for Argentina market revealed that it was not at all affected by international maize market prices in the long run equilibrium path and it was found to be a separate market. At the same time the short run disequilibria of the Argentinean market with relation to the markets of Nizamabad and Davangere were found significant at two months lag period and the speed of convergence was at 57 and 35 per cent respectively.

In the case of United States market short run disequilibrium were found with relation to Udumalpet, Nizamabad, Davangere and Chhindwara market with two months lag period. The speed of convergence was about 33, 56, 35 and 30 per cent respectively with short run price movements along the long run equilibrium path.

The results of the study confirms that both the domestic and international maize markets were integrated while Argentina market integrated in the short run but seems to be functioning as a separate market in the long run.

Summary and Conclusion

CHAPTER VI

SUMMARY AND CONCLUSION

Maize (*Zea mays* L.) is one of the most versatile emerging crops having wider adaptability under varied agro-climatic conditions. Globally, maize is known as queen of cereals because it has the highest genetic yield potential among the cereals. It is cultivated on nearly 180 million ha. (2013-14) in about 110 countries having wider diversity of soil, climate, biodiversity and management practices.

In India, maize is the third most important food crop after rice and wheat. During 2013-14, it is cultivated in 9.4 million ha. mainly during *Kharif* season covering 85 per cent area. Maize in India, contributes nearly 9 per cent of the national food basket and more than Rs. 100 billion to the agricultural GDP at current prices apart from generating employment of over 100 million man-days at the farm and downstream agricultural and industrial sectors. In addition to staple food for human being and quality feed for animals, maize serves as a basic raw material as an ingredient to thousands of industrial products that includes starch, oil, protein, alcoholic beverages, food sweeteners, pharmaceutical, cosmetic, film, textile, gum, package and paper industries etc.

Considering the economic importance of maize, the study was undertaken with an overall objective to assess the evolutionary trends of the maize crop, time series tools, mainly linear and compound trends, seasonal indices and Fourier analysis were extensively used. To understand the export demand, an econometric modeling was attempted in the study. The study also examines the integration between different domestic and international markets.

The present study was carried out based on secondary data. The required information for the study was collected from the secondary sources viz., various issues of Agricultural Situation in India and authenticated published sources of the Government of India. The study was carried out in such a way to understand comparative performance of the crop in its entire sphere during three time periods namely the Post Green Revolution (1970-1991), Post Liberalization (1992-2013) and the overall study periods (1970-2013).

A negligible amount of 0.14 per cent increase in area was observed during the post green revolution period. The area under maize increased to a large extent of 58 and 61 per cent during the post liberalization and the overall study periods respectively. Similarly, the fluctuations in area during all the three periods were also found to be 2.09 per cent, 15.38 per cent and 16.16 per cent respectively. This implies that the growth in terms of area secured to be stable. The compound growth rate during post liberalization period (2.29 %) far exceeded that of during post green revolution (-0.02 %) and overall study periods (0.98 %).

It was evident from the linear trends, during post liberalization period the area added (165.7 thousand hectare annually) was more than two and a half times of the addition during the overall study period (68.43 thousand hectare annually). Also the result of harmonic analysis of the area indicated that no significant cyclical fluctuations existed in the maize area during all the three periods.

During the post green revolution period the increase in productivity accounted for only 7.81 per cent, but during post liberalization and overall study period the same increased by 46 and 91 per cent respectively. Also the average productivity improved from 1191 kilogram per hectare during the post green revolution period to 1970 kilogram per hectare during the post liberalization period but it was only 1580 kilogram per hectare during the overall study period. The fluctuation in terms of productivity was found to be lower during both the post green revolution (16.64 %) and post liberalization (16.99 %) periods and was higher (30.28 %) during the overall study period.

In absolute term the increase in yield was about 47.3 kilogram per hectare annually during post liberalization period which is more than two and a half times than that of during post green revolution period (19.3 kilogram per hectare) while during the overall study period the same was about 35.1 kilogram per hectare annually which is almost double than that of during post green revolution period. Similarly, the same trend was recorded in the compound growth rate. A significant seven year cycle during post green revolution period and also a significant ten year cycle for the overall study period were observed at 5 per cent level. No cyclical fluctuation was found for the post liberalization period.

The increase in production of maize during the post green revolution period was 7.67 percent and further increased to 142.06 and 223.14 per cent during the post liberalization and the overall study periods. It could also be seen that average production of maize has doubled from 6965 thousand tonnes during the post green revolution period to 14598 thousand tonnes during the post liberalization period and to 10780 thousand tonnes during the overall study period. The coefficient of variation of production was found to be lower during the post green revolution period (17.29 %) but was higher during the post liberalization (32.11 %) and the overall study periods (47.60 %). This trend confirms that the growth in production was not stable.

It was seen from the linear trends, that the output added was about 120.2, 684.3 and 360.7 thousand tonnes annually during the post green revolution, the post liberalization and the overall study periods respectively. Similarly the compound growth rate of production during the post green revolution, the post liberalization and the overall study periods were 1.69, 4.75 and 3.25 per cent per annum respectively. Also from harmonic analysis it was evident that only during the post green revolution period production has exhibited a seven year cycle, which lost its significance when aggregated with the post liberalization period.

The Total Domestic Consumption (TDC) here includes consumption of maize for Feed and Residual (FR) and for Food, Seed and Industrial use (FSI). The increase in consumption of maize for FR was higher (241.38 %) during post liberalization period. At the same time the average TDC of maize was comparatively higher (13245 thousand tonnes) during the post liberalization period. Comparatively fluctuations were found to be lower in the consumption of maize for FSI during all the three periods. This implies that the consumption of maize for FSI was secured and found to be stable in all the three periods.

The growth rates of consumption of maize for FR, FSI and TDC were significant both in absolute and compound terms during all the three periods. The linear trend during the post green revolution period was high for TDC with an additional consumption of 126.8 thousand tonnes annually, followed by FR and FSI. The same trend was observed in consumption during the post liberalization period. But during the overall study period the trend changed slightly and the high additional consumption of 285 thousand tonnes annually was observed for TDC, followed by FSI with 219.4 thousand tonnes annually and FR with 65.6 thousand tonnes annually.

The compound growth rates of consumption for FR, FSI and TDC during the post green revolution period were 10.62, 0.77 and 1.77 per cent per annum respectively. The same trend was also observed during the post liberalization period. The compound growth rate was higher in FSI and it was found to be 9.62 per cent per annum during the overall study period.

During the post green revolution period significant seven year cycle was observed and no fluctuations were observed during post liberalization period. But during the overall study period six to seven years and ten year cycles were identified.

The annual average producer price, that proxied the domestic price, had been steadily growing over the decades. In absolute terms, during the post green revolution period the incremental price was only rupees 79.09 per tonne annually whereas it was about rupees 497.40 and 253.66 per ton annually during the post liberalization and the overall study period respectively. Similarly, the same trend was recorded in the compound growth rate. The compound growth rate of price during the post green revolution, the post liberalization and the overall study periods were 5.95, 7.15 and 7.00 per cent per annum respectively. The results of harmonic analysis showed the evidence of seven year cyclical fluctuations during the post green revolution period and no fluctuations during the post liberalization and the overall study periods.

While the prices exhibited cyclical fluctuations, seasonally they were quite stabilized. The seasonal indices were calculated for the monthly average prices of maize in the selected five different domestic markets for the period from January 2003 to December 2013. The seasonal index 109.17 of Udumalpet market for the month of august indicated that the price in the month of august was nine percent above the monthly average and the price in the month of March was six percent less than the monthly average. Similarly in all other markets seasonal indices were above the monthly average during the months of July and August and below the average during October and November. That is, the price was above average at the time of *rabi* harvest and below average at the time of *kharif* harvest.

The growth rate of international price was significant both in absolute and compound terms. In linear trends, during the post liberalization period, the price increase was about rupees 475.48 per tonne annually while the increase was about 53.33 and 229.49 rupees per tonne during the post green revolution and the overall study periods respectively. Similarly, the same trend was recorded in the compound growth rate. The compound growth rate of international prices 5.92, 7.70 and 7.77 per cent during the post green revolution, the post liberalization and the overall study periods respectively came closer to that of domestic prices implying that the domestic market was closely responding to international conditions.

During the post green revolution, the post liberalization and the overall study periods the average stock of maize were 436, 488.59 and 462.48 thousand tonnes respectively and the average stock position was almost static. The fluctuation in the stock position was high and unstable and was about 78, 66.54 and 71.41 per cent during the post green revolution, the post liberalisation and the overall study periods respectively.

Due to this volatility the growth rate of Indian maize stock position exhibited the same trend both in absolute and compound terms during the post green revolution, the post liberalization and the overall study periods. The compound growth rate of stock was negative and increased to 9.01 per cent per annum during the post liberalisation period and further on aggregation stabilized at 0.836 per cent per annum. The linear trends of stocks registered the negative trend during the post liberalization period and increased to 30.388 thousand tonnes annually during the post liberalisation period which on aggregation showed an increase of 2.833 thousand tonnes annually. The results of harmonic analysis indicated that no significant cyclical fluctuations existed during the post liberalisation and the overall study period but seven year cyclical fluctuation was observed during the post green revolution period may be due to fluctuations in production and productivity.

Maize exports have emerged as one of the most important price influencing factors. An attempt has been made with the available limited data set, to study the trend and other growth parameters during the post green revolution and post liberalisation periods. It could be seen that the average export of maize was 4.402 thousand tonnes during the post green revolution period which increased significantly to 1293.86 and 838.87 thousand tonnes during the post liberalization and the overall study period. High fluctuations in growth dimensions were also observed. The coefficient of variation for export was found to be higher in all the three periods. This trend confirmed that the growth in export was not stable.

From the linear trends it was observed that the exports registered a negative trend during the post green revolution period and increased to 219.38 thousand tonnes annually during the post liberalisation period which on aggregation showed an increase of 111.32 thousand tonnes annually during the overall study period. The compound growth rate of exports during the post green revolution period was negative then increased to 40.81 and 32.55 per cent per annum during the post liberalisation and the overall study periods respectively. The same trend was exhibited in the Indian share of maize exports to the world export. The Indian exports found to be widely fluctuating with no apparent trend pattern and the Indian Share (IS), declined sharply at almost 1.70 per cent per annum during the overall study period even as the total world maize trade was expanding at about 1.55 per cent per year. The value realised on exports on the other hand, had been significantly growing on account of increased prices. No fluctuations in growth dimensions were observed and the world export was stable. This trend confirmed that the growth in world export was stable. The Schuster's 'k' values indicated that no significant cyclical fluctuations existed in the maize export during the overall study period.

Maize is one of the important goods that human beings depend on for both food and manufacturing and it gains importance as population increases. There is high demand for maize in domestic as well as in international level. So analysing export demand is important for policy and planning at the country level.

Indian maize exports were impacted by ending stocks in India, number of live animals in India, total domestic consumption in India, ending stocks in the rest of the world, number of live animals in the rest of the world, rest of world maize exports, total consumption in the rest of the world, Indian annual maize trade weighted exchange rate, Indian maize price, price of substitute crop sorghum, Indian average annual rainfall and Indian population relative to the rest of the world population. To remove the auto correlation and to improve the significance, two variables, Indian average annual rainfall and Indian population relative to world population were dropped and some of the variables were replaced by lagged variables in the model.

The results of the reduced form equation indicated the relationship between the dependent and independent variable with expected signs. The intercept was significant at 5 per cent level indicating that the export would be 4327 thousand tonnes while all other variables were kept constant. Also if the ending stock of maize in India and rest of world consumption change by 1000 MT in a given year, Indian maize export would increase by 295.3 MT after two years and 9 MT in the given year respectively while other factors held constant.

If the number of live animals in India and in the rest of the world changes by 1000 head in a given year, Indian maize export decreases by 10 MT after one year and 2 MT in the given year respectively. If the Indian consumption, rest of the world maize ending stocks and rest of the world maize exports change by 1000 MT, Indian maize exports decrease by 141, 7 and 5 MT respectively while other factors held constant.

The coefficient of ER_{INR} was – 78.577 indicated that if the annual maize trade weighted exchange rate increase by one rupee, Indian maize exports decrease by 78.6 thousand MT in the given year while other factors held constant. If the price of maize and sorghum in India changes by one rupee in a given year, Indian maize export increases by 197 MT after one year and decreases by 199 MT in the given year while other factors held constant.

Cointegration analysis was used to test the integration of maize markets. The domestic markets viz. Chhindwara, Kota Davangere, Nizamabad and Udumalpet and the international markets viz. Argentina and United States were selected. The results of correlation indicated that all the markets were highly correlated. The positive correlation showed that an increase in the price of one market would follow the increase in the price of other market.

The price volatility for maize in the domestic markets was estimated through ARCH and GARCH models. It was observed that Udumalpet and Kota markets were highly volatile when compared to other markets. In the present study, all the variables were found to have minimum AIC values at the second lag. Hence throughout the analyses, second lag of the variables were used wherever necessary. The stationarity of the markets was tested using Augmented Dickey-Fuller (ADF) test and found that the prices were stationary in their first differences.

Having confirmed that the price series were stationary in their first differences, cointegration between the markets was tested using Johansen-Juselius maximum likelihood procedure for the presence of short run and long run relationship between the domestic and international maize markets. It was found that Nizamabad and Argentinean maize markets were integrated with other markets each with two cointegrating equations. The existence of cointegration between markets confirms that there was a long run relationship between markets.

Since cointegration test indicate only the existence of long run relationship among the markets, Granger Causality test was used to analyse the direction of relationship among different maize market price series. The results revealed that in two cases Chhindwara, Nizamabad and United States, Udumalpet, there exists bidirectional causality. In cases of other markets unidirectional causality of prices was observed.

Accordingly, the VECM results revealed the existence of short run disequilibrium. The estimated error term coefficients revealed that in the domestic Udumalpet maize market 28 per cent disequilibrium got corrected within a month by changes in its own prices and the remaining was influenced by other internal and external market forces. Moreover the coefficient of own lagged price of Udumalpet market was also found significant and revealed that the impact of its own price gets corrected within two months lag period. In this case, the speed of convergence was at 30 per cent with short run price movements along the long run equilibrium path. The coefficients of own lagged price of Nizamabad maize market was also found significant and revealed that the impact of its own price gets corrected within one month lag indicating the short run price movements along the long run equilibrium path was stable. At the same time with relation to Udumalpet market the speed of convergence of prices in Nizamabad market was marginal at 29 per cent with short run price movements along the long run equilibrium path getting stable after two months lag period.

Findings also show that the price movements of Davangere market were heavily influenced by the price changes in other domestic markets. The effect of all the domestic markets except that of Kota market was observed causing short run disequilibrium in the prices of Davangere market. The coefficient of its own lagged price was significant with the impact of taking one month lag period. The speed of convergence of the short run price movements along the long run equilibrium path was also found to be at 29 per cent. At the same time it was also observed that more than 53, 54 and 38 per cent of short run disequilibria got corrected with one month lag in the Davangere market with relation to Nizamabad, Chhindwara and Udumalpet markets respectively. In the case of Chhindwara market, the coefficient of its own lagged price was found significant at one month lag period. The speed of convergence for the short run disequilibrium to get corrected was at the marginal (26 %). On the other hand, with relation to Nizamabad market about 31 per cent of short run disequilibrium in Chhindwara market got corrected with two months lag period. For the Kota maize market the short run disequilibrium was found to exist at two months lag period with the speed of convergence at 20, 27 and 42 per cent with relation to Davangere, Kota and United States markets respectively. Further the error correction estimates for Argentina market revealed that it was not at all affected by international maize market prices in the long run equilibrium path and it was found to be a separate market. At the same time the short run disequilibria of the Argentinean market with relation to the markets of Nizamabad and Davangere were found significant at two months lag period and the speed of convergence was at 57 and 35 per cent respectively. In the case of United States market short run disequilibrium were found with relation to Udumalpet, Nizamabad, Davangere and Chhindwara market with two months lag period. The speed of convergence was about 33, 56, 35 and 30 per cent respectively with short run price movements along the long run equilibrium path.

Policy Implications

The results of the study had brought out certain invariant basic trends of maize crop and might serve as first approximations and might serve as hypotheses, rigorously testable with expanded models as additional data are made available in future.

The immediate modification might relate to further disaggregation of the model employed in the study. The area under HYV / Hybrid maize, maize area under different sources of irrigation, productivity of labour, average labour employed per hectare of maize cultivation and capital and the like might be profitably incorporated into the model. These additions, if proved to be price response, could provide valuable information to regulate the performance of the crop in every sphere through market intervention policies.

Considering the importance in the price formation process, the stock holding might be explained through causal relationship rather than allowing it to operate as a residual activity. Similarly consumption equation could further be disaggregated between feed, residuals (for ethanol), food (ready to serve, fast food and specialty high valued food), seed and industrial use and possibly among consumer categories so that ways and means of regulating it could be devised. As such, the present study suggested no possible way to regulate exports and domestic consumption to ensure sustainable food security. Though not a problem at present, it may need regulation in the future.

Similarly, the international prices and exports of maize might be probed in an expanded framework. Specifically, direct exports and forward contracts along with the quality distribution of exports need to be properly integrated into the basic framework. Bilateral trade agreements also need to be endogenised to explore their impact on exports and domestic consumption.

One important lacuna is the non-consideration of cost elements in the present analysis. This too might, when integrated provide additional information on the wisdom of expanding maize area viz., replacing other crops, besides enhancing the understanding of cost effectiveness in the international markets.

Maize demand is even throughout the year; however supply is skewed with 75 per cent of production in *kharif* season. *Rabi* maize has emerged as an important crop in the non-traditional areas that could help to meet demand requirement consistently throughout the year. There is potential to increase the production of maize by increasing the production of *rabi* maize in the coming years. Production of maize can increase the income and employment opportunities of the farmers due to its diversified uses.

In the context of globalization, tariff policy becomes important for agricultural commodities. In other words, it is important to monitor exports, imports, global supply and demand and fix tariffs accordingly. There is a need to balance between producer prices and consumer prices by careful calibration of minimum support prices and tariff policy (import duties).

Though maize is a highly profitable crop on the basis of its return to investment, government should increase investments in maize research and extension as a matter of priority. Such investment should focus on developing improved, stress resistant varieties; developing new methods and techniques for preventing post-harvest losses; and detailed characterization of maize genetic resources. Modern inputs and production technology can help the farmers to increase income through increased yield and improve their socio-economic conditions.

The relatively higher cost of production and poor quality of our output has affected the competitiveness. High cost of labour coupled with low productivity has been the primary reason for the high cost of production. It is being estimated that maize demand will continue to increase in view of increasing demand in poultry and livestock sectors in the country and growing non- vegetarian population and changing food habits. Future increases in the production through expansion of area are minimal. Need to take drastic measures to improve productivity and quality of maize produced in the country on a war footing to improve competitiveness and long-term viability as we are far below the world's average productivity.

The efforts must be taken to ensure a stable external market. The creation of an autonomous body in line with the commodity boards could be an acknowledged improvement, to which the stakeholders might pledge their efforts. As far as marketing is concerned, an effective integrated marketing plan should be evolved for getting the biggest profits through research, setting objectives, strategy and measurement.

Similarly, in prime locations of maize producing states by augmenting production, Exclusive Export Promotion Zones may be established to produce exportable value additions and thereby creating employment opportunities and also providing assistance for the development of chain of allied small scale operators. This in addition will contribute to the agricultural GDP and the economy as a whole.

Eighty per cent of India’s current exports are to Vietnam, Indonesia and Malaysia. The top importing countries, Japan, Korea and China are both much closer to India than USA, Brazil and Argentina (top exporting countries). India could have a cost advantage due to lower shipping costs. Further, declining exports from USA and price parity offered by Indian maize provides India an opportunity to increase exports to these countries. Farmers should be educated on handling post-harvest cleaning, grading and switching to standardized packaging of produce to meet export market requirement.

In the export sphere, the strategies need to be more specific and target oriented. Of course that needs to be correspondingly matched by cost effective strategies in domestic production. This might begin with strategies to increase the exports in value added form in few specific categories in which it could introduce all possible cost effective methods and follow it with gradual extension to cover other categories of exports in a phased manner.

On the export front, diversification of export market portfolio, targeting value addition and niche segment opportunities in specific markets, etc are warranted at once. Indian maize in the domestic and the international markets requires new initiatives for meeting the emerging challenges. In keeping with the requirements of the export and domestic markets, there is a focus on quality control. Implementation of ISO Standards and HACCP (Hazard Analysis & Critical Control Points) has therefore acquired growing importance. Efforts might also be continued to persuade producers to increase production of exportable quality maize variety.

The private sector involvement in Indian agriculture is a recent development. Technology can be the prime mover of agriculture growth in future. Future breakthrough technologies in agriculture could come increasingly from the private sector. The government has to play a more proactive role as coordinator, facilitator and also as a regulator. Higher investment in basic infrastructure like roads, canal waters, watersheds, check dams, etc. could attract private investment in other areas of the supply chain.

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