PRICE VOLATILITY OF BLACK PEPPER AND ITS IMPLICATIONS IN KERALA

By

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(2013-11-206)

THESIS

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DECLARATION

I, hereby declare that this thesis entitled **"PRICE VOLATILITY OF BLACK PEPPER AND ITS IMPLICATIONS IN KERALA"** is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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Proverbs 3: 4-5

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Introduction

1. INTRODUCTION

Black pepper, the "King of spices", is one of the oldest and best-known spices in the world. Indigenous to India, especially Kerala, this 'black gold' holds supreme position in the world market because of its celebrated varieties 'Malabar Garbled' and 'Tellicherry Extra Bold'. Though India is the largest consumer among the black pepper producing countries in the world, the country has lost its position as the major producer and exporter of black pepper to Vietnam, since 1999.

India is one among the leading producers of pepper in the world, with an area of 1.23 lakh ha and production of 65,000 tonnes in 2012-13 (Spices board, 2015). Kerala and Karnataka are the major pepper growing states, which account for more than 80 per cent of the production in the country. According to Spices Board, the area under pepper in Kerala was 1.7 lakh hectares with a production of 16500 tonnes in 2011-12 while in the case of Karnataka, area was 0.21 lakh hectares and the production was 16,000 tonnes. Idukki and Wayanad districts are the major producing regions of black pepper in the state as well as the country, while Kochi happens to be the major trading centre. The area under pepper in Kerala has increased from 1.08 lakh ha in 1980-81 to 1.69 lakh ha in 1990-91 and subsequently to 2.02 lakh hectares in 2000-01. Since then it has shown a declining trend and was 0.85 lakh hectares in 2013-14. The production in the country increased from 28,519 tonnes in 1980-81 to 46,802 tonnes in 1990-91 and then to 60,930 tonnes in 2000-01. Consequent to the reduction in area under the crop since 2000-01, the production also showed a declining trend and was as low as 36,670 tonnes in 2013-14 (GOK, 1983, 1993, 2001, 2015).

The economic reforms of 1991 and the subsequent trade liberalization policies including the WTO agreement and the Free Trade Agreements have brought challenges and prospects for Indian agriculture. The agricultural trade liberalization policies have been operating mainly through prices and it has been argued that free

trade creates high volatility in the world prices of agricultural commodities (Sekhar, 2004). This volatility would be directly transmitted to domestic prices due to the increased integration with the world markets, eventually leading to rise in the volatility of the Indian prices (Jha and Srinivasan, 2001). The vulnerability of the developing countries to volatility in international prices has increased as liberalization of markets has shifted price risk from governments to households (Hallam and Sarris, 2006). Price transmission from world to domestic markets is affected by several factors: trade policy, transport costs, geographic condition, the level of self-sufficiency and exchange rates (Dawe, 2008). Though the most important source of price volatility in agriculture is yield variability due to weather shocks, the demand shocks, in particular income shocks (Gilbert, 2010) and policy shocks (Christiaensen, 2009) are also important. Production responsiveness is low in agriculture because input decisions depend on expected prices while, the short-term demand elasticity are low because the actual commodity price may not be a large component of the overall value of the final product (Gilbert, 2006). There has also been a contention that the recent shocks to commodity markets have partly come from excessive speculation (UNCTAD 1995). Change in currency exchange rates between trading nations can have significant effects on international trade and prices. Increased connection between energy and agriculture raises questions about volatility transmission from more volatile energy and oil markets (Du *et. al.,* 2009).

Whether caused by market fundamental factors or non-fundamental factors, price volatility is a major issue for all the participants of the commodity supply chain. The impact of price volatility can either be ex-ante effects arising through decisions of the producers to alter their allocation towards or away from risky activities or the ex-post effects of extreme outcomes arising either as producers adjust their expectations of future incomes in response to current savings, or as they adjust their current expenditure plans to income shortfalls (Dehn *et. al.,* 2005). Higher price volatility means higher costs of managing risks which would eventually translate into

higher consumer prices (Tothova, 2011). The commodity price trends and volatility affect the incidence of poverty through impact on employment opportunities and earnings of producers. At the farm household level, the impact of price volatility depends on whether global and border price trends are passed through to the producer at local level and whether improvements in productivity and production are able to compensate in a context of falling prices.

Black pepper as an internationally traded commodity is always associated with vulnerable price fluctuations. Pepper price variations are influenced by many factors like international prices, domestic production and consumption, trade agreements and export–import policies. The prices of pepper move cyclically through time and show considerable volatility from year to year. Pepper traded internationally shows price changes of more than five per cent from one month to another (Chopra and Bessler, 2005). The volatility in pepper prices is highly evident from price movements of the commodity. The annual average price of Malabar Garbled pepper (MG1) in Kochi market increased from 33 Rupees per kilogram in 1990-91 to 215 Rs/kg in 1999-00, which subsequently decreased to as low as 66 Rs/kg in 2005-06. Then the price showed an increasing trend and was ₹140 in 2007-08, which again decreased to ₹129 in 2008-09. After that the price has been continuously increasing and was as high as ₹750 in August 2014 which subsequently decreased to ₹610 in May 2015 (www.indianspices.com).

Even though futures' trading is an effective strategy for covering the price risk, in the case of agricultural commodities, in India, it has so far proven beneficial only for a few commodities with stringent and timely regulatory actions, while it has had an adverse impact on other cases and has not benefited majority of the small farmers (Lingareddy and Tulsi, 2008). The limited flexibility in the cropping pattern to market forces in the case of trade dependent perennial cash crops like pepper has been causing income volatility and increased risk for the producers. This has been dissuading the farmers from undertaking long term investments and were either

shifting away from crops like pepper or neglecting the crop in many of the years. Trade liberalization being the order of the day and since the market volatility as well as uncertainties are here to stay, it is important to ascertain the specific roles of international prices and domestic policies in the price volatility of a trade dependent crop like black pepper, so as to make informed decisions in policy making. Even though there are numerous studies on the macro-level implications of price volatility, researches on the producer level implications of price volatility in Kerala are very limited and such studies are much warranted for assisting the producer households to cope up with the market volatility and also to minimise the negative effects of market uncertainties.

With the above background, the present study is aimed at assessing the extent and determinants of price volatility in black pepper in the pre-liberalization and post-liberalization periods. It is also aimed at assessing the transmission of volatility between Indian and international spot and future markets of black pepper. The study identifies the reasons for price volatility and test whether domestic factors including the futures trading or the transmission of the international price causes the price volatility. The micro-level implications of price volatility on crop production as well as livelihood security of the farm households on a comparative framework between farmers with assured prices and farmers without any contractual agreement at two points of time helps in understanding the differential impact of price volatility which could in turn aid formulation of price stabilization policies.

The specific objectives of the study are

1) To estimate the magnitude and determinants of volatility in the prices of black pepper.
2) To identify the price transmission between international and domestic markets.
3) To study the relationship and transfer of volatility between the spot and future market prices of black pepper.

4) To assess the implications of price volatility of black pepper on the input use, production, employment and income at the producer level.

1.1 LIMITATIONS OF THE STUDY

The study is based on the responses of farmers in Idukki district of Kerala state and hence generalizations need not be completely accurate. The normal errors inherent in social surveys like bias in reporting the data, inadequacy of information; common limitations of statistical analysis etc might also have affected the study slightly. In spite of the above, maximum care has been taken to ensure that such limitations do not affect the authenticity of findings or results of the study.

1.2 PLAN OF THESIS

The thesis has been divided and presented in five chapters. The first chapter gives a general introduction to the thesis explaining the theoretical background of the study, its relevance and significance, objectives and major limitations. The second chapter is intended for providing the theoretical and empirical background of the study by reviewing previous studies related to the present research. The third chapter describes the study area and methodology followed. The fourth chapter includes the results and discussion and a summary of the study is presented in the fifth chapter followed by reference, abstract and appendices.

Review of literature

2. REVIEW OF LITERATURE

The literature review is a critical discussion and summary of literature in the particular area of research and helps to justify the methodology proposed for the study. In this chapter an attempt has been made to review the important past studies which are relevant to the present study from the point of view of the objectives as well as the methodology. The reviews are classified under the following headings:

2.1 Indian pepper economy

2.2 Magnitude of price volatility

2.3 Causes and consequences of price volatility

2.4 Transmission of price volatility

2.5 Relationship between spot and futures prices

2.6 Micro level implications of price volatility

2.1 INDIAN PEPPER ECONOMY

Nirmal and Ravindran (1992) stated that the average productivity of black pepper vines in India is very low compared to other major black pepper producing countries. According to them, prevalence of low yielding cultivars was one of the major factors affecting productivity. To increase productivity they recommended the replacement of old low yielding cultivars with new high yielding cultivars having good quality attributes. They also observed that piperine, oleoresin and essential oils are the important factors contributing to quality of black pepper production as a spice.

According to Madan (2000), black pepper production has made considerable contribution to rural employment and farmers' income in Kerala and Tamil Nadu. Although pepper prices fluctuate sharply, pepper farming was still thriving and getting extended to new areas because the producers were still maintaining the hope of getting better returns on investment. He concluded by endorsing that quality has

become the key word in the world of spices and hence efforts to produce clean pepper need to start from the farm itself.

Ravindran (2000) opined that although black pepper had originated in Kerala and had been under cultivation for centuries, the yield of pepper in India was one of the lowest in the world mainly because the intensive cultivation practices were not in vogue, and people had been growing pepper in a casual way (plant and forget). As a result, there was a wide gap existing between the productivity in India which was about 320 kg/ha and that of other countries like Thailand which was as high as 4500 kg/ha.

Peter and Nybe (2002) expressed the view that price competition in the global markets was the major challenge for the Indian pepper industry. According to them, a realistic price reduction to offer healthy competition to major competitors, combined with technology adoption for augmenting productivity and quality of black pepper were the prerequisites for the success of the pepper industry in India in the context of a liberalized trade regime.

Selvan and Cherian (2008) reported that black pepper was grown in almost every homestead or plot of land in the plains and high ranges like Idukki and Wyanad of Kerala, the major producing state in India and hence, small and marginal farm holdings dominated 80 per cent of the total number of pepper farms in Kerala.

Umarji (2008) reported that the harvesting season of black pepper in Vietnam, the world's largest producer and exporter, was from March to mid-May. Consequently, Vietnam was quoting low price during these months which in turn hampered the competitiveness of Indian black pepper. However, rising demand from the Middle East and a falling rupee have boosted pepper exports from India.

Nair (2011) reported that the global demand of pepper was soaring to 2,80,000 metric tons by the year 2020 which will further increase to 3,60,000 metric tons by the year 2050. Among the primary constraints in pepper production, the most

important according to him was the absence of an ideotype that combines many positive traits to boost production potential.

Yogesh and Mokshapathy (2013) pointed out that the productivity of pepper in India was one of the lowest in the world which was about 306 kg/ha. It was found that the production of pepper has got a significant influence on its export. The impressive gain in the share of world exports by other competitors, both in terms of quality and cost, was the major deterrent for pepper exports from India.

2.2 MAGNITUDE OF PRICE VOLATILITY

Instability in pepper prices differs not only from country to country, but also from period to period, depending on various endogenous and/or exogenous factors. The long-term variability was found to be very high between 1982 and 1987, two to three times higher than in the early 1970s and even three to four times higher than that in the second half of the 1970s. Volatility of pepper prices showed only slight decline between 1988 and 1992. Black and white pepper price fluctuations were more or less similar during the period 1970-1988, but afterwards white pepper prices became more unstable (UNCTAD, 1995).

Diao and Roe (2000) found that as more countries open their economies to trade, a multitude of export markets for food may mitigate international price volatility. The effect of the Asian crisis on US agriculture was small because falling exports in Asia were accompanied by increasing exports to other countries such as Mexico. They concluded that as countries diversify their export bases, they were less likely to suffer from rising volatility.

Jha and Srinivasan (2001) analysed the effects of liberalizing food grain trade on domestic price instability in India using a multi-market equilibrium model. The result demonstrated that the freeing of trade by India leads to greater domestic price instability and higher world price stability. They concluded that under liberalized

trade, variable levies or subsidies when compared to buffer stocks were more effective in stabilizing domestic prices.

Yang *et al.* (2001) examined the effect of the agricultural liberalization policy on agricultural commodity price volatility using Generalized Autoregressive Conditional Heteroscedasticity (GARCH) models. Results of the study indicated that the liberalization policy has caused an increase in the price volatility for three major grain commodities *viz.,* corn, soybeans and wheat; little change for oats, but a decrease in price volatility for cotton.

Buguk *et al.* (2003) examined the extent to which volatility in primary input markets (soybeans and corn) spills over into catfish markets. They analyzed the univariate volatility spillover for prices in the supply chain using EGARCH model and found that there exist strong price volatility spillovers from feeding material (corn and soybeans) to catfish feed and farm- and wholesale-level catfish prices.

Sekhar (2004) measured the degree of price volatility of important agricultural commodities (wheat, rice, groundnut oil, soyabean oil, coconut oil, sugar, cotton, and coffee) in major international and Indian markets. This study employed intra-year and inter-year volatility measures to analyse domestic and international markets and also GARCH estimates was used to identify periods of high volatility and volatility clustering. It was observed that the intra-year variability was generally lower in the domestic markets than in international markets and on the other hand inter-year variability was higher in the domestic markets. The study found that the decades of 70s and 90s showed higher price variability for most commodities in international markets. The period 1972-75 was a period of high price volatility.

White and Dawson (2005) estimated the price risk for a representative UK arable farm using different models and found that the GARCH model with t-distributed errors gave the best fit. It was concluded that the UK arable farms faced substantial price risk.

Kumar and Sharma (2006) evaluated the government price policy in controlling food price variability in India using monthly indices of wholesale prices of wheat, rice and coarse-grains. The analysis showed that inter-year variability in annual nominal prices declined for both wheat and rice in the nineties as compared to eighties while the intra-year variability shot up for wheat while it came down for rice during nineties. These findings reflected that the price stabilization measures were unsuccessful in reducing the price variability in India during the nineties.

Easwaran and Ramasundaram (2008) attempted to study the efficiency of futures market and outlined the status of futures market in agricultural commodities in India. They statistically analyzed the data on price discovery in a sample of four agricultural commodities traded in futures exchanges. They used Wald chi-square procedure to test the market efficiency and unbiasedness of futures prices and observed that the futures market in those commodities were not efficient, which implies that price discovery does not occur in agricultural commodity futures market

Roache (2010) measured the volatility of food commodity spot prices using the GARCH approach and found that low frequency volatility was positively correlated across different commodities, suggesting an important role for common factors.

Tothova (2011) reported that larger fluctuations in prices limit the ability of consumers to secure supplies and control input costs. Due to price transmission issues, contractual agreements and relatively low percentage of raw commodity in the processed products, consumer prices do not necessarily follow commodity prices directly. The biggest drawbacks of volatility was the associated uncertainties in production, marketing, investment in technology, innovation etc. resulting in higher costs of managing risks which would eventually translate into higher consumer prices.

Anoopkumar (2012) explored the dynamics of domestic price instability of five major plantation crops; coffee, tea, natural rubber, black pepper and small cardamom

using Cuddy Della Vale index. The crops such as natural rubber, black pepper and coffee were reported showing greater price instability in monthly as well as average annual prices as the domestic prices of these crops were highly integrated with the global market whereas, small cardamom and tea were found to be highly domestic market oriented commodities.

Kuruvila *et al.* (2012) measured the extent of volatility in major international and domestic markets in different time periods by using GARCH model and found that the monthly nominal prices of pepper, cardamom, tea and coffee in the Indian market exhibited higher volatility in the post-WTO period. Eventhough the international volatility was also found to be high, it was comparatively lesser than those in the domestic markets.

2.3 CAUSES AND CONSEQUENCES OF PRICE VOLATILITY

Sekhar (2004) applied regression analysis to identify the factors that affect domestic price movements of some important agricultural commodities (wheat, rice, palm oil, groundnut oil, soybean oil, coconut oil, sugar, cotton, tea and coffee) in India and found that international prices and market arrivals were the factors significantly influencing price movements. It was also found that the output fluctuations was not an important determinant of price fluctuations.

Dehn *et al.* (2005) reported that the impact of price volatility can either be ex-ante effects of volatility and ex-post effects of extreme outcomes. The ex-ante effects of volatility will arise through agents' decisions to alter their allocation toward or away from risky activities. The ex-post effects arise either as agents adjust their expectations of future incomes in response to current savings, or as they adjust their current expenditure plans to income shortfalls that they find impossible or too costly to make good through borrowing.

Petersen *et al.* (2005) reported that price volatility was subject to low and high frequency effects and it was studied using rational expectations competitive storage

model. Low frequency volatility was defined as the changes in the level of price variability which persist for more than one harvest year. In other words, it is the component of volatility which tends to move slowly through time. The weather and pest related shocks, together with uncertainty about the expected harvest during the growing season were classified as the high frequency volatility. According to them, for many of the market participants and policy makers, managing low frequency volatility could be more challenging as uncertainty regarding its persistence was likely to be higher.

According to Cashin and McDermmot (2006), the striking feature of commodity prices is the variability and it has two aspects, the duration and amplitude. A high degree of variability in commodity prices and export earnings has serious consequences in the efficiency of resource-use, terms of trade, real income and fiscal position and there by complicate the task of development planning in commodity dependent developing countries which rely up on a few commodities for the major share of their export earnings.

Srinivasan (2008) analysed the spot and futures prices of four agricultural commodities (chickpea, potato, rubber and soy oil) in India. These prices were highly interdependent as evident from the high degree of positive correlation between them. The futures markets were found to give signals to the spot markets on the direction in which prices will move and the futures prices were in turn determined on the basis of the conditions in the spot markets. The extent to which two markets influenced each other depended on the level of integration of the two markets. It was concluded that developing the spot markets along with the futures markets and ensuring higher participation from the farmers were essential to integrate the futures and spot markets.

Subervie (2008) demonstrated that producers in developing countries were predominantly vulnerable to fluctuations in world prices because of their wide exposure to price shocks and limited coping ability. She showed that the effectiveness

of risk-coping strategies was conditioned by the influence of macroeconomic factors such as infrastructure, inflation and financial development. While underdevelopment of infrastructure was found to decreased the producers' capacity to cope with price instability, inflation increased the producers' vulnerability and poor financial development discouraged investment and self-insurance.

According to Abbott and Battisti (2009), the evolution of recent price changes in agricultural commodities could largely be explained by the changes in supply and demand factors. The fast economic growth in Asian economies, particularly in China was the major factor on the demand side while on the supply side, the under investment in agriculture as well as low commodity inventory levels of recent years were the major contributory factors for the price variations. A factor of recent origin was the increasing diversion of food crops to the production of biofuels.

Apart from specific commodity market fundamentals macroeconomic and financial factors including changes in oil prices, world money supply and the value of dollar were found influencing agricultural commodity price volatility. In addition to these, climate change, trade policies in exporting and importing countries and the feedback between price expectation and market responses also contributed to price volatility of agricultural commodities (Gilbert, 2010).

According to Gilbert and Morgan (2010), the important sources of price volatility in agriculture were production and consumption shocks. Production could vary either because of variations in area planted or because of yield variations, typically due to weather shocks whereas, demand shocks due to changes in income as well as prices of substitutes and shifts in tastes caused variation in consumption. Policy shocks also played an important role in price volatility (Christiensen, 2009).

Malik *et al.* (2010) studied the factors affecting commodity prices in Indian commodity market. They reported that price hike in agricultural commodities was due to a combination of factors, including droughts in key grain-producing regions,

low stocks of cereals and oilseeds, increased use of feedstock to produce bio fuel and rapidly rising oil prices.

Lukas and Matthias (2013) found that previous period volatility, stocks, production short falls, international price volatility, functionality of markets and transaction costs were the major determinants of domestic food price volatility. While volatility in the previous period resulted in persistence of domestic price volatility; stocks stabilized and production shortfalls destabilized domestic prices.

Tadesse *et al.* (2013) investigated the main drivers of food price spikes and volatility for wheat, maize, and soybeans. The analysis indicated that exogenous shocks as well as the linkages between food, energy, and financial markets played a significant role in explaining food price volatility and spikes.

Federal ministry of food and agriculture (2015) reported that since 2007, the agricultural commodity markets have experienced extreme price fluctuations more and more frequently causing severe problems in supply. The main reasons for this were changes in fundamental supply and demand factors including the population growth, changed dietary habits along with the increase in the consumption of feed grain and food.

2.4 TRANSMISSION OF PRICE VOLATILITY

Basu and Ray (1991) examined the movement of terms of trade in India for the period from 1947 to 1986 using cointegration analysis. The results indicated the presence of a common trend in the agricultural and manufacturing price indices. The short-run dynamics suggested the existence of a unidirectional casual relation from the prices of manufactured goods to agricultural prices.

Baharumshah and Habibullah (1994) analyzed the association among weekly pepper prices in six diverse markets of Malaysia in the long run using the cointegration technique for a period 1986-91. As per the empirical findings of the study there was high cointegration between the regional pepper markets in Malaysia

and also there was consistent movement in the prices of pepper across spatial markets representing competitive pricing behaviour.

Sinharoy and Nair (1994) examined whether the movements in international prices of Indian black pepper have reflected the variations in pepper prices in other exporting countries and whether the domestic price of pepper has moved synchronously with the international prices using cointegration analysis. The results indicated that due to open trade status for pepper, prices have moved synchronously indicating integration of the domestic market with the world pepper market.

Baffes and Ajwad (2001) studied market integration and price transmission, both spatially and vertically by using cointegration and Error Correction Model and highlighted several factors that impede the pass-through of price signals. Distortions introduced by governments either in the form of policies at the border, or as price support mechanisms, agricultural trade policy instruments such as import tariffs, tariff rate quotas and export subsidies or taxes, intervention mechanisms, as well as exchange rate policies, insulate the domestic markets and hinder the full transmission of international price signals by affecting the excess demand or supply schedules of domestic commodity markets (Quiroz and Soto, 1996; Abdulai, 2000; Sharma, 2002).

Joseph (2004) explored the dynamics of integration of domestic market with the world market of selected plantation crops in Kerala by employing cointegration analysis and error correction model. The analysis of the extent of transmission of world price to domestic market revealed that the level of integration was higher in the case of black pepper followed by rubber and coffee. Period-wise analysis revealed that markets were integrated even before liberalization except for cardamom, and the extent of integration accentuated in the post-reform period for all the crops. It was concluded that liberalization policies have made the transmission of world price to domestic market much better, leading to increased market integration of domestic and world market.

Rajesh *et al.* (2006) examined the nature and the extent of market integration among various domestic and international markets of pepper and cardamom during pre- and post- liberalization periods using the Maximum Likelihood (ML) method of multiple cointegration. All the price series in domestic and international markets during pre-liberalization and post-liberalization periods contained a single unit root and were integrated of order one. Even though the pepper markets were cointegrated even in the pre-liberalization era, the number of markets that were cointegrated was higher in post-liberalization period than in the pre-liberalization period.

According to Rapsomanikis *et al.* (2006) a fundamental issue when analyzing trade policy reform in global agricultural markets is the extent to which domestic agricultural commodity markets in developing countries respond to changes in international prices. Price transmission from the world to domestic markets is central in understanding the extent of the integration of economic agents into the market process. The absence of market integration, or of complete pass-through of price changes from one market to another, has important implications for economic welfare. Incomplete price transmission arising either due to trade and other policies, or due to transaction costs such as poor transport and communication infrastructure, results in a reduction in the price information available to the economic agents and consequently may lead to decisions that contribute to inefficient outcomes.

Hema *et al.* (2007) analysed the price behaviour and mechanism of price transmission in black pepper. They employed cointegration technique and Error Correction Model to study the long-run relationship among farm harvest price, domestic price and export price which revealed that the three series of prices were moving together over the years. The negative coefficients of the error-correction estimates of black pepper indicated the long-run convergence of all prices to equilibrium, barring some short-run divergences.

Saran and Gangwar (2008) studied the performance of egg market by using the Engle-Granger Cointegration test for six major wholesale egg markets in India and

observed that these six wholesale egg markets were highly cointegrated which indicated that they were competitive and efficient at the wholesale levels.

Bathla (2008) measured the extent to which price policy reforms have accentuated the integration of agriculture markets across the states in India by using multivariate cointegration and Vector Error Correction Model for the period from 1980-81 to 2002-03 and also discussed the policy options for improving commodity price transmission. The results of the study confirmed greater spatial market integration in the post-liberalization period for rice, wheat, sugar and groundnut. For cotton and soyabean seed, transmission of price signals across the states were not found in the post-reform period. For all the selected commodities, the short-run dynamics captured through error-term had small coefficients, indicating a slow speed of adjustment of commodity prices to their long-run equilibrium path.

Shinoj *et al.* (2008) analysed the degree of spatial market integration and price transmission between the major coastal markets in India using monthly retail price data of important marine fish species. They observed that the degree of integration and rate of price transmission differ according to species. The highest integration was observed for mackerel because of its affordability to all income classes as well as the resultant wider consumer base. The spatial market integration between major shrimp markets in the country appeared to be the least on account of its greater market share outside the country.

Bastine *et al.* (2010) while assessing the trade performance and transmission of price volatility in black pepper using pair-wise and multiple cointegration analysis found that liberalization has improved the transmission of price signals between the domestic and international markets and there was co-movement of international and domestic prices of pepper. According to them, the major factor which explained variation in producer prices of pepper in Kerala was international price transmitted through the export and import unit values.

According to FAO (2011), the extent to which global prices were transmitted to domestic markets depended on the strength of integration of those markets. Measures such as import duties, export taxes, non-tariff barriers or domestic policies such as price support all influenced the extent to which price changes in domestic markets reflect those in international markets.

Kuruvila *et al.* (2012) studied the degree of integration between the Indian and international markets of plantation crops in different time periods using pair-wise cointegration analysis. The study proved that the markets of pepper and cardamom were co-integrated or the prices moved together even before WTO Agreement and liberalization *per se* has not much improved the co-movement of prices among the domestic and international markets.

Felix *et al.* (2013) examined whether prices in urban consumer markets within developing countries were co-integrated with the prices in world agricultural commodity markets. They used Error Correction Model to study the response of consumer prices to changes in world market prices and exchange rates for wheat, rice, maize and sorghum in urban centers of the developing world and found that developing countries consumer markets were co-integrated with the world markets. The transmission of changes in world prices as well as real exchange rates to domestic consumer prices was low and the movement of domestic consumer prices to a new equilibrium with the world prices after a shock to the latter was relatively slow.

Thomas *et al.* (2013) studied integration between Indian and international edible oil markets using Johansen's Cointegration Method and the cointegration between these markets was attributed to trade liberalization. They also examined the consequences of this integration on price stability and production dynamics and also observed that India has tried to balance the interests of both producers and consumers while fixing the import tariffs.

2.5 RELATIONSHIP BETWEEN SPOT AND FUTURES PRICES

Naik and Jain (2002) carried out cointegration test to examine the presence of stable long run relationship between spot and future market prices of Indian agricultural commodities (castor seed, pepper, turmeric, potato, guar and hessian). Data used in this study pertain to the period 1990 to 2000 for castor seed, pepper, turmeric, potato and guar and from 1993 to 2000 for hessian. They found strong evidence of cointegration between the spot and future market prices of black pepper in the maturity month for the May and August contracts.

Singh *et al.* (2005) studied the movement of spot and futures prices of wheat and maize markets in India using cointegration analysis. The futures contracts behaved in the expected manner and the existence of a long run relationship between spot and futures prices, converging to a long-run equilibrium for maize as well as wheat even in the presence of a short run disequilibrium between these two was conformed. This phenomenon of price convergence of spot prices and future prices for both maize and wheat clearly showed that the farmers are mitigating price risk by fututres trading.

Zapata *et al.* (2005) examined the relationship between sugar futures prices traded in New York and the world cash prices for exported sugar using cointegration analysis and concluded that the cointegration between futures and cash prices had proven the usefulness of sugar futures contract in reducing market/ price risk faced by market participants who were selling at the world price.

A study by Lokare (2007) found that although Indian commodity market was yet to achieve minimum critical liquidity in commodities like sugar, pepper, gur and groundnut, almost all the commodities show an evidence of cointegration between spot and future prices revealing the improved operational efficiency, though at a slower rate. However, for a few commodities, the volatility in future price was

substantially lower than the spot price, indicating an inefficient utilization of information.

Kaur and Rao (2009) studied the correlation between spot and future prices to ascertain the impact of spot prices on the prices of future contracts for agricultural commodities like chana, Malabar pepper, refined soya oil and guar seed for all the contracts of these commodities over a period of 13 months from July 2008 to July 2009. In the case of pepper, they found a strong positive correlation between spot and future market prices.

Sendhil *et al.* (2013) examined cointegration and price transmission between futures and spot market prices of food grains in India using Johansen's cointegration method. The study showed the presence of co-integrating relationship between the futures and spot market prices of chickpea, wheat and maize. There was no cointegration between two prices in the case of barley, indicating inefficiency in its trading which was attributed to higher transaction cost. Generally, inefficient markets have high transaction cost and prevent price transmission (Brosig *et al.*, 2011). The results showed efficiency in the performance of futures trading, in terms of price transmission, for most of the contracts in food grains.

Sendhil and Ramasundaram (2014) examined the performance of wheat futures market in terms of price transmission between Indian and US futures, domestic futures and spot markets, and extent of integration between those markets. They found that price transmission occurred due to the flow of market information which was a consequence of development in information technologies, the speed of convergence depended on the market regulations and policy changes, and market integration itself is one of the indicators for efficient functioning of markets. The analysis on extent of volatility in spot prices due to futures trading and in its absence indicated the persistence of volatility for all periods. The study concluded that the wheat futures are efficient in price transmission but inefficient in price stabilization.

2.6 MICRO LEVEL IMPLICATIONS OF PRICE VOLATILITY

Varangis and Lewin (2006) based on a survey of farmers under taken by the World Bank's Commodity Risk Management Group reported that price, weather and health risks were the most important risks faced by the rural households. They also studied the types of risk at the micro level for coffee cultivation and stated that coffee farmers in India showed more concerns on weather and prices rather than the size of their holding.

Mehta (2009) examined the role of price and income, along with food-security goals, in the decision-making of farmers regarding shift from low-value crops (food crops) to high-value commercial crops (horticultural crops). It was shown that higher food requirements at home inhibit the extent of crop substitution decision of the farmers. However, farmers were less responsive to the changes in the prices of food grains as higher income from high-value crops provide adequate money to purchase food crops from the market Relative income from the crops have been found to explain the crop-substitution decisions of the farmers. The farmers calculate the aggregate gain from the crop rather calculating only the price of the crop, while making the decision to shift.

Jha (2012) attempted to study the different sources of household income of an average farmer. He reported that significant proportion of farmers particularly small and marginal farmers were poor and hence they were increasingly diversifying into non-farm activities for livelihood. Considering the small size of holdings of marginal farmers, crop husbandry provided limited scope for increasing the household income and land saving enterprise therefore becomes important.

Rosli *et al.* (2013) conducted a field survey in Sarawak, Malaysia to study the factors influencing technology adoption in pepper farming. The results showed that the number of pepper vines, farming experience, and education level were the significant factors influencing technology adoption in pepper farming.

Parvathi and Waibel (2015) collected data from smallholder black pepper farm households in Idukki district to study the factors responsible for the shift of farmers from inorganic cultivation practices to organic. The domestic black pepper scarcity and soil fertility problems pushed many small holder farmers to shift to alternative agricultural systems like certified organic farming to increase production and some of these organic farmers were also fair trade certified.

Magrini *et al.* (2015) examined the consequences on welfare arising from price surges and price volatility using household survey data in five countries *viz.*, Bangladesh, Ethiopia, Malawi, Niger, and Tanzania. They analysed the household responses to price shocks at the micro level to support policy intervention with evidence-based suggestions. They found that the variations across countries for the same price shocks depends on differences in the share of food expenditure over total consumption, the specific budget share devoted to cereals, the substitution effect among food items and the relative number of net sellers and net buyers accessing the market.

Methodology

3. METHODOLOGY

This chapter deals with the methodology used for the present study including the types of price data and other secondary data, details of the study area, sampling procedure, method of data collection and different tools of analysis.

3.1 TYPES OF DATA

The present study is based on both secondary and primary data. The data on prices of black pepper and other secondary data published by various institutions were collected in order to find out the magnitude, determinants and transmission of price volatility between the domestic markets, the international and domestic markets and the spot and future markets of black pepper. To assess the micro-level implications of price volatility on input use, production, employment and income at the producer level, primary data was collected from selected farm households in Idukki district of Kerala state.

3.2 SOURCES OF DATA AND PERIOD OF STUDY

The details of secondary data with the source and period for which the data was collected is presented in Appendix II. The main items of observation were annual, monthly, weekly and daily prices in domestic and international markets of black pepper from 1980 to 2014 which were collected from various sources such as Spices Board, Directorate of Economics and Statistics, Spices Market Weekly, Journal of Arecanut, Spice and Medicinal plants and also from statistical publications of International Pepper Community (IPC). In addition to these, price data on black pepper futures in India were also collected. Various analyses were carried out for both nominal and real prices. Nominal prices in both domestic and international markets were adjusted to remove the effects of changes in general price level over time using respective wholesale price indices. In the case of domestic prices, the annual, monthly and weekly Wholesale Price Indices (WPI) for black pepper published by the Department of Industrial Policy and Promotion with 1983-84 and

2004-2005 as 100 were collected and the base period of 1983-84 was in turn adjusted as 2004-2005=100. The international prices were deflated using the WPI for food (with 2005 as 100) published by the World Bank. Data pertaining to area, production, export and consumption of black pepper in major producing countries for the period from 1980 to 2013 were collected from various Statistical Year Books published by IPC. District-wise data on area, production and productivity of black pepper in Kerala from 1980-81 to 2013-14 were collected from various issues of Agricultural Statistics and Statistics for planning published by the Directorate of Economics and Statistics, Thiruvananthapuram.

3.3 AREA OF THE STUDY

The study was undertaken in Idukki district of Kerala state, since the district accounted for the largest share of about 51.4 per cent of the area under the crop in Kerala during Triennium Ending 2013-14.

3.3.1 Idukki District

Idukki, a high range district of Kerala with mountainous hills and dense forests, is known as the "spice bowl". As per the 2011 census, the district accounts only for 3.32 percentage of the total population of the state and had the lowest population density in the state. While agriculture is the main occupation of the people in the district, dairy forms the major supplementary source of income for the farmers. The district has agro-climatic conditions suitable for the cultivation of plantation crops and spices, and the major crops cultivated include black pepper, cardamom, tea, coffee, rubber and coconut.

3.3.1.1 Location

Idukki district lies between $9^0$15' and 10^0 21' of North latitude and 76^0 37' and 77^0 25' of East longitude. It has an area of 4,479 km^2 and is the second largest district of Kerala, extending by 115 km from South to North and 67 km from East to West. The district is bound on the East by Theni district of Tamil Nadu while, Ernakulum

and Kottayam districts are on the West. In the South, it is bound by Pathanamthitta district and in the North by Thrissur and Coimbatore districts of Kerala and Tamil Nadu respectively.

3.3.1.2 Land utilization pattern

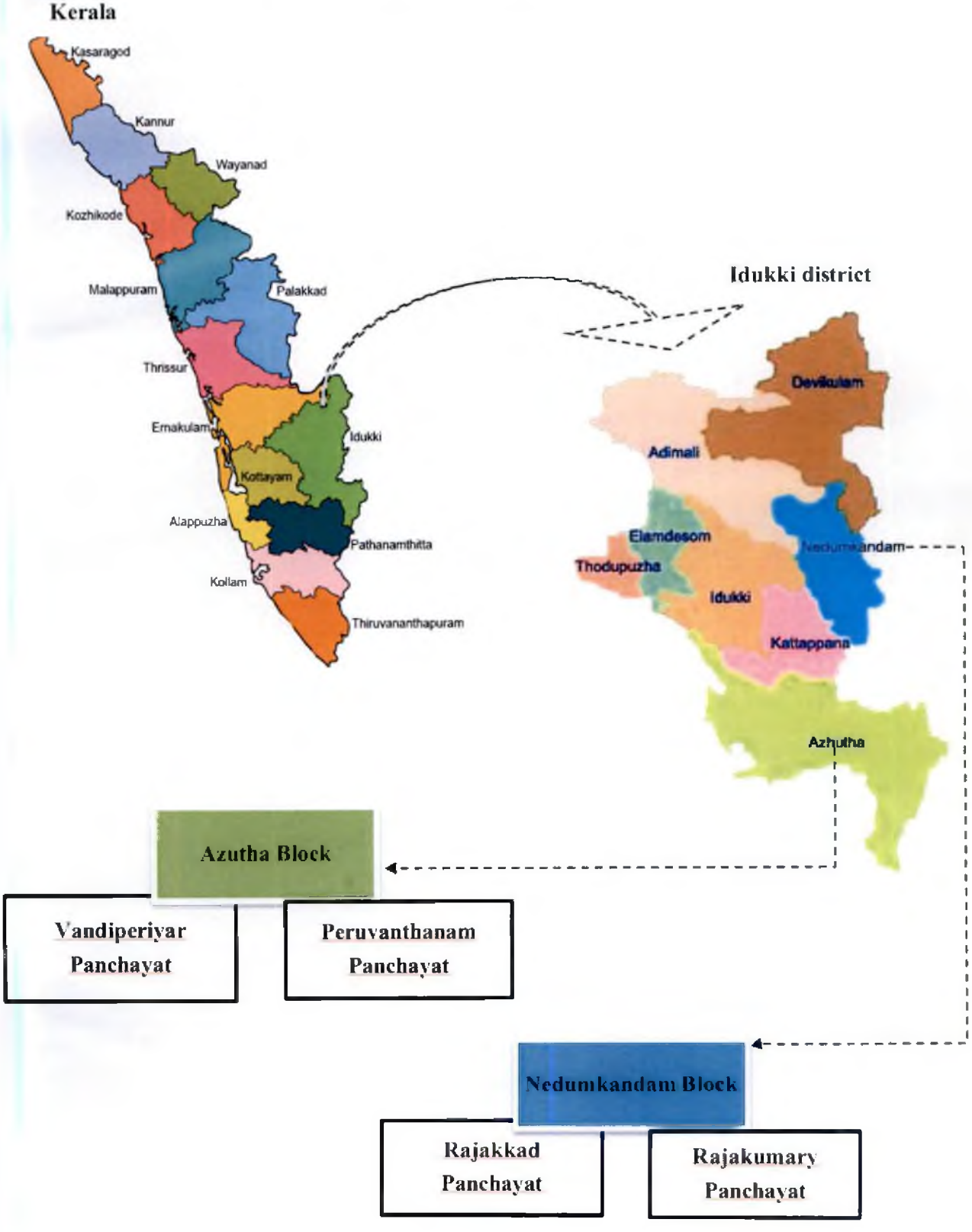
The land utilization pattern of Idukki district in 2013-14 is presented in Table 3.1. The net area sown in the district was around 47 per cent of the geographical area and the area sown more than once was 13 per cent of the geographical area. While forests accounted for 45 per cent of the area of the district, the share of land put to non-agricultural uses was only 2.91 per cent.

Table 3.1 Land utilization pattern of Idukki district in 2013-14

Particulars	Area in Hectares	Percentage to total geographical area
Total geographical area	436328	100
Forest land	198413	45.47
Land put to non- agricultural uses	12700	2.91
Barren and uncultivable land	1833	0.42
Permanent pastures and grazing land	0	0.00
Land under miscellaneous tree crops	248	0.06
Cultivable wasteland	2321	0.53
Fallow other than current fallow	1220	0.28
Current fallow	1647	0.38
Marshy land	0	0.00
Still water	10480	2.40
Water logged area	1	0.00
Social forestry	1355	0.31
Net area sown	206110	47.24
Area sown more than once	57061	13.08
Total cropped area	263171	60.31

Source: Agricultural Statistics 2013-14, Directorate of Economics and Statistics, Kerala.

Figure 1 Map of the study area



3.3.1.3 Topography and climate

The climate in the district under goes a sudden variation from West to East. The western parts of the district comprising midland area experiences moderate climate with temperature varying between 21^0C to 27^0C with minimum seasonal variation. The eastern parts of the district located in the highland have a comparatively cold climate with temperature varying between minus 1^0C to 15^0C in November/January and 5^0C to 15^0C during March/April. The district receives plenty of rainfall from the South-West monsoon during June-August and the North-East monsoon during October-November. The annual rainfall in the district varies from 2500 to 4250 mm.

3.3.1.4 Demographic features

The population of Idukki district as per the 2011 census was 11,08,974. The density of population is 254 per square km and the sex ratio in the district is 1006 females per 1000 males. The literacy rate in the district has increased from 88.69 per cent in 2001 to 92.30 per cent in 2011. According to 2011 census, the total number of workers in the district was 5,16,363 comprising of 4,15,947 main workers and 1,00,416 marginal workers.

3.3.2 Description of the Selected Panchayats

The two blocks in Idukki district having the maximum area under pepper *viz.*, Nedumkandam and Azutha, were selected for the study. From each of the block, two panchayats having maximum area under pepper were identified i.e., Vandiperiyar and Peruvanthanam panchayats from Azutha block and Rajakkad and Rajakumary panchayats from Nedumkandam block.

3.3.2.1 Panchayat-wise distribution of area

The panchayat-wise distribution of area according to the types of land is presented in Table 3.2. As evident from the table, dry land accounted for about more than 60 per cent of the total area of panchayats in Azutha block while in Nedumkandam block it was more than 90 per cent.

Table 3.2 Panchayat-wise area according to type of land

Block	Panchayat	Area in Hectares			
		Wetland	Dryland	Others (Plantation)	Total
Azutha	Vandiperiyar	3 (0.02)	10183.6 (67.13)	4982.7 (32.85)	15169.3 (100)
	Peruvanthanam	-	3794.8 (62.04)	2322.2 (37.96)	6117 (100)
Nedumkandam	Rajakkad	75.6 (2.44)	2951.8 (95.14)	75.1 (2.42)	3102.5 (100)
	Rajakumary	148.7 (3.90)	3616.1 (94.83)	48.6 (1.27)	3813.4 (100)

Source: Panchayat Level Statistics, 2011, Idukki
Note: Figures in parentheses indicate per cent to row total

3.3.2.2 Cropping pattern

The cropping patterns in the selected blocks are presented in Table 3.3. It could be observed from the table that among the crops grown in both the blocks, black pepper accounted for the highest area. It accounted for 31 per cent of the total cropped area in Azutha block and 52 per cent in Nedumkandam block.

Table 3.3 Cropping pattern in selected blocks (2013-14)

Crop	Area in Hectares	
	Azutha	Nedumkandam
Tapioca	1964.72 (7.58)	511 (2.39)
Ginger	106.44 (0.41)	38.83 (0.18)
Turmeric	50.39 (0.19)	14.24 (0.07)
Coconut	2750.42 (10.61)	1756.59 (8.21)
Arecanut	452.64 (1.75)	317.26 (1.48)
Pepper	7943.29 (30.64)	11076.69 (51.78)
Clove	166.88 (0.64)	109.49 (0.51)
Nutmeg	312.08 (1.20)	236.66 (1.11)
Cocoa	627.07 (2.42)	491.48 (2.30)
Banana and Plantain	1470.64 (5.67)	895.59 (4.19)
Vegetables	517.25 (2.00)	170.44 (0.80)
Jack	4318.31 (16.66)	3273.97 (15.30)
Mango	1981.88 (7.64)	1163.39 (5.44)
Others	3264.98 (12.59)	1337.15 (6.25)
Gross Cropped Area	25926.99 (100)	21392.78 (100)

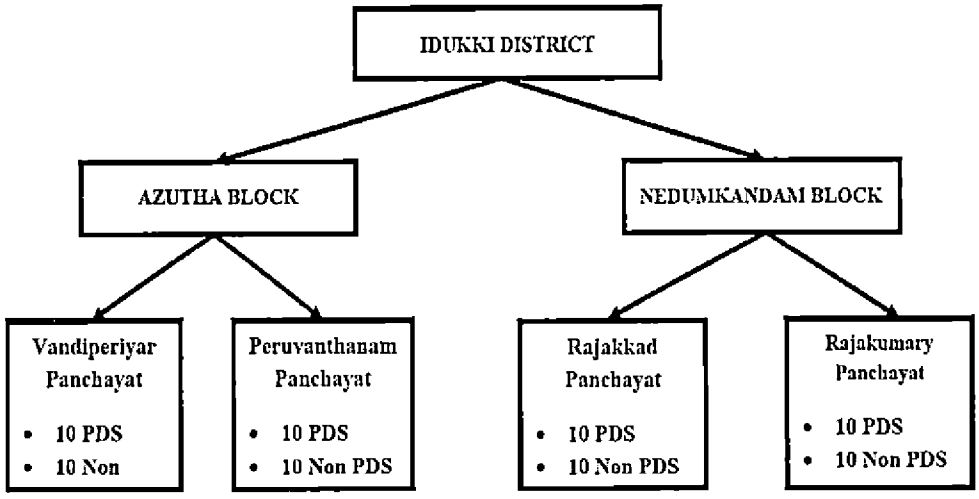
Source: Agricultural Statistics 2013-14, Directorate of Economics and Statistics, Kerala.
Note: Figures in parentheses indicate per cent to column total

3.4 SAMPLING DESIGN

The micro-level study was conducted in Idukki district, which was purposively selected for the study as it accounted for more than 50 per cent of the area under black pepper in Kerala State. Two blocks in the district having the largest

area under black pepper *viz;* Nedumkandam and Azhutha were selected for the study. From each of the block, two panchayats having maximum area under pepper *viz.*, Vandiperiyar and Peruvanthanam panchayats from Azutha block and Rajakkad and Rajakumary panchayats from Nedumkandam block were selected. Up to panchayath level, purposive random sampling was done and there after stratified random sampling procedure was followed to select the farmers. The farmers in the study area having pepper as the major crop in gross cropped area were randomly selected from a combined list of pepper farmers obtained from field offices of Spices board and Krishi Bhavans. Before selection from the list, these farmers were categorized into two groups, as members of the Peermedu Development Society (PDS), who are having a contractual agreement with the society and non-members of PDS. In each of the two categories, 10 farmers were selected from each of the panchayat and therefore, 20 farmers were selected from each of the block. Data was collected from 40 farmers belonging to each of the category. Thus, the total sample size for the micro-level study was 80. For the assessment of implications of price volatility, primary data were collected from the same 80 farm households at two points of time, the first in May-June 2014 and the second one during May-June 2015 using a pretested interview schedule.

Figure 2 Distribution of samples



3.4.1 Collection of Data

Farm level data was collected from the respondents by personal interview method using a well-structured interview schedule. Information about socio-economic profile of farmers and data regarding input use, production, cost of production, price of output, farm and non-farm income, cost of cultivation, consumption expenditure, borrowing, investment and constraints in cultivation were collected from the farm households at two points of time.

3.5 ANALYSES OF DATA

3.5.1 Volatility of Commodity Prices

3.5.1.1 Intra-annual volatility

The extent of volatility in the prices of black pepper and the temporal changes of volatility was examined by constructing a series of annual observations from monthly and weekly data by using intra-annual standard deviation of changes in log prices (Gilbert, 2006) and scaled inter-annual range as suggested by Parkinson (1980), Garman and Klass (1980) and Kunitomo (1992).

The intra-annual volatility in monthly prices was measured as the intra-annual standard deviation of changes in log prices, which is defined as

$$S_{YM} = \sqrt{\frac{1}{11}\sum_{m=1}^{12}(\ln P_{y,m} - \ln P_{y,m-1} - \delta y)^2} \text{ for year y,}$$

Where $\delta y = \frac{1}{12}(\ln P_{y,12} - \ln P_{y,0})$ is the y^{th} year drift and $P_{y,0} = P_{y-1,12}$

This estimate is scaled onto an annual basis using the factor of $\sqrt{12}$

The intra-annual volatility in weekly prices was measured as the intra-annual standard deviation of changes in log prices, which is defined as

$$S_{YW} = \sqrt{\frac{1}{51}\sum_{w=1}^{52}(\ln P_{y,w} - \ln P_{y,w-1} - \delta y)^2} \text{ for year y,}$$

Where $\delta y = \frac{1}{52}(\ln P_{y,52} - \ln P_{y,0})$ is the y^{th} year drift and $P_{y,0} = P_{y-1,52}$

This estimate is scaled onto an annual basis using the factor of $\sqrt{52}$.

3.5.1.2 Inter-annual volatility

The inter-annual volatility measure or the scaled inter-annual range called as the Parkinson's measure as suggested by Parkinson (1980) and modified by Garman and Klass (1980) and Kunitomo (1992) was used to estimate the inter-annual volatility of monthly prices.

Parkinson's measure is defined as $S_y^p = (\frac{(\ln^{P_y^H} - \ln^{P_y^L})}{2\sqrt{\ln 2}})$

Where, $P_y^H = Max_{m-1}^{12} P_{y,m}$, is the highest monthly average price in the year and $P_y^L = Min_{m-1}^{12} P_{y,m}$, is the lowest monthly average price in the year.

In the case of weekly prices, the inter-annual volatility was estimated as

$$S_y^p = (\ln^{P_y^H} - \frac{\ln^{P_y^L}}{2\sqrt{\ln 2}})$$

Where, $P_y^H = Max_{w-1}^{12} P_{y,w}$, is the highest weekly average price in the year and $P_y^L = Min_{w-1}^{12} P_{y,w}$, is the lowest weekly average price in the year.

This estimate is an unbiased estimate of the annual price volatility on the assumption that the price process follows a random walk.

3.5.1.3 Instability in annual prices

Instability indices were used to examine the extent of variation involved in annual prices of black pepper.

3.5.1.3.1 Cuddy-Della Valle Index

The annual instability in prices was measured by Cuddy-Della Valle Index (Cuddy and Della Valle. 1978) which is given as

Cuddy-Della Valle Instability Index (%) = CV x $\sqrt{\left(1 - \overline{R}^2\right)}$

Where, CV is the coefficient of variation in per cent, and $\overline{R^2}$ is the coefficient of determination from a time trend regression adjusted for its degrees of freedom.

3.5.1.3.2 Instability Index derived from exponential trend

Another measure of instability in annual prices is measured as the percentage deviation of prices from their exponential trend levels and is estimated as follows:

$$\text{Instability Index} = \frac{1}{n}\sum_{t=1}^{n}[(|Y_t - y_t|)/y_t] \times 100$$

where,

$Y_{(t)}$ is the observed magnitude of the variable.

$y_{(t)}$ is the magnitude estimated by fitting an exponential trend to the observed value

n is the number of observations.

The vertical bar indicates the absolute value (i.e. disregarding signs).

3.5.1.3.3 Coppocks Instability Index

The annual instability of prices of black pepper was also measured using Coppocks Instability Index (CII). CII is calculated as the antilog of the square root of the logarithmic variance using the following formula:

$$CII = [(\text{Antilog})\sqrt{[V\log - 1]} \times 100$$

where, $V\log = \frac{1}{(N-1)}\Sigma(\log P_{t+1} - \log P_t - M)^2$

$$M = \frac{1}{(N-1)}\Sigma(\log P_{t+1} - \log P_t)$$

N = Number of years

P= Price of black pepper

M = Arithmetic mean of the differences between logs of P_t and P_{t+1}, P_{t+1} and P_{t+2} etc.

V log = Logarithmic variance of the price series

3.5.1.4 Generalized Autoregressive Conditional Heteroscedasticity (GARCH) Models

Generalized Autoregressive Conditional Heteroscedasticity (GARCH) Models distinguishes the predictable and unpredictable components of prices and also allows

the variance of the unpredictable element to be time varying. Such time varying conditional variances was estimated by using GARCH (1,1) model (Bollerslev. 1986; Gujarati *et. al.*,2009) and were used to identify periods of high volatility.

GARCH (1,1) Models is $Y_{it} = a_0 + b_1 P_{t-1} + b_2 P_{t-2} + \varepsilon_t; t = 1,2 \ldots \ldots, t$

$\sigma^2_{i,t} = \theta + \alpha_i \varepsilon^2_{i,t} + \beta_i \sigma^2_{i,t-1}$

Where,

P_t is the price in time t

σ^2_t is the error variance in time t

$(\alpha_i + \beta_i)$ gives the degree of persistence of volatility in price series

If $(\alpha_i + \beta_i)$ is closer to 1, greater is the tendency of volatility to persist for longer time and if the sum exceeds 1, it is indicative of an explosive series with a tendency to meander away from mean value.

GARCH (p,q) Model is $\sigma^2_{i,t} = \omega + \sum_{i=1}^{p} \beta_i \sigma^2_{t-i} + \sum_{i=1}^{q} \alpha_i \varepsilon^2_{t-i}$

3.5.2 Market integration and price transmission

3.5.2.1 Cointegration

Cointegration is regarded as the empirical counterpart of the theoretical notion of a long run relationship between two or more variables. The market integration concept explains the relationship between the prices in the two or more than two markets that are spatially separated. When markets are integrated it implies that the markets in the system operate in unison, as a single market system. In the present case, cointegration analyses were employed to study the nature of relationship between domestic and international market prices.

3.5.2.1.1 Model of multiple cointegration

The study empirically evaluates spatial integration of domestic and international markets. Using the Maximum Likelihood (ML) method of cointegration developed by Johansen (1988) and extended by Johansen and Juselius (1990), the

study specifically examined whether the domestic and international markets are integrated and linked together into a single economic market. This method treats all the variables as explicitly endogenous and takes care of the endogenity problem by providing an estimation procedure that does not require arbitrary choice of variable for normalization. It also allows test for multiple co-integrating vectors.

3.5.2.1.2 Testing stationarity

To ensure appropriate model specification and to reduce the possibility of arriving at misleading results, it is important to examine the time series characteristics of the data. This involves tests for the order of integration of the variables.

The most widely used tests for unit roots are the Dickey Fuller (DF) and Augmented Dickey Fuller (ADF) tests. Both tests the null hypothesis that the time series has a unit root or in other words, it is non-stationary. The DF test was applied by running the regression of the following form,

$$\Delta = \beta_1 + \delta P_{t-1} + u_t$$

where, $\Delta P_t = (P_t - P_{t-1})$; $Pt = \ln P_t$

The ADF test was run with the equation,

$$\Delta Y_t = \beta_1 + \delta P_{t-1} + \sum_{i=1}^{P} \alpha_i \Delta P_{t-i} + \epsilon_t$$

$$\Delta Y_t = \beta_1 + \delta P_{t-1} + \beta_2 t + \sum_{i=1}^{P} \alpha_i \Delta P_{t-i} + \epsilon_t$$

Where, $\Delta P_{t-1} = (P_{t-1} - P_{t-2})$

ϵ_t for t = 1, ... , N is assumed to be Gaussian white noise i.e., $\epsilon_t \sim (0, \sigma^2)$. The first equation in ADF is with constant term and no trend whereas the second one is with constant and trend. The number of lagged terms p is chosen to ensure that the errors are uncorrelated. In all the tests the null hypothesis was $\delta=0$ which implied that the time series Y_t was non-stationary. In the present study, ADF tests were used to ascertain the stationarity of the price variables.

3.5.2.1.3 Testing for cointegration

The test for the order of integration of each variable in the model was to establish whether the time series was non-stationary and how many times the variable needs to be differenced to result in a stationary series. However, first differencing is not an appropriate solution to the non-stationarity problem and it prevents detection of the long-run relationship that may be present in the data, i.e. the long-run information is lost, which is precisely the main question being addressed.

The economic interpretation of cointegration is that if two (or more) series are linked to form an equilibrium relationship spanning the long-run, then even though the series themselves may contain stochastic trends (i.e., be non-stationary) they will nevertheless move closely together over time and the difference between them will be stable (i.e., stationary). The concept of cointegration mimics the existence of a long-run equilibrium to which an economic system converges over time, and u_t defined above can be interpreted as the disequilibrium error (ie., the distance that the system is away from equilibrium at time t).

An approach to testing for cointegration is to construct test statistics from the residuals of a co-integrating regression in levels mostly using Engle Granger and Augmented Engle Granger tests. However, in the case of a system of variables Johansen Maximum likelihood procedure (Johansen and Juselius, 1990) is the most applicable method since it permits the existence of cointegration between the system of variables without imposing any bias on the estimates. The Johansen test for cointegration is a multivariate unit root test which estimates the co-integrating rank 'r' in the multivariate case and is also able to estimate the parameters β of these co-integrating relationships. This test procedure is most efficient because it identifies the number of co-integrating vectors between the non-stationary level variables in the context of a Vector Error Correction Model (VECM). Basically, this is a Vector Auto Regression (VAR) model in error correction form. In a system with two or more variables, a VECM, like the VAR model, treats each variable as potentially

endogenous and relates the change in one variable to past equilibrium errors and to past changes in all variables in the system.

Following Johansen and Juselius (1990), the maximum likelihood method of cointegration is explained as follows:

If Pt denotes (nx1) vector of I(1) prices, then the k-th order vector autoregressive (VAR) representation of Pt may be written as k.

$$Pt = \sum_{i=1} \Pi i \, Pt - i + \mu + \beta t + et \, (t = 1, 2 \ldots\ldots t)$$

The procedure for testing cointegration is based on the error correction (ECM) representation of Pt given by

$$\Delta Pt = \sum_{i=1}^{K-1} \acute{\Gamma} i \Delta \, Pt - i + \Pi i \, Pt - k + \mu + \beta t + et$$

Where, $\acute{\Gamma} i = - (1 - \Pi_1 - \ldots\ldots - \Pi t)$; $i = 1, 2 \ldots K-1$; $\Pi = - (1 - \Pi_1 - \ldots. - \Pi k)$. Each of the Π_1 is an n x n matrix of parameters; e_t is an identically and independently distributed n-dimensional vector of residuals with zero mean and variance matrix. Ωe; μ is a constant term and t is trend. Since, P_{t-k} is I (1), but ΔP_t and ΔP_{t-1} variables are I (0). Equation will be balanced if Π Pt-k is 1(0). So, it is the Π matrix that conveys information about the long run relationship among the variables in Pt. The rank of Π, r, determines the number of co-integrating vectors, as it determines how many linear combinations of Pt are stationary. If r = n, the prices are stationary in levels. If r = 0, no linear combination of Pt is stationary. If 0< rank (Π) = r<n, and there are n x r matrices $\acute{\alpha}$ and β such that $\Pi = \acute{\alpha}\beta$, then it can be said that there are r co-integrating relations among the elements of Pt. The co-integrating vector β has the property that βPt is stationary even though Pt itself is non-stationary. The matrix $\acute{\alpha}$ measures the strength of the co-integrating vectors in the ECM as it represents the speed of adjustment parameters. Two likelihood ratio test statistics were proposed. The null hypothesis of at most 'r' co-integrating vector against a general alternative hypothesis of 'more than r' co-integrating vectors was tested by

Trace statistic (λ-trace) = -T ∑ ln (1- λi)

The null hypothesis of r co-integrating vector against the alternative of r + 1 is tested by the maximum Eigen value statistic (λ max) = -T ln (1- λr+1)

λi are the estimated Eigen values (characteristics roots) obtained from the Π matrix. T is the number of usable observations (Johansen and Juselius, 1990).The number of co-integrating vectors indicated by the tests is an important indicator of co-movement of the prices. An increase in the number of cointegration vectors implies an increase in the strength and stability of price linkages.

3.5.2.2 Granger Causality Test

Cointegration between two variables implies the existence of causality between them in atleast one direction (Granger, 1980). Cointegration itself cannot be used to make inferences about the direction of causation between the variables. The Granger causality test provides additional evidence for the presence and as direction of price transmission occurring between two series. If two markets are integrated, the price in one market, P_D would be found to Granger-cause the price in the other market,P_I and/or vice versa. The test involves estimating the following pair of regressions

$$P_{Dt} = \sum_{i=1}^{n} \alpha_i P_{It-i} + \sum_{j=1}^{n} \beta_j P_{Dt-j} + u_{1t}(1)$$

$$P_{It} = \sum_{i=1}^{n} \lambda_i P_{It-i} + \sum_{j=1}^{n} \delta_j P_{Dt-j} + u_{2t}(2)$$

Unidirectional causality fromP_{It} toP_{Dt} is indicated if the estimated coefficients on the lagged P_{It} in the first regression are statistically different from zero as a group. And the set of estimated coefficients in lagged P_{Dt} in (2) is not statistically different from zero. Conversely, unidirectional causality from P_{Dt} to P_{It} exists if the set of lagged P_{It} in the first regression is not statistically different from zero and the set of lagged P_{Dt} coefficients in (2) is statistically different from zero. Bilateral causality is suggested when the sets of P_{It} to P_{Dt} coefficients are statistically

different from zero in both the regressions. When the sets of both the coefficients are not statistically significant in both the regressions, independence is suggested.

3.5.3 Relationship between spot and future prices

The relationship between spot and future prices of black pepper and the consequent implications on volatility in spot market prices were analysed using daily data on spot and future prices from the National Commodity Derivatives Exchange (NCDEX). The data on these prices on all contracts right from the start of trading in March 2003 until March 2015 were used for the analysis. The relationship and transmission between futures and spot prices were analysed using market integration analysis using Johansen's (1988) multivariate approach and the Vector Error Correction Model. In order to compute the extent of volatility in the spot market consequent to futures trading, GARCH models were fitted.

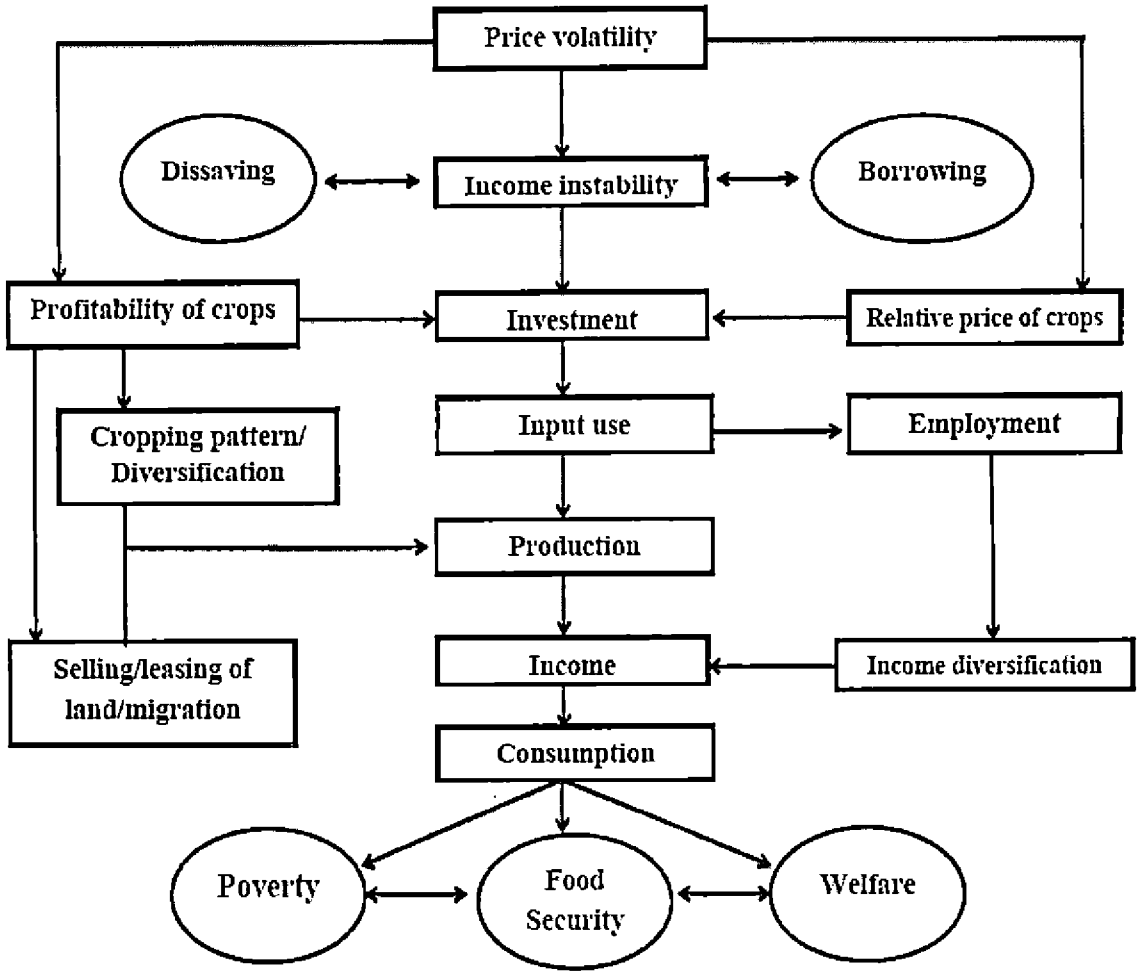
3.5.4 Micro level implications of price volatility

3.5.4.1 Conceptual framework on micro-level implications of price volatility

A conceptual framework showing a theoretical basis on the micro-level implications of price volatility of black pepper on the producer households is given below as Figure 3.

The direct impact of price volatility of black pepper on producer household is through the effect on income as it causes income instability for the producers, which they compensate either by dissaving or by borrowing money from other sources. The income instability and the resultant dissaving will in turn affect the investment decisions of the farm households. Since price volatility would be changing the relative prices as well as profitability of black pepper, it would in turn be affecting the investment decisions as well as input use.

Figure 3 Flow chart on conceptual framework on implications of price volatility



Black pepper being a perennial crop, producers show the tendency to neglect the crop during years of negative shocks and there would be lesser replanting in those years. When the volatility is on the positive side, producers would be motivated to increase the area under the crop or make replanting decisions and also under take the management practices for the existing crop which at times even lead to overuse of inputs. Consequently, the intensity of input use including fertilisers, manures, labour etc., would be either increasing or decreasing based on the direction of the volatility and the resultant investment decisions. A coping mechanism of producer households

to price volatility is crop diversification, which even though would be reducing price risk, also decrease the production as well as marketable surplus of the commodity under question. Consequent to changes in relative profitability of raising the crop as a result of price volatility, the farmers also migrate after leasing out their lands or selling it, affecting the income of the households. Fall in employment in farms will make the farmers to diversify their income sources to off-farm as well as non-farm activities. The resultant variations in income because of all the above coping mechanisms would in turn affect the consumption of farm households affecting their food security as well as welfare and also making these households to fall into the poverty trap or the vicious circle of poverty. Price volatility on the higher side would also communicate wrong signals to the farmers, making them to increase the area under the crop resulting in over production, market glut and fall in prices.

3.5.4.2 Percentage and tabular analysis

Percentage and tabular analyses were used for the data which was collected twice from 80 black pepper producer households, 40 PDS and 40 non-PDS farmers at an interval of one year for deriving the farm household level implications of price volatility of black pepper.

3.5.4.3 Factors determining vulnerability to price volatility - Linear regression model

To understand the factors that determine the vulnerability of black pepper farmers to price volatility, a linear regression model was fitted. The vulnerability to price volatility was hypothesised as a function of socio-economic factors, biophysical features and adaptive measures of the individual farmers and farm households.

The specified yield gap function is as follows:

$Y = b_0 + b_1X_1 + b_2 X_2 + b_3 X_3 + b_4X_4 + b_5X_5 + b_6X_6 + b_7X_7 + b_8 X_8 + b_9X_9 + b_{10}X_{10} + b_{11}X_{11}$

Where,

Y = Coefficient of Variation of black pepper prices

X_1 = Age in years

X_2 = Total area in hectares

X_3 = Experience in farming in years

X_4 = Number of family members

X_5 = Percentage share of income from black pepper in total income

X_6 = Membership in PDS (=1, if a member, =0, if not a member)

X_7 = Period of storage of black pepper in months

X_8 = Income from sources other than crops in Rupees

X_9 = Transportation cost in Rupees

X_{10} = Gender (=1, if male,= 0, if female)

X_{11} = Education (= 1, if SSLC and above, = 0, upto SSLC)

b_0 is the intercept

$b_1, b_2, b_3, b_4, b_5, b_6, b_7, b_8, b_9, b_{10}, b_{11}$ are the regression coefficients

Variables such as age, education, gender and experience in farming are human assets of farmers which help to reduce the vulnerability to price volatility. Higher percentage of income from black pepper, large household size and higher transportation costs will increase the susceptibility of farmers to price variations, while factors such as higher non-crop income and total area, storage and contract farming are adaptive measures against increased vulnerability of farmers to price volatility.

3.5.4.4 Constraints in production of black pepper

To identify the constraints in production and to understand the role of price volatility as a constraint in black pepper production, Garett ranking technique was used. As the first step in constraint analysis, major problems faced in production and marketing were identified. The respondents were then asked to rank the identified problems and the major constraints were identified by Garett ranking technique. In

this method, the rank assigned to different constraints were transformed into percentage using the formula:

$$\text{Per cent position} = \frac{100(R_{ij} - 0.5)}{N_j}$$

Where, R_{ij} = Rank given for i^{th} factor by j^{th} individual

N_j= Number of factors ranked by j^{th} individual

Here 0.5 is subtracted from each rank because the rank is an interval on a scale and its midpoint best represents the interval. Then, the percentage positions were transformed into scores on a scale of 100 points referring to the table given by Garett and Woodworth (1969). From the scores so obtained, the mean score level was derived and constraints were ranked based on the mean score level.

Results and discussion

4. RESULTS AND DISCUSSION

Analysis was done within the framework of the specified methodologies and also with specific reference to each of the objectives set forth for the present study. The main focus of the study was to analyse the price volatility of black pepper in domestic as well as international markets and its implications at the producer level. In this chapter several possible models described in the methodology were tried to obtain consistent results and these results were used to draw meaningful inferences. As already mentioned in the previous chapters, this study was based on secondary as well as primary data. The results of the analyses carried out using secondary and primary data are discussed and presented under the following headings.

4.1 Magnitude and determinants of price volatility

4.2 Price transmission and market integration

4.3 Relationship between spot and futures prices

4.4 Micro-level implications of price volatility

4.1 MAGNITUDE AND DETERMINANTS OF PRICE VOLATILITY

4.1.1 Intra-annual and Inter-annual Volatility

4.1.1.1 Intra-annual volatility

Intra-annual volatility measures the dispersion of prices within a year. Monthly and weekly prices of black pepper in both nominal and real terms were used for intra-annual volatility analysis.

4.1.1.1.1 Intra-annual volatility of monthly black pepper prices

The intra-annual volatility indices of monthly nominal and real black pepper prices are presented in Table 4.1. It could be observed from the table that the intra-annual volatility of monthly nominal prices in rupee as well as dollar terms declined marginally in the post-WTO period. A similar pattern was observed for all the real prices with the exception of Cochin Malabar Garbled in rupee, for which the intra-

annual volatility was lower when compared to all other markets in the pre-WTO period and it increased in the post-WTO period. In the case of international prices, the decline in intra-annual volatility in the post-WTO period was comparatively more when compared to the Indian prices. The volatility of international prices in both rupee and dollar terms showed a declining tendency in the four sub-periods, where as in the domestic market, Cochin Malabar garbled prices exhibited a slight increase in intra-annual volatility in period III and subsequently decreased in period IV and Malabar Ungarbled increased in period II and then declined in rest of the periods. The intra-annual price volatilities in the international markets in Period IV and overall period were lower than the domestic markets. The difference between the values of the intra-year volatility indices for Malabar Garbled pepper in both Cochin (domestic) and New York (international) markets decreased in the post-WTO period. All the volatility indices were having a value of less than 10 per cent in all the periods. For the overall period, the prices of Calicut Nadan exhibited the highest intra-annual volatility.

The intra-annual volatility indices for real and nominal monthly black pepper prices in rupee as well as dollar terms for different years from 1980 to 2014 are plotted in Figure 4 through Figure 7. It could be observed from the figures that the divergence between the volatility indices for different prices narrowed down in the post-WTO period and the pattern became closer from the mid-1990s. This behaviour of the intra-annual volatility indices was better discernible in the case of prices in rupee rather than dollar. The decline in intra-annual volatility in the post-WTO period was also distinctly noticeable in the plotted figures.

Intra-annual volatility measure indicates the uncertainty that farmers face in their planting decisions. Typically, farmers can diversify to different seasonal as well as perennial crops instead of a single perennial crop like pepper. The higher the intra-annual volatility, the more difficult the optimal planting choice will be.

Table 4.1 Intra-annual volatility indices of monthly black pepper prices (in per cent)

Commodity	Nominal price							Real price						
	Pre WTO	Post WTO	Period I	Period II	Period III	Period IV	Over all Period	Pre WTO	Post WTO	Period I	Period II	Period III	Period IV	Over all Period
Prices in rupee														
Cochin - Malabar Garbled	6.99	6.81	7.10	6.58	7.27	6.16	6.88	3.17	4.15	2.95	3.33	5.18	3.20	3.75
Cochin – UnGarbled	8.66	7.35	8.22	8.47	7.59	6.37	7.89	7.25	4.67	6.57	6.12	5.45	3.37	5.73
Calicut – Nadan	9.33	8.00	9.31	9.26	7.90	6.47	8.55	8.00	6.70	7.60	7.95	7.61	3.58	7.23
New York - Malabar Garbled1	8.53	6.32	8.51	7.73	6.20	5.34	7.23	7.91	5.34	8.49	5.37	6.00	4.71	6.39
New York - Lampong	8.27	6.29	8.48	7.18	6.36	5.34	7.10	8.14	5.25	8.90	5.12	6.00	4.71	6.44
New York – Brazil	8.32	6.38	8.54	7.42	6.32	5.34	7.18	8.06	5.46	8.91	5.30	6.11	4.71	6.53
New York - Sarawak	7.95	6.28	7.89	7.31	6.36	5.34	6.97	7.75	5.39	8.60	5.12	6.03	4.71	6.36
Prices in dollar														
Cochin - Malabar Garbled	7.33	7.16	7.29	7.12	7.54	6.53	7.23	8.01	7.35	8.06	7.62	7.70	6.36	7.62
Cochin – UnGarbled	8.82	8.54	8.22	9.31	9.20	6.74	8.65	9.43	8.85	8.95	9.66	9.66	6.55	9.09
Calicut – Nadan	9.56	8.74	9.36	9.58	9.23	6.72	9.07	10.2	9.01	10.1	10.1	9.56	6.48	9.50
New York - Malabar Garbled1	8.27	6.30	8.22	7.77	6.12	5.14	7.11	8.62	7.28	8.40	8.46	7.37	5.98	7.83
New York - Lampong	7.84	6.25	8.11	7.07	6.26	5.14	6.91	8.18	7.25	8.34	7.74	7.47	5.98	7.63
New York – Brazil	7.88	6.39	8.19	7.35	6.22	5.14	7.00	8.29	7.32	8.42	8.01	7.42	5.98	7.72
New York - Sarawak	7.40	6.22	7.44	7.08	6.23	5.14	6.71	7.99	7.30	7.94	8.01	7.44	5.98	7.58

Note: The intra-annual volatility indices reported here are the average values of the intra-annual volatility indices for all the years in the respective periods

Figure 4 Intra-annual volatility of monthly nominal black pepper prices in rupees

(in per cent)

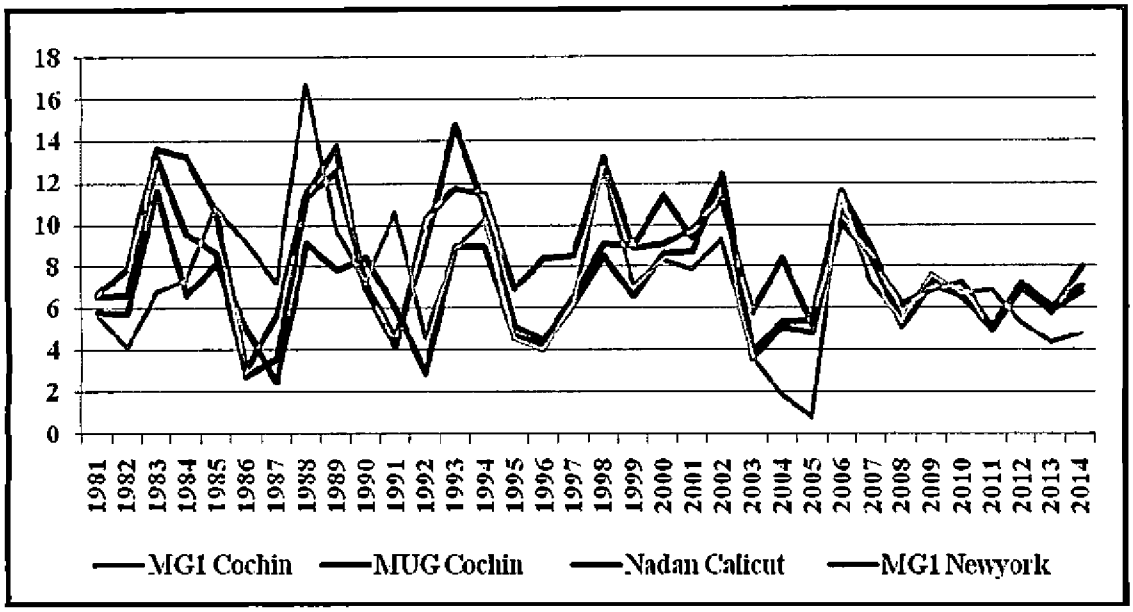


Figure 5 Intra-annual volatility of monthly real black pepper prices in rupees

(in per cent)

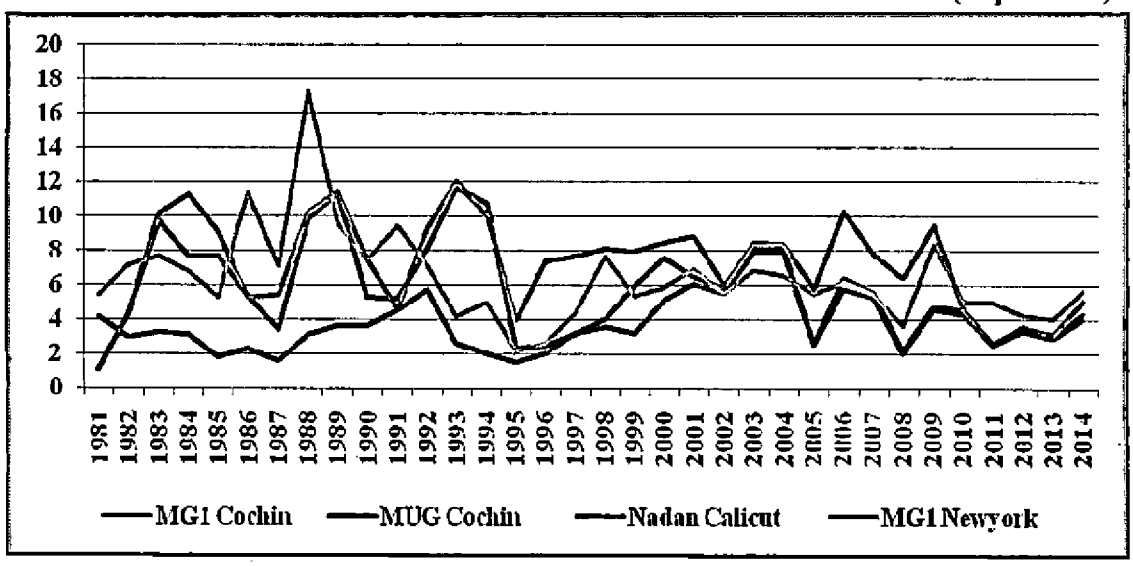


Figure 4 Intra-annual volatility of monthly nominal black pepper prices in rupees

(in per cent)

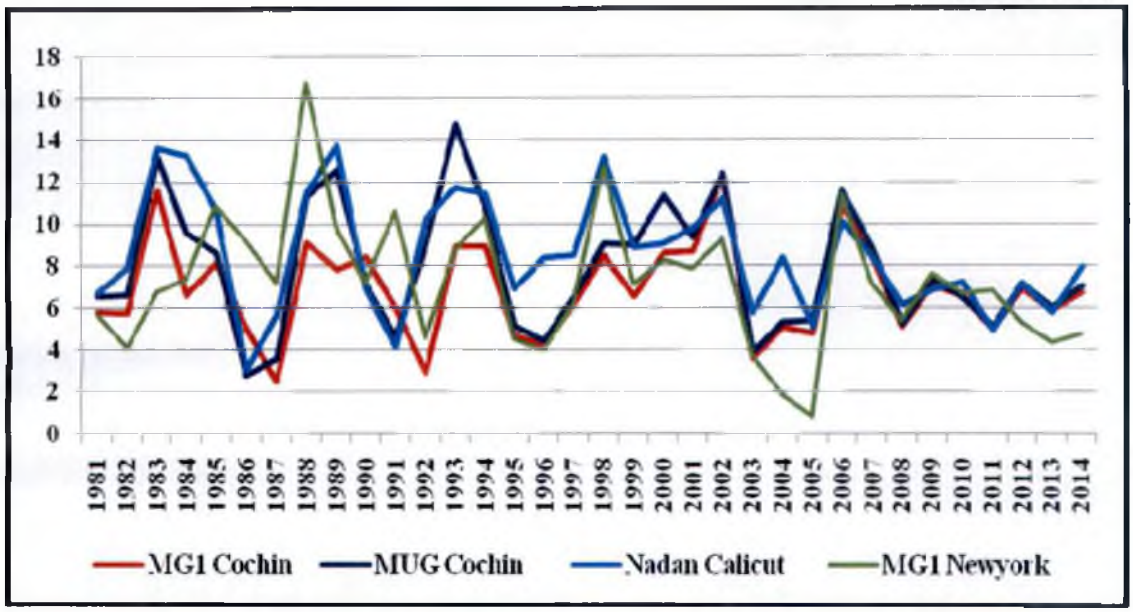


Figure 5 Intra-annual volatility of monthly real black pepper prices in rupees

(in per cent)

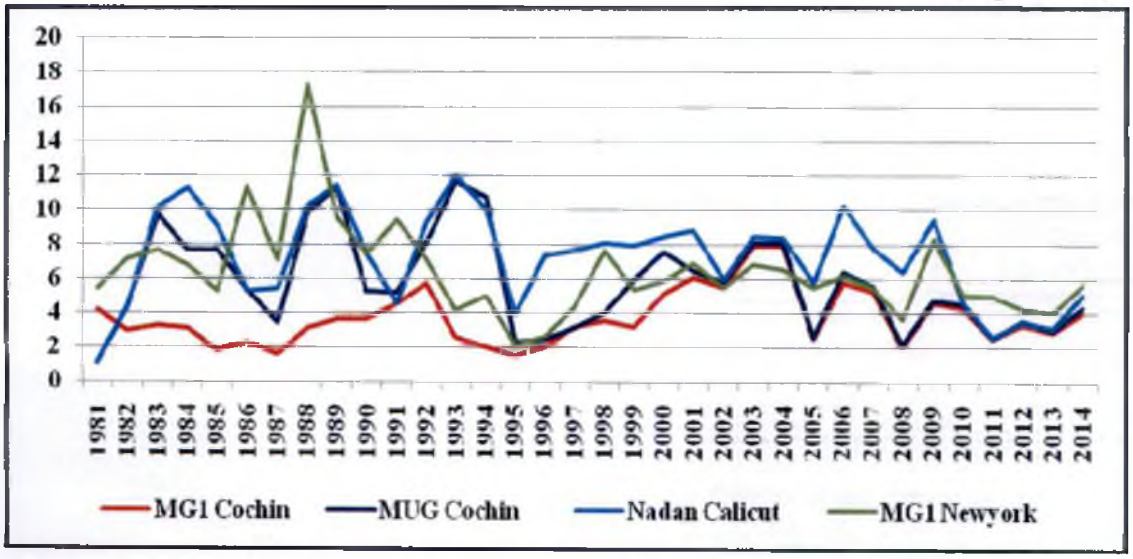


Figure 6 Intra-annual volatility of monthly nominal black pepper prices in dollar

(in per cent)

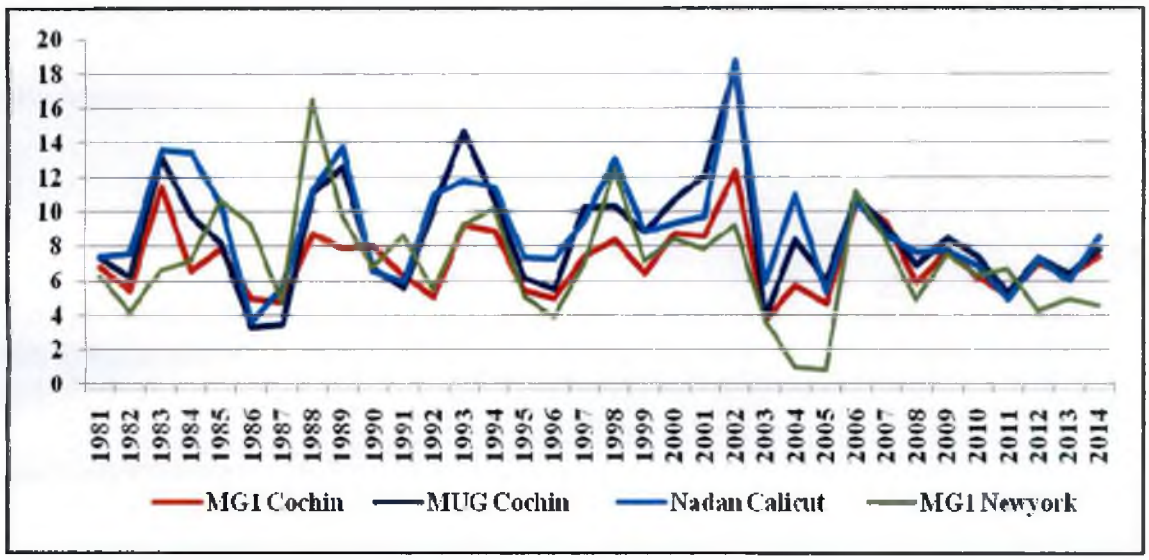
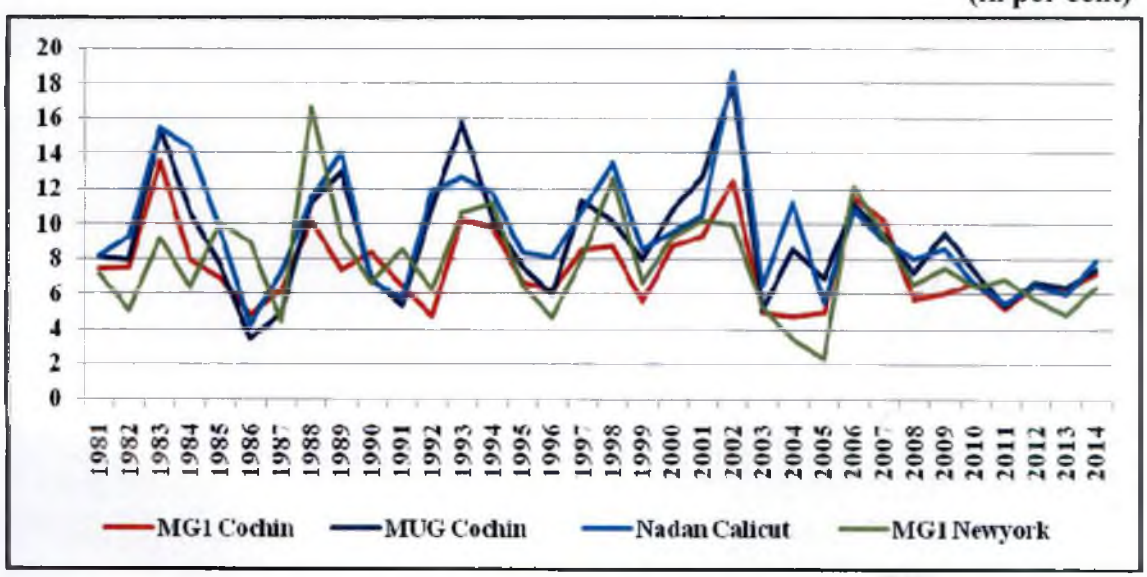


Figure 7 Intra-annual volatility of monthly real black pepper prices in dollar

(in per cent)



The correlation between the intra-annual volatility indices of Indian and international market prices of black pepper in the pre-WTO and post-WTO periods are given in Table 4.2. It could be observed from the table that the correlation between the intra-annual volatility of domestic and international prices increased considerably and in most of the cases, it more than doubled in the post-WTO period. The highest correlation was found between MG Cochin and other international prices and this indicates that within the year variations in the Indian market of black pepper exhibited a similar pattern as that of the international prices in the post-WTO period.

Table 4.2 Correlation between intra-annual volatility indices for monthly prices of black pepper in Indian and international markets

Market/Prices	Cochin MG		Cochin MUG		Calicut Nadan	
	Pre-WTO	Post-WTO	Pre-WTO	Post-WTO	Pre-WTO	Post-WTO
	Nominal Prices in rupee					
New York - MG1	0.41	0.77	0.21	0.76	0.15	0.55
New York - Lampong	0.42	0.82	0.23	0.80	0.13	0.54
New York - Brazil	0.46	0.79	0.40	0.78	0.35	0.52
New York - Sarawak	0.44	0.78	0.45	0.73	0.40	0.54
	Nominal Prices in dollar					
New York - MG1	0.42	0.74	0.33	0.60	0.27	0.53
New York - Lampong	0.43	0.79	0.34	0.65	0.23	0.53
New York - Brazil	0.48	0.75	0.50	0.61	0.42	0.51
New York - Sarawak	0.51	0.75	0.53	0.61	0.48	0.53
	Real Prices in rupee					
New York - MG1	0.11	0.68	0.10	0.64	0.04	0.59
New York - Lampong	0.22	0.72	-0.18	0.67	-0.27	0.55
New York - Brazil	0.24	0.69	-0.01	0.69	-0.08	0.57
New York - Sarawak	0.24	0.65	0.09	0.59	0.02	0.58
	Real Prices in dollar					
New York - MG1	0.47	0.82	0.37	0.66	0.25	0.62
New York - Lampong	0.57	0.86	0.42	0.70	0.31	0.61
New York - Brazil	0.61	0.84	0.58	0.67	0.49	0.60
New York - Sarawak	0.51	0.82	0.53	0.66	0.49	0.62

4.1.1.1.2 Intra-annual volatility of weekly black pepper prices

The average intra-annual volatility indices for weekly black pepper prices in both nominal and real terms are presented in Table 4.3. The magnitudes of the

estimated intra-annual volatility indices for weekly prices were larger in comparison with those computed for the monthly prices indicating that the weekly prices were more volatile. There was a reduction in the intra-year volatility in the post-WTO period for weekly nominal and real black pepper prices in the domestic as well as international markets. The intra-annual volatility for international nominal prices was comparatively lower than that for the domestic prices in the pre-WTO and post-WTO periods. In the case of weekly real prices, with the exception of Cochin Ungarbled and Calicut Nadan, the magnitude of within the year price fluctuations was lower for prices of New York Malabar Garbled 1 in comparison with domestic prices in the post-WTO period. The intra-annual volatility of nominal rupee prices in domestic markets decreased from period I to period II, then increased marginally in period III and decreased in period IV. For dollar prices, with the exception of period IV which showed falling within the year volatility, all other prices did not exhibit much variation in intra-annual volatility. The intra-annual price volatility of international markets in period III was lower than that in the domestic markets. The difference between the values of the intra-year volatility indices for domestic and international markets increased in the post-WTO period. For the overall period, Calicut Nadan exhibited the highest intra-annual volatility. The intra-annual volatility indices for weekly real and nominal black pepper prices in rupee as well as dollar terms for different years from 1980 to 2014 are plotted in Figure 8 through Figure 11. It could be observed from the figures that the volatility indices for different prices moved closely in the pre-WTO as well as post-WTO periods as clearly indicated by marginal changes in magnitude of intra-annual volatility indices, with the exception of real rupee prices. This behaviour of the intra-annual volatility indices for weekly prices could be better observed in the case of Indian prices. The correlation coefficients between the intra-annual volatility indices for domestic and international market prices, presented in Table 4.4 revealed that correlation between volatility indices was more in the case of nominal prices in the post-WTO period.

Table 4.3 Intra-annual volatility indices of weekly black pepper prices (in per cent)

Commodity	Nominal							Real						
	Pre WTO	Post WTO	Period I	Period II	Period III	Period IV	Over all Period	Pre WTO	Post WTO	Period I	Period II	Period III	Period IV	Over all Period
Prices in rupee														
Calicut – Nadan	9.69	9.65	9.80	9.72	10.1	8.18	9.66	9.85	8.00	10.6	7.43	9.10	6.67	8.76
Calicut –Wayanadan	9.57	9.48	10.0	9.04	10.2	7.88	9.52	10.1	8.24	11.1	7.33	9.56	6.56	9.00
Cochin – UnGarbled	9.16	8.91	9.10	9.24	9.34	7.39	9.01	9.59	7.50	9.94	7.58	8.49	6.05	8.36
New York – MG 1	8.26	7.73	8.40	8.47	6.98	7.92	7.95	8.95	8.01	9.48	7.82	8.16	7.69	8.39
Prices in dollar														
Calicut – Nadan	10.2	9.92	9.87	10.4	10.6	7.90	10.0	10.7	10.5	10.6	10.8	11.1	8.54	10.6
Calicut –Wayanadan	10.0	9.77	10.0	9.80	10.7	7.71	9.88	10.4	10.2	10.6	10.1	10.9	8.48	10.3
Cochin – UnGarbled	9.65	9.13	9.20	9.88	9.86	7.08	9.34	10.2	9.66	9.97	10.4	10.4	7.82	9.89
New York – MG 1	8.00	7.42	8.32	7.97	6.97	6.91	7.66	8.62	8.35	9.01	8.75	7.75	8.13	8.46

Table 4.4 Correlation between intra-annual volatility indices for weekly prices of black pepper in Indian and international markets

Market/Prices	Calicut Nadan		Calicut Wayanadan		Cochin Ungarbled	
	Pre-WTO	Post-WTO	Pre-WTO	Post-WTO	Pre-WTO	Post-WTO
New York MG1(Nominal rupee)	0.47	0.66	0.61	0.61	0.44	0.61
New York MG1(Nominal dollar)	0.26	0.68	0.30	0.65	0.17	0.63
New York MG1(Real rupee)	0.38	0.53	0.47	0.48	0.30	0.35
New York MG1(Real dollar)	0.39	0.70	0.50	0.67	0.36	0.65

Figure 8 Intra-annual volatility of weekly nominal black pepper prices in rupees

(in per cent)

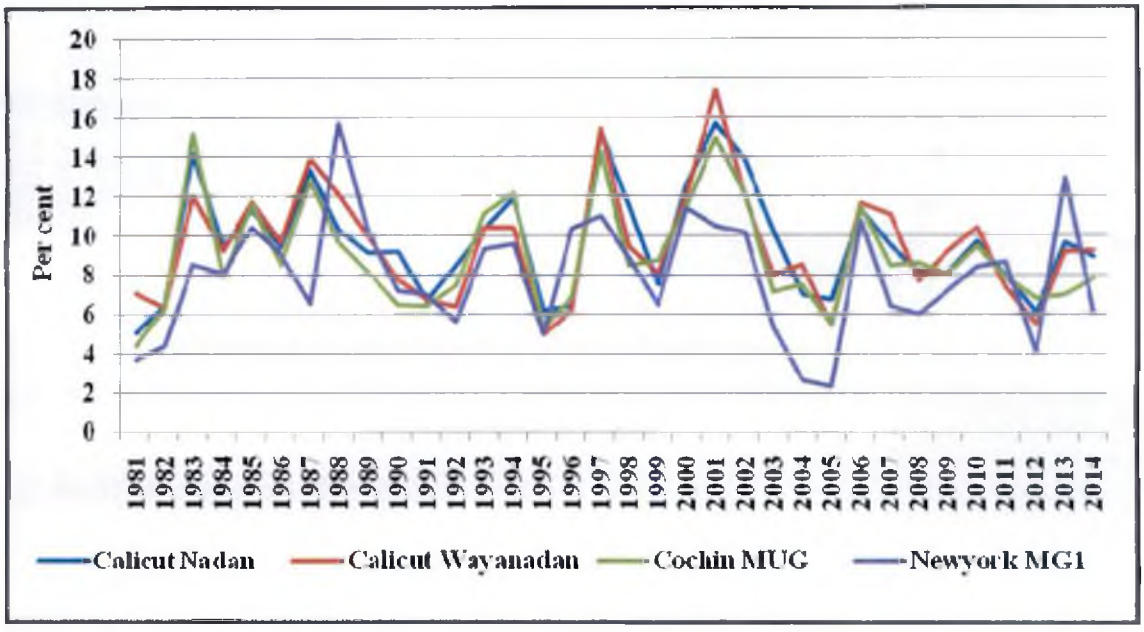


Figure 9 Intra-annual volatility of weekly real black pepper prices in rupees

(in per cent)

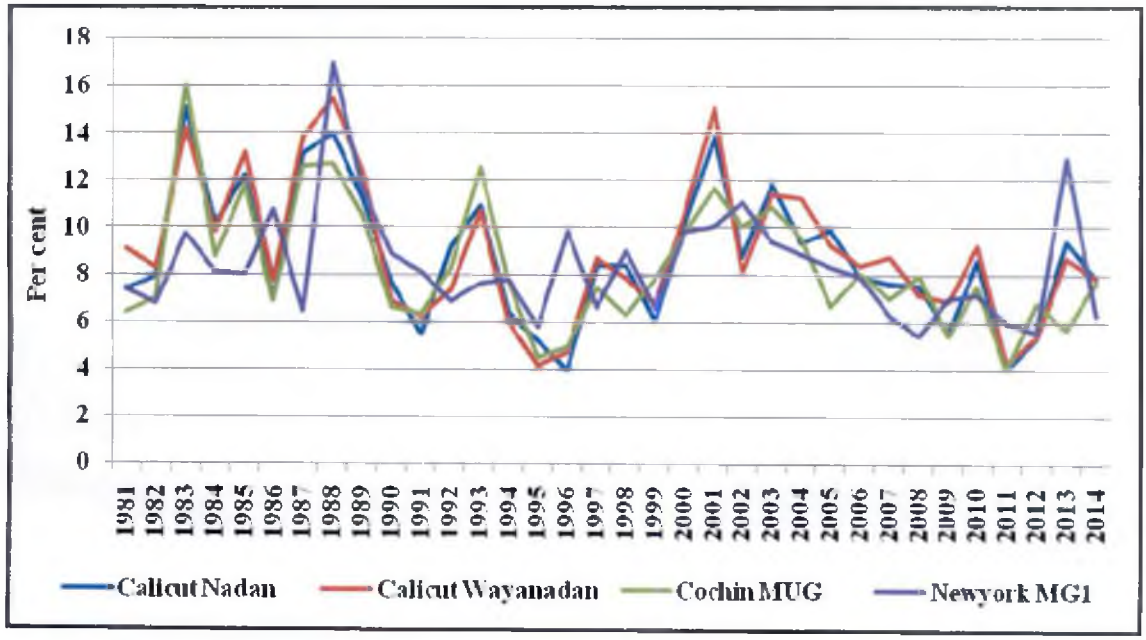


Figure 10 Intra-annual volatility of weekly nominal black pepper prices in dollar
(in per cent)

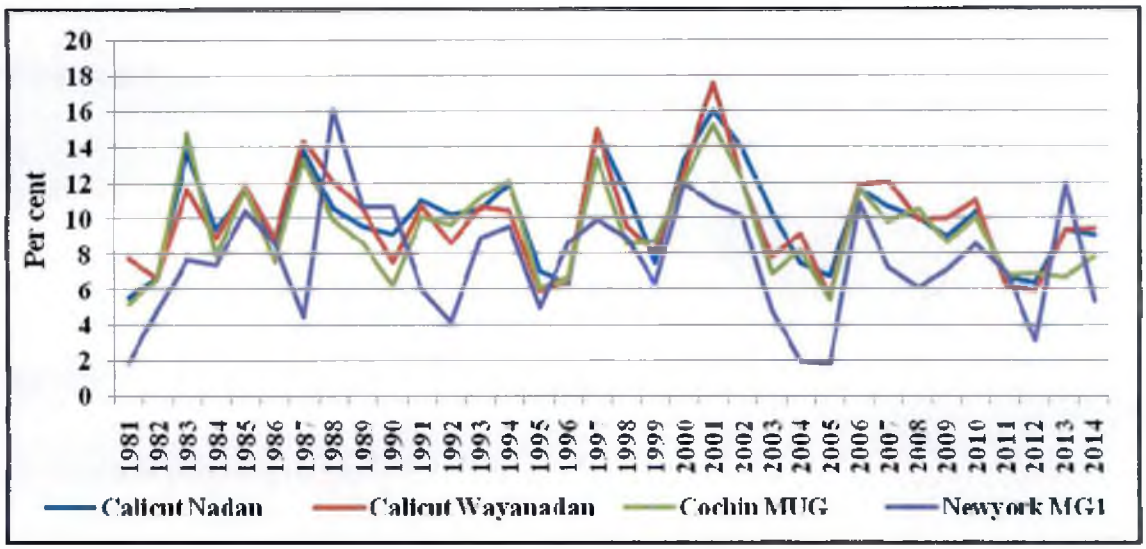
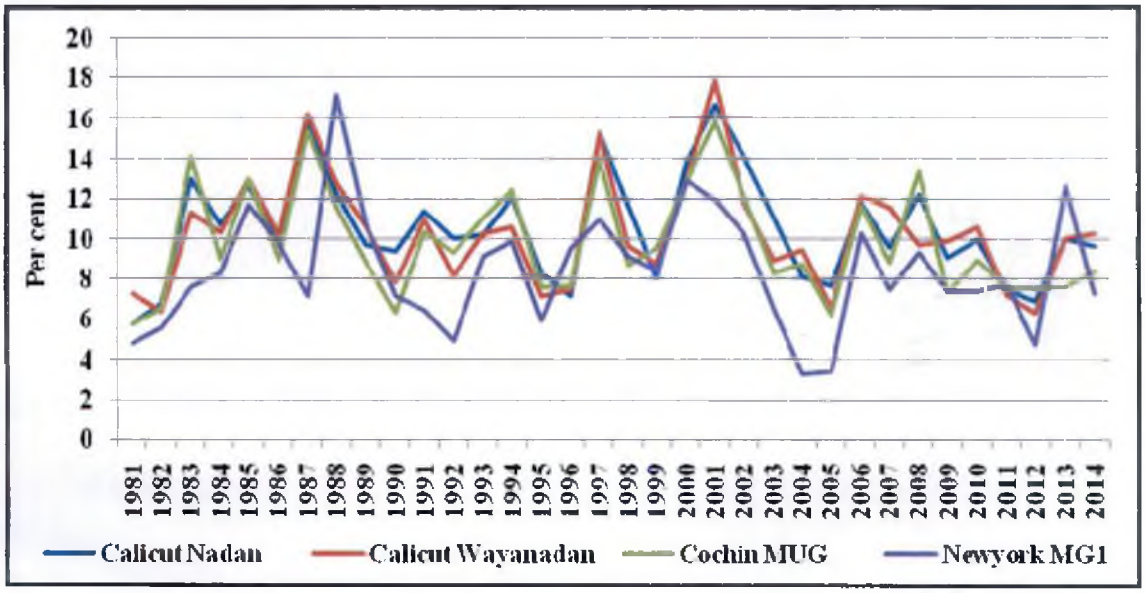


Figure 11 Intra-annual volatility of weekly real black pepper prices in dollar
(in per cent)



4.1.1.2 Inter-annual volatility

The inter-annual volatility measures the dispersion of black pepper prices between two successive years. Monthly and weekly black pepper prices in both nominal and real terms were used for inter-annual volatility analysis.

4.1.1.2.1 Inter-annual volatility of monthly black pepper prices

The inter-annual volatility indices estimated for monthly black pepper prices for different periods are presented in Table 4.5. The inter-annual volatility as indicated by the Parkinson's index showed a mixed pattern for prices in rupee in the domestic market. While the inter-annual volatility increased for Malabar Garbled Cochin, that of Cochin Ungarbled decreased to some extent in the post-WTO period in the domestic markets for both nominal and real prices. In the international markets, the year to year variability decreased for all the markets in the post-WTO period for real as well as nominal rupee and dollar prices and the decrease was found to be least for real dollar prices. The inter-annual volatility during period II in all markets except for real rupee price in international markets were higher than the volatility in period I. Then the inter-annual volatility for nominal prices in domestic and international markets increased in period III but that for real dollar declined in both the markets. The lowest inter-annual volatility in all of the periods under consideration was found in the New York market for nominal price in period III and for real price in period II. The volatility indices for domestic prices in dollar were slightly higher than those for the prices in rupee, which could be attributed to the volatility in exchange rate of dollar in terms of Indian rupee. The inter-annual volatility indices for real and nominal monthly black pepper prices in rupee as well as dollar terms for different years from 1980 to 2014 are plotted in Figure 12 through Figure 15. It could be observed from the figures that the volatility indices for different prices moved closely in the pre-WTO as well as post-WTO periods with the exception of real rupee prices.

Table 4.5 Inter-annual volatility indices of monthly black pepper prices (in per cent)

Commodity	Nominal price							Real price						
	Pre WTO	Post WTO	Period I	Period II	Period III	Period IV	Over all Period	Pre WTO	Post WTO	Period I	Period II	Period III	Period IV	Over all Period
Prices in rupee														
Cochin - Malabar Garbled	21.2	22.3	20.0	21.6	22.5	23.4	21.7	4.9	7.3	4.1	5.7	8.6	7.2	6.3
Cochin – UnGarbled	23.6	22.8	21.8	23.5	22.4	23.6	22.7	8.6	7.4	7.2	8.4	8.5	7.2	7.9
Calicut – Nadan	24.4	24.0	23.8	24.8	22.7	24.0	23.8	8.9	9.3	8.8	9.9	9.9	7.0	9.2
New York - Malabar Garbled1	24.1	21.2	21.1	22.8	20.0	22.3	21.4	15.2	10.1	16.7	9.8	11.6	9.7	12.3
New York - Lampong	24.1	21.3	21.2	22.7	20.3	22.3	21.5	14.4	10.0	15.7	9.7	11.4	9.7	11.9
New York – Brazil	23.6	21.4	21.9	22.6	20.3	22.3	21.7	14.7	10.1	16.3	9.6	11.5	9.7	12.1
New York - Sarawak	23.5	21.4	19.1	22.9	20.3	22.3	21.0	13.5	10.0	15.0	9.1	11.4	9.7	11.5
Prices in dollar														
Cochin - Malabar Garbled	24.3	23.2	20.1	24.6	24.5	21.7	22.9	26.3	23.2	25.9	27.3	21.9	21.6	24.5
Cochin – UnGarbled	25.9	24.0	21.9	26.4	25.1	21.8	24.1	27.9	24.1	27.3	29.1	23.0	21.4	25.7
Calicut – Nadan	26.1	24.8	23.3	26.5	25.5	21.6	24.6	28.1	25.5	28.9	29.8	23.5	21.6	26.6
New York - Malabar Garbled1	25.6	21.1	22.2	23.5	21.1	20.0	22.0	25.0	23.6	25.2	26.1	22.6	21.9	24.2
New York - Lampong	25.5	21.3	22.0	23.7	21.5	20.0	22.0	25.4	23.7	25.5	26.6	22.6	21.9	24.5
New York – Brazil	24.7	21.5	22.5	23.5	21.6	20.0	22.2	25.7	23.7	26.1	26.4	22.5	21.9	24.6
New York - Sarawak	25.0	21.4	20.0	23.9	21.5	20.0	21.5	25.4	23.8	25.2	27.1	22.5	21.9	24.5

Note: The inter-annual volatility indices reported here are the average values of the annual volatility indices for all the years in the respective periods

Figure 12 Inter-annual volatility of monthly black pepper nominal prices in rupees (in per cent)

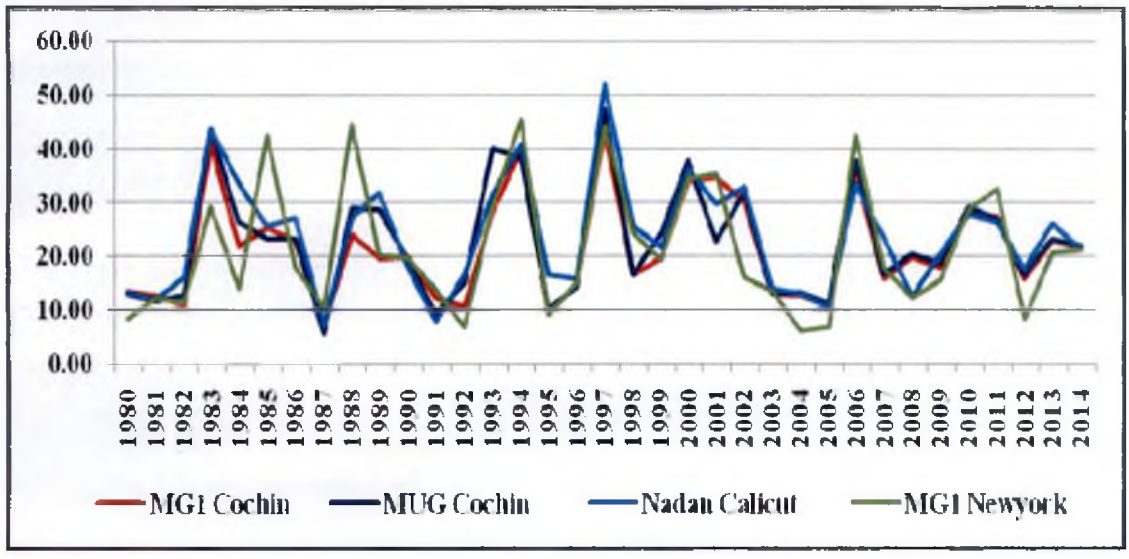


Figure 13 Inter-annual volatility of monthly black pepper real prices in rupees (in per cent)

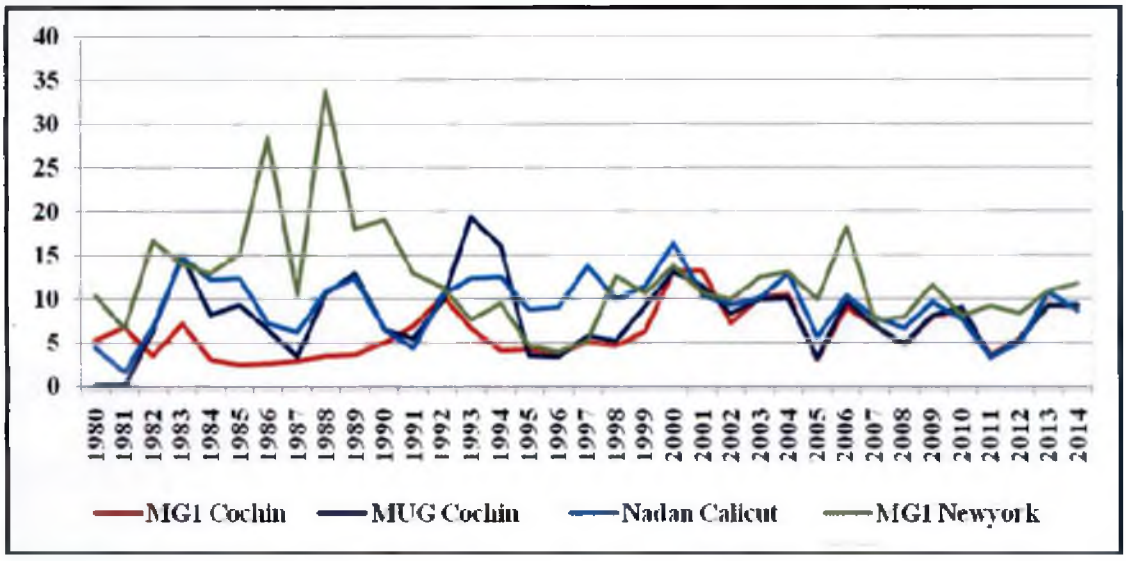


Figure 14 Inter-annual volatility of monthly black pepper nominal prices in dollar (in per cent)

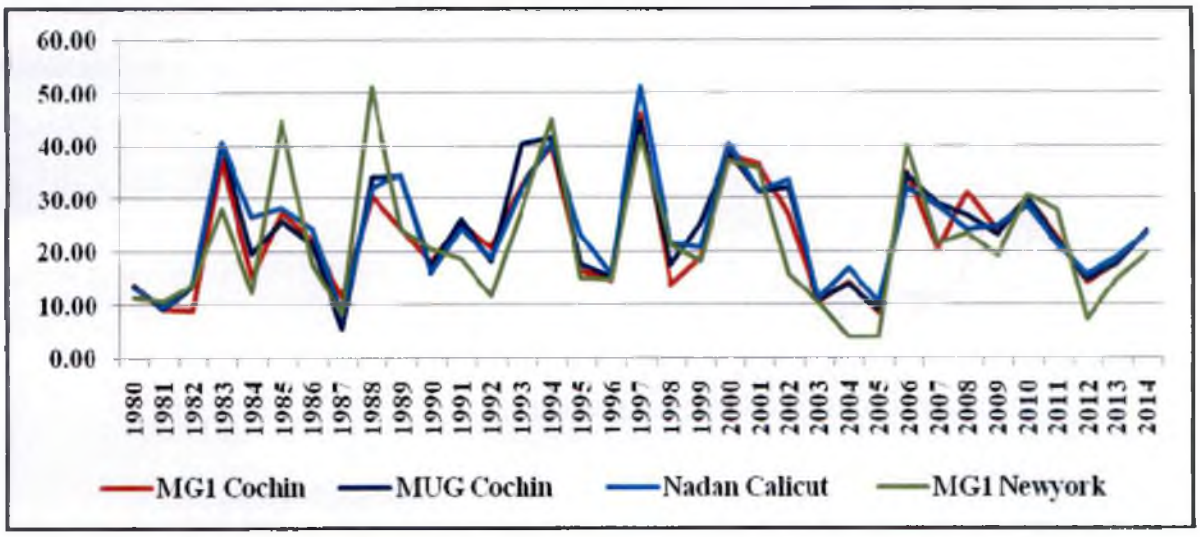
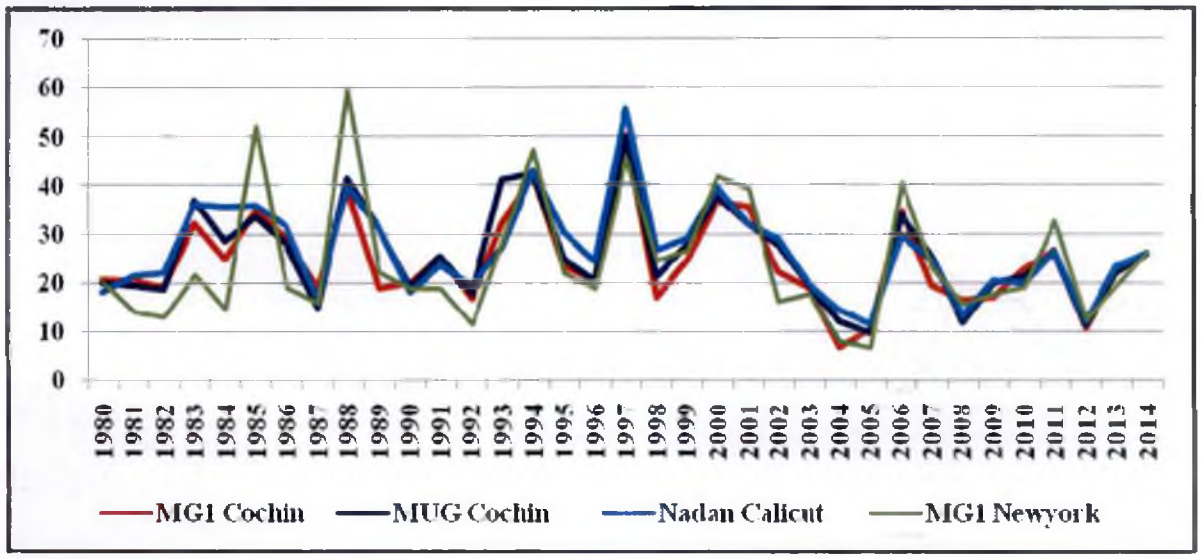


Figure 15 Inter-annual volatility of monthly black pepper real prices in dollar (in per cent)



The correlation between the inter-annual volatility indices of Indian and international market prices of black pepper in the pre-WTO and post-WTO periods are given in Table 4.6. The correlation between the inter-annual volatility of domestic and international prices increased in the post-WTO period. The highest correlation was found between MG Cochin and other international prices.

Table 4.6 Correlation between Inter-annual volatility Indices for monthly prices of Black Pepper in Indian and International markets

Market/Prices	MG Cochin		MUG Cochin		Nadan Calicut	
	Pre-WTO	Post-WTO	Pre-WTO	Post-WTO	Pre-WTO	Post-WTO
	Nominal Prices in rupee					
MG1 New York	0.78	0.90	0.70	0.84	0.65	0.84
Lampong New York	0.77	0.91	0.71	0.83	0.67	0.84
Brazil New York	0.88	0.90	0.80	0.83	0.77	0.84
Sarawak New York	0.81	0.91	0.77	0.83	0.73	0.84
	Nominal Prices in dollar					
MG1 New York	0.78	0.90	0.74	0.88	0.73	0.83
Lampong New York	0.75	0.91	0.72	0.87	0.70	0.82
Brazil New York	0.82	0.90	0.79	0.87	0.78	0.83
Sarawak New York	0.83	0.90	0.79	0.87	0.78	0.83
	Real Prices in rupee					
MG1 New York	-0.44	0.57	0.04	0.64	0.13	0.31
Lampong New York	-0.26	0.51	-0.08	0.61	-0.11	0.33
Brazil New York	-0.22	0.55	0.00	0.64	0.07	0.34
Sarawak New York	-0.22	0.54	-0.06	0.62	-0.02	0.29
	Real Prices in dollar					
MG1 New York	0.85	0.94	0.74	0.91	0.70	0.85
Lampong New York	0.87	0.94	0.80	0.91	0.79	0.85
Brazil New York	0.89	0.94	0.81	0.91	0.81	0.86
Sarawak New York	0.87	0.94	0.81	0.91	0.80	0.86

4.1.1.2.2 Inter-annual volatility of weekly black pepper prices

The inter-annual volatility indices of weekly black prices of both nominal and real prices are presented in Table 4.7. The inter-annual volatility increased in the post-WTO period in the domestic market and international market for nominal price where as it decreased in the case of real prices in international market. The inter-annual volatility in the domestic market was found to be higher than those in the international market but in the case of real price in rupee, that for the international price was higher. The volatility increased in period II and III in both Indian and international markets in nominal price where as in real terms volatility showed a declining trend for different periods. In an inter-annual sense, the Indian prices were highly volatile in comparison with the international prices.

The inter-annual volatility indices for real and nominal weekly black pepper prices in rupee as well as dollar terms for different years from 1980 to 2014 are plotted in Figure 16 through Figure 19. It was found that the volatility indices of domestic as well as international prices moved closely in the pre-WTO and post-WTO periods.

The correlation between the inter-annual volatility indices of Indian and international weekly prices of black pepper in the pre-WTO and post-WTO periods are given in Table 4.8. The correlation between the inter-annual volatility of domestic and international prices increased in the post-WTO period with an exemption of real prices in dollar.

Table 4.7 Inter-annual indices of weekly black pepper price (in per cent)

Commodity	Nominal							Real						
	Pre WTO	Post WTO	Period I	Period II	Period III	Period IV	Over all Period	Pre WTO	Post WTO	Period I	Period II	Period III	Period IV	Over all Period
Prices in rupee														
Calicut – Nadan	27.8	28.1	27.9	28.6	28.3	26.3	28.0	16.1	15.3	16.6	13.6	17.6	14.0	15.7
Calicut –Wayanadan	24.7	27.2	24.1	26.3	28.4	25.3	26.1	15.1	14.3	16.7	11.2	17.0	12.7	14.6
Cochin – UnGarbled	26.0	27.0	25.5	26.7	28.1	25.5	26.6	14.2	14.8	14.9	12.1	18.0	12.1	14.6
New York - MG1	24.0	23.6	23.2	25.5	22.4	24.4	23.8	18.9	17.1	20.7	14.6	19.1	16.5	17.9
Prices in dollar														
Calicut – Nadan	27.3	29.9	27.2	30.5	30.2	25.0	28.8	32.6	29.5	33.2	32.9	28.4	26.8	30.8
Calicut –Wayanadan	26.8	28.0	27.3	27.7	28.9	24.1	27.5	31.7	27.8	33.0	30.4	27.3	25.1	29.5
Cochin – UnGarbled	26.1	29.0	25.5	28.9	30.2	24.6	27.8	31.6	28.5	31.8	32.0	27.8	25.6	29.8
New York - MG1	24.5	22.6	23.3	25.4	22.8	20.9	23.4	26.9	26.3	28.1	28.7	24.5	22.2	26.5

Table 4.8 Correlation between inter-annual volatility indices for weekly prices of black pepper in Indian and international markets

Market/Prices	Calicut Nadan		Calicut Wayanadan		Cochin Ungarbled	
	Pre-WTO	Post-WTO	Pre-WTO	Post-WTO	Pre-WTO	Post-WTO
New York MG1(Nominal rupee)	0.84	0.83	0.78	0.89	0.86	0.84
New York MG1(Nominal dollar)	0.76	0.80	0.82	0.87	0.79	0.83
New York MG1(Real rupee)	0.21	0.27	0.23	0.29	0.01	0.32
New York MG1(Real dollar)	0.72	0.88	0.78	0.93	0.81	0.92

Figure 16 Inter-annual volatility of weekly black pepper nominal prices in rupees

(in per cent)

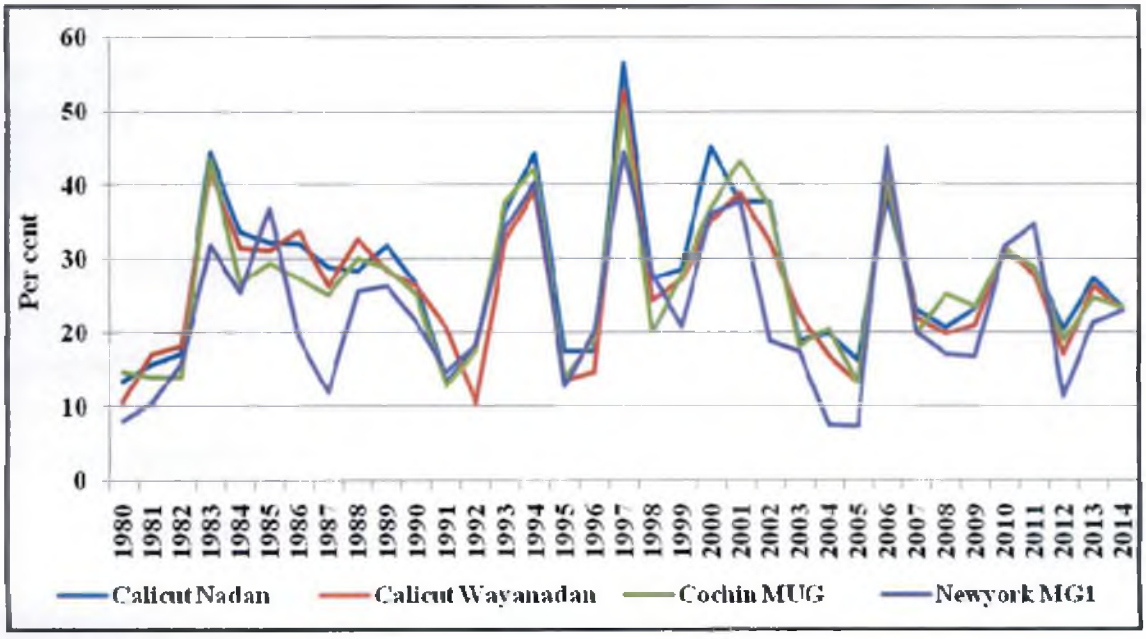


Figure 17 Inter-annual volatility of weekly black pepper real prices in rupees

(in per cent)

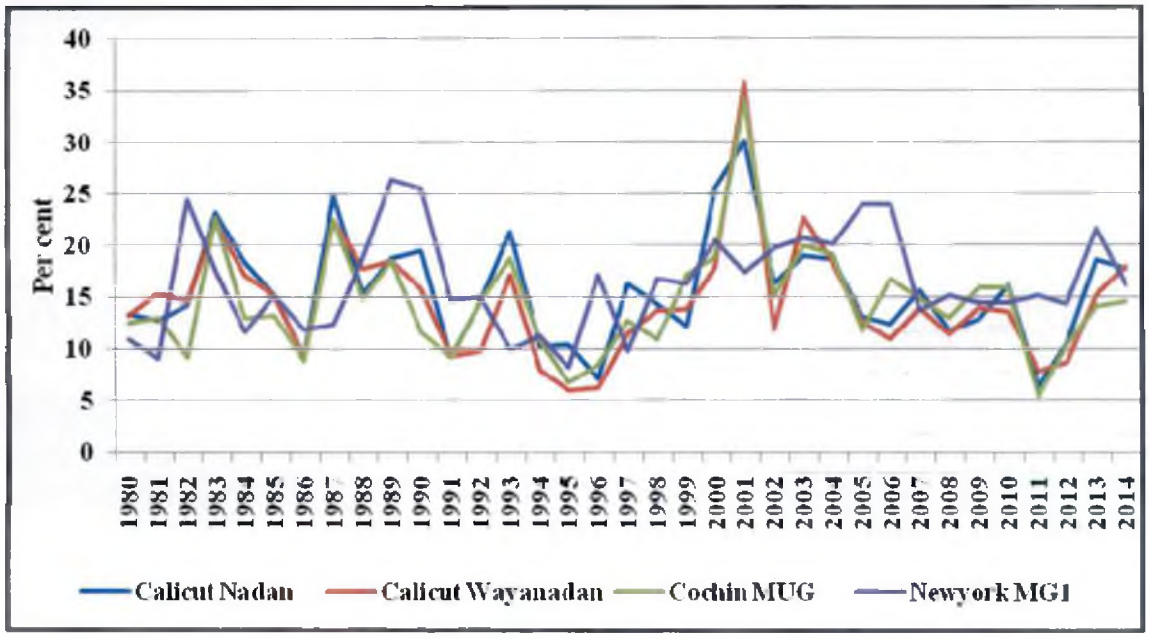


Figure 18 Inter-annual volatility of weekly black pepper nominal prices in dollar

(in per cent)

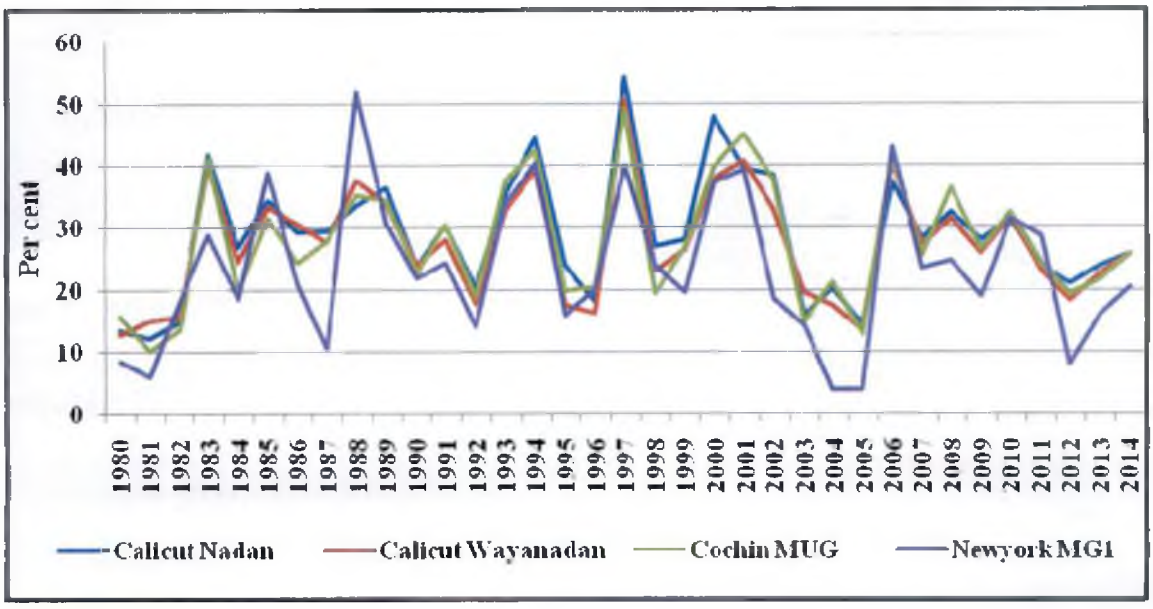
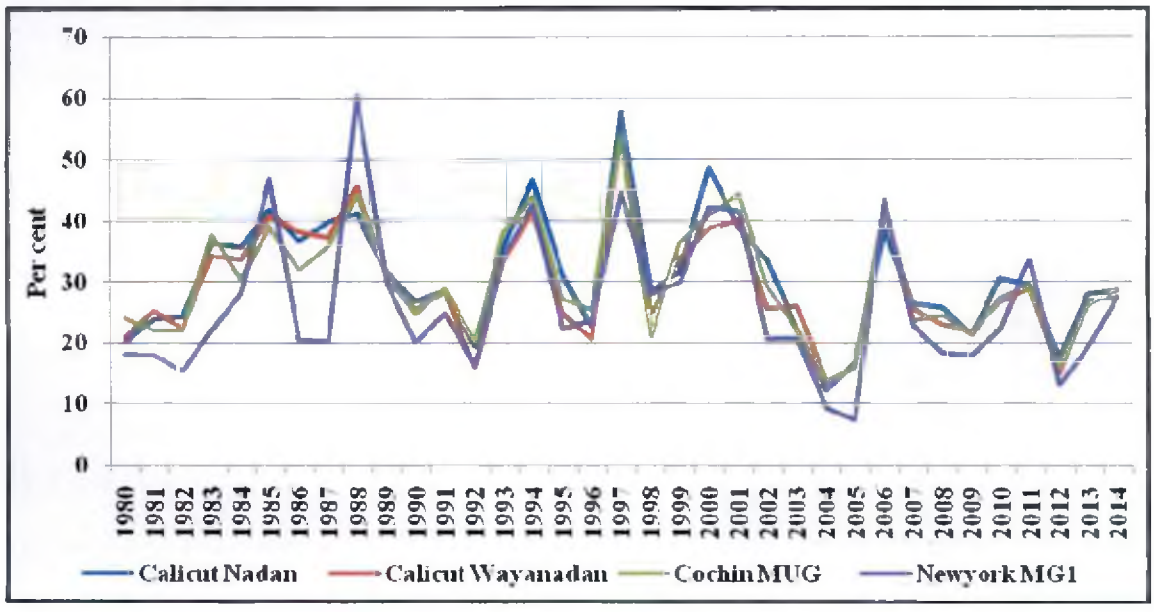


Figure 19 Inter-annual volatility of weekly black pepper real prices in dollar

(in per cent)



4.1.2 Volatility of annual prices

4.1.2.1 Instability Index derived from exponential trend

The price volatility of the nominal and real annual prices and Export Unit Value estimated as the percentage deviation of the price from its exponential trend level are presented in Table 4.9 and 4.10. The volatility indices for nominal as well as real prices in both rupee and dollar, with the exception of nominal dollar prices in international market, were found to be higher in the post-WTO period. The instability in nominal and real international annual prices was higher than domestic price instability in pre-WTO period where as in the post-WTO period domestic price instability became higher. For nominal pepper prices in dollars, since the instability in the pre-WTO period itself was greater than that for the prices in rupee terms, magnitude of the absolute increase in volatility in the post-WTO period appeared to be considerably lower. In the case of real prices, the instability was higher in the pre-WTO period and it decreased in the post-WTO period. Annual instability of nominal rupee and dollar prices in period III was higher when compared to other periods whereas the volatility in period II and IV were considerably lower than other two periods.

The producer price volatility as indicated by the variability in Farm Harvest Price in nominal and real terms for Kerala state and Idukki and Wyanad districts were found decreasing in different periods except for nominal prices in period III. Even though the volatility in farm harvest prices has decreased over different sub-periods, its magnitude was found to be high in many of the periods indicating a high level of producer price volatility. The Export Unit Value in nominal terms showed a decline in volatility in period II which again increased in period III and in real prices, the variability in EUV declined for different periods.

Table 4.9 Instability indices derived from exponential trend of annual black pepper prices in rupee

Commodity	Nominal price							Real price						
	Pre WTO	Post WTO	Period I	Period II	Period III	Period IV	Over all Period	Pre WTO	Post WTO	Period I	Period II	Period III	Period IV	Over all Period
Cochin - Malabar Garbled	32.2	50.9	24.6	19.3	31.4	9.3	44.5	1.9	5.9	1.7	2.4	3.3	4.7	4.3
Cochin – UnGarbled	32.9	50.9	23.7	18.3	31.5	9.2	44.7	3.7	6.6	3.2	3.2	3.4	4.9	5.4
Calicut – Nadan	32.6	51.3	24.4	18.5	30.9	9.1	44.9	2.8	7.2	2.7	2.4	3.3	5.0	5.4
New York - Malabar Garbled1	36.3	46.0	25.9	16.9	30.8	8.4	43.4	5.8	4.4	5.6	4.1	4.3	3.1	5.2
New York - Lampong	37.9	45.9	26.1	17.6	30.9	8.4	44.4	6.5	4.4	4.9	3.9	4.3	3.1	5.5
New York – Brazil	39.5	46.0	27.7	17.2	30.9	8.4	45.2	7.2	4.4	5.6	4.2	4.3	3.1	6.1
New York - Sarawak	37.7	46.0	25.6	17.1	31.0	8.4	44.3	6.6	4.4	4.8	4.6	4.3	3.1	5.4
Kerala - Farm Harvest Price	34.0	52.9	25.1	17.3	23.1	5.2	46.1	14.5	17.5	15.2	11.9	10.9	8.5	16.1
Idukki - Farm Harvest Price	34.2	52.6	24.9	17.2	23.6	5.1	46.1	15.1	17.7	16.1	12.1	10.8	8.7	16.6
Wayanad - Farm Harvest Price	34.0	51.4	24.7	17.1	21.4	4.9	45.4	14.8	16.3	15.5	12.3	11.3	9.0	15.7
Export Unit Value	33.5	41.2	26.2	13.7	25.1	9.4	39.2	5.2	7.9	5.1	6.3	6.8	1.2	7.1

Table 4.10 Instability indices derived from exponential trend of annual black pepper prices in dollar

Commodity	Nominal price							Real price						
	Pre WTO	Post WTO	Period I	Period II	Period III	Period IV	Over all Period	Pre WTO	Post WTO	Period I	Period II	Period III	Period IV	Over all Period
Cochin - Malabar Garbled	38.6	47.5	25.5	26.0	33.4	10.9	45.0	48.6	46.0	33.8	30.0	27.9	7.0	47.1
Cochin – UnGarbled	39.6	48.8	25.5	25.7	34.0	10.9	45.9	49.3	47.1	33.8	29.6	28.4	7.2	48.0
Calicut – Nadan	38.7	48.2	25.2	25.8	32.9	10.8	45.3	48.5	46.3	33.5	29.8	27.4	7.1	47.2
New York - Malabar Garbled1	42.3	42.2	26.6	23.2	32.4	9.6	43.2	52.1	41.6	35.0	27.2	26.5	6.6	46.5
New York - Lampong	44.3	42.1	26.8	23.8	32.5	9.6	43.8	54.6	41.7	35.1	27.9	26.5	6.6	47.5
New York – Brazil	46.1	42.1	28.4	23.5	32.5	9.6	44.6	56.7	41.6	36.7	27.6	26.5	6.6	48.4
New York - Sarawak	43.8	42.2	26.3	23.4	32.5	9.6	43.6	54.1	41.7	34.7	27.5	26.6	6.6	47.3
Kerala - Farm Harvest Price	39.4	51.3	24.8	22.3	24.7	6.1	46.5	47.1	46.1	33.6	25.6	24.4	7.1	46.5
Idukki - Farm Harvest Price	39.6	51.1	24.3	22.3	25.2	6.1	46.7	47.4	46.0	33.7	25.6	25.3	7.3	46.5
Wayanad - Farm Harvest Price	39.4	49.7	24.4	22.0	23.0	6.0	45.7	47.1	44.7	33.1	25.2	22.8	7.3	45.6
Export Unit Value	39.9	38.7	27.0	20.4	26.6	10.5	40.8	49.8	36.4	35.3	24.6	21.2	5.1	42.1

4.1.2.2 Coppocks Instability

The results of the analyses of instability in annual prices and Export Unit Values using Coppocks Instability Index are presented in Table 4.11 and 4.12. The instability of both domestic and international prices in real and nominal terms with the exception of real prices in dollars increased in the post-WTO period. The annual price instability in India was higher than the international price instability in pre and post-WTO periods. The only exception to this pattern was real price in rupee, for which the instability in international market was higher in the pre-WTO period and it decreased in the post-WTO period. The nominal prices in dollar and real price in rupee were showing an increasing trend for different periods. But, for nominal rupee and real dollar prices, the volatility of annual price decreased in period II compared to period I. The instability in nominal and real Farm Harvest Prices in rupee in Kerala state, Idukki and Wyanad districts were found increasing in period II and later declined in period III and IV. The instability in nominal and real dollar Farm Harvest Price was the highest in period III. The instability in Export Unit Value in nominal and real terms showed a decline in volatility in period II which again increased in period III.

4.1.2.3 Cuddy-Della Valle Instability

The results of the instability in annual prices measured using Cuddy-Della Vale Instability index are presented in Table 4.13 and 4.14. The volatility indices for nominal as well as real prices were higher in Post-WTO period except for real international price in rupee and nominal international price in dollar. For nominal pepper prices in rupee, the instability in the post-WTO period was almost two times that of the volatility in the pre-WTO period. The instability of nominal price in Period III for both rupee and dollar was high when compared to other periods. The instability of producer prices in nominal and real terms was found decreasing for different periods except for period III. Even though the instability in producer price has decreased its magnitude was found to be comparatively high in many periods. The instability in nominal Export Unit Value showed a decline in volatility in period II, which again increased in period III.

Table 4.11 Coppocks Instability Index of annual black pepper prices in rupee

Commodity	Nominal price							Real price						
	Pre WTO	Post WTO	Period I	Period II	Period III	Period IV	Over all Period	Pre WTO	Post WTO	Period I	Period II	Period III	Period IV	Over all Period
Cochin - Malabar Garbled	31.8	36.2	33.2	29.1	36.6	22.2	34.5	2.8	7.7	1.8	6.6	6.9	8.5	6.2
Cochin – UnGarbled	32.1	36.3	32.6	29.8	37.5	22.2	34.6	5.2	8.4	5.4	7.2	7.8	8.9	7.2
Calicut – Nadan	31.8	36.5	32.4	29.9	37.6	22.4	34.6	2.5	9.2	2.4	7.2	8.9	9.3	7.2
New York - Malabar Garbled1	31.3	31.9	31.6	26.6	33.7	19.1	31.7	12.4	7.3	11.6	10.9	6.2	8.2	9.7
New York - Lampong	30.6	31.7	30.9	26.5	33.4	19.1	31.3	10.9	7.3	10.2	10.2	6.2	8.2	9.0
New York – Brazil	31.6	31.9	33.1	25.7	33.5	19.1	31.7	11.5	7.4	10.5	10.9	6.2	8.2	9.3
New York - Sarawak	30.4	31.8	30.3	26.8	33.6	19.1	31.2	11.3	7.6	9.5	11.8	6.2	8.2	9.3
Kerala - Farm Harvest Price	28.9	36.7	26.7	38.6	37.2	15.6	33.6	21.4	27.0	22.5	29.3	21.4	22.0	24.8
Idukki - Farm Harvest Price	28.6	36.9	26.3	38.9	37.5	15.6	33.7	22.1	27.5	23.0	29.9	22.2	22.3	25.4
Wayanad - Farm Harvest Price	28.5	36.1	26.1	38.6	36.2	15.0	33.1	22.2	27.1	23.5	29.8	21.1	22.2	25.2
Export Unit Value India	29.6	27.5	31.4	22.2	29.8	18.8	28.4	8.9	10.2	9.7	12.3	7.1	3.1	9.7

Table 4.12 Coppocks Instability Index of annual black pepper prices in dollar

Commodity	Nominal price							Real price						
	Pre WTO	Post WTO	Period I	Period II	Period III	Period IV	Over all Period	Pre WTO	Post WTO	Period I	Period II	Period III	Period IV	Over all Period
Cochin - Malabar Garbled	34.9	37.6	33.1	35.7	41.0	26.8	36.9	41.1	38.4	43.1	36.7	37.7	18.7	39.6
Cochin – UnGarbled	36.9	39.1	33.1	38.4	43.8	26.8	38.5	42.8	39.6	43.1	39.4	39.9	19.0	41.0
Calicut – Nadan	36.0	38.0	32.3	37.9	42.0	26.6	37.6	41.9	38.3	42.3	38.9	37.6	19.4	39.9
New York - Malabar Garbled1	34.6	33.7	32.7	32.3	38.6	24.5	34.4	40.3	34.1	42.3	33.6	34.7	13.3	36.8
New York - Lampong	34.1	33.5	32.0	32.2	38.3	24.5	34.0	40.2	33.8	42.0	33.6	34.4	13.3	36.6
New York – Brazil	35.0	33.6	34.2	31.4	38.4	24.5	34.4	41.3	33.9	44.2	32.8	34.4	13.3	37.1
New York - Sarawak	33.9	33.6	31.3	32.7	38.5	24.5	34.0	40.0	34.1	41.4	34.2	34.5	13.3	36.6
Kerala - Farm Harvest Price	33.3	37.7	27.2	44.0	39.3	20.1	36.1	36.9	40.5	34.6	44.4	41.8	19.4	39.1
Idukki - Farm Harvest Price	33.2	37.8	26.8	44.4	39.4	20.1	36.1	37.1	40.9	34.6	44.9	42.4	19.7	39.4
Wayanad - Farm Harvest Price	33.0	37.0	26.9	44.0	38.1	19.4	35.6	36.9	39.8	34.7	44.3	40.6	19.5	38.6
Export Unit Value India	33.1	29.1	31.9	28.4	34.1	23.1	31.1	38.9	29.3	41.4	29.7	31.0	12.6	33.5

Table 4.13 Cuddy-Della Valle Instability Index of annual black pepper prices in rupee

Commodity	Nominal							Real						
	Pre WTO	Post WTO	Period I	Period II	Period III	Period IV	Over all Period	Pre WTO	Post WTO	Period I	Period II	Period III	Period IV	Over all Period
Cochin - Malabar Garbled	35.8	65.3	30.3	34.3	41.5	15.1	80.5	2.4	8.4	2.1	3.6	4.6	7.2	6.5
Cochin – UnGarbled	37.1	65.5	30.6	33.2	41.3	15.4	80.7	4.6	9.0	4.0	4.6	4.8	7.6	7.4
Calicut – Nadan	36.4	66.2	30.4	33.0	40.7	15.7	81.0	3.4	9.5	3.3	3.7	4.7	7.8	7.5
New York - Malabar Garbled1	40.5	55.6	32.1	32.8	40.1	7.5	68.0	8.3	5.7	7.8	5.8	5.5	5.3	6.8
New York - Lampong	41.3	55.6	31.6	33.1	40.0	7.5	67.9	8.9	5.7	7.7	5.4	5.5	5.3	7.2
New York – Brazil	42.2	55.6	33.0	33.3	40.0	7.5	68.1	10.1	5.8	8.5	5.7	5.5	5.3	8.0
New York - Sarawak	41.3	55.6	31.7	33.1	40.1	7.5	68.0	9.0	5.8	7.3	6.6	5.5	5.3	7.2
Kerala - Farm Harvest Price	37.3	68.3	31.4	30.4	29.7	9.8	86.6	18.1	20.5	18.8	14.3	16.6	13.9	19.4
Idukki - Farm Harvest Price	37.3	67.9	31.6	30.5	30.3	10.0	86.1	18.8	20.8	20.0	14.6	17.3	14.1	19.8
Wayanad - Farm Harvest Price	37.3	66.8	31.2	30.2	28.0	10.0	84.5	18.5	19.8	19.1	14.7	16.4	14.2	19.0
Export unit value	36.3	52.4	31.1	28.3	31.8	7.4	67.2	6.9	9.8	7.2	7.4	8.6	2.0	9.2

Table 4.14 Cuddy-Della Valle Instability Index of annual black pepper prices in dollar

Commodity	Nominal							Real						
	Pre WTO	Post WTO	Period I	Period II	Period III	Period IV	Over all Period	Pre WTO	Post WTO	Period I	Period II	Period III	Period IV	Over all Period
Cochin - Malabar Garbled	48.7	54.6	32.2	31.7	43.7	15.1	57.6	63.0	53.6	48.0	37.8	49.4	18.4	55.9
Cochin – UnGarbled	49.6	55.4	32.6	31.4	44.3	15.2	58.3	64.1	54.3	48.5	37.0	50.1	18.6	56.7
Calicut – Nadan	48.7	55.3	32.1	31.1	42.9	15.4	57.9	63.2	53.7	48.0	36.8	47.9	18.9	56.0
New York - Malabar Garbled1	51.7	47.4	34.2	29.7	42.5	11.4	51.3	65.9	49.6	49.1	37.4	46.6	11.2	55.0
New York - Lampong	54.0	47.4	34.2	30.1	42.4	11.4	51.5	67.9	49.6	49.6	37.8	46.4	11.2	55.7
New York – Brazil	56.0	47.4	35.7	29.9	42.4	11.4	51.9	69.8	49.7	51.1	37.9	46.4	11.2	56.5
New York - Sarawak	53.6	47.5	34.0	30.0	42.5	11.4	51.5	67.6	49.8	49.5	38.0	46.6	11.2	55.7
Kerala - Farm Harvest Price	46.5	57.8	33.2	30.0	31.3	9.5	62.1	60.6	53.4	48.6	34.4	33.7	14.8	54.7
Idukki - Farm Harvest Price	47.1	57.5	33.4	30.1	31.8	9.6	61.8	61.2	53.3	49.1	34.6	34.3	15.0	54.8
Wayanad - Farm Harvest Price	46.6	56.5	32.9	30.0	29.4	9.5	60.6	60.6	52.2	48.3	34.0	31.4	15.0	53.9
Export unit value	49.2	44.1	33.4	25.8	33.7	11.4	50.4	63.3	42.8	48.6	34.3	36.4	8.3	49.7

4.1.3 Determinants of Price Volatility

The extent of price volatility in black pepper depends of many factors like variability in rupee-dollar exchange rate; behaviour of the prices and the time series components of prices like trend, seasonality, cyclicality and irregular variations; variations in production and consumption in India and other countries; changes in international trade (export and import); futures trading etc.

4.1.3.1 Exchange rate volatility

The price volatility transmission from world price to domestic wholesale as well as the producer price begins with the average export price in US dollar. The transmission of variability from Export Unit Value in US dollar to wholesale price or Farm Harvest Price in rupee is primarily determined by the variations in rupee dollar exchange rates. The variability in exchange rates often differs within a year and between the years. The intra-annual and inter-annual volatility for average monthly and weekly rupee-dollar exchange rates are presented in Table 4.15

Table 4.15 Intra-annual and inter-annual volatility of rupee-dollar exchange rates

Volatility/Period	Pre WTO	Post WTO	Period I	Period II	Period III	Period IV	Over all Period
Monthly average exchange rate							
Intra-annual volatility	2.0	1.9	1.3	2.3	2.2	2.2	1.9
Inter-annual volatility	7.6	5.7	5.5	6.8	5.7	6.9	6.1
Weekly average exchange rate							
Intra-annual volatility	2.6	1.8	2.1	2.6	1.6	2.5	2.1
Inter-annual volatility	6.3	5.8	5.6	6.2	5.1	8.5	6.0

In the case of monthly average exchange rates, the magnitude of intra-annual volatility in comparison with the inter-annual volatility was considerably low. The intra-annual volatility of monthly average rupee-dollar exchange rate exhibited only a negligible decline in the post-WTO period where as the inter-annual volatility declined from 7.6 per cent in pre-WTO period to 5.7 in the post-WTO period. The intra-annual volatility in monthly average exchange rate increased in 1990s (Period II) and was almost constant in the subsequent periods while the inter-annual volatility moved up and down in alternate manner in various sub-periods. For the weekly average exchange rates, it was found that the magnitude of the intra-annual and inter-annual volatility of exchange rates decreased in the post-WTO period. The magnitude of intra-annual volatility of weekly dollar exchange rates increased in the pre-WTO period as compared to that for the monthly exchange rate and a reverse pattern was observed for the inter-annual volatility. The marginal decrease or no change in the intra-annual volatility and a decrease in inter-annual volatility of black pepper prices could be directly attributed to these behavioural patterns of the volatility of the monthly and weekly rupee-dollar exchange rates.

4.1.3.2 Behaviour of black pepper prices

4.1.3.2.1 Movements in monthly prices of black pepper

The prices of black pepper in rupee in the domestic and international markets (Figure 20) moved closely especially in the pre-WTO period. After 1995, there was a slight divergence between the two market prices and the international price was always higher than the domestic prices. The prices of black pepper in dollar in the domestic and international markets (Figure 21) showed fluctuations even before liberalization and the international price was higher than the domestic prices in pre- and post-WTO periods. The prices in the domestic market were the lowest value in 2004 and then started increasing from 2005, crossed the eight dollar mark in 2011 and rose above ₹500 in January 2014. The price crossed ₹725 in May 2014 and after a slight decline again rose to ₹743 in July 2014 and was ₹708 in December 2014.

Figure 20 Movements in monthly prices of black pepper (in rupee per kilogram)

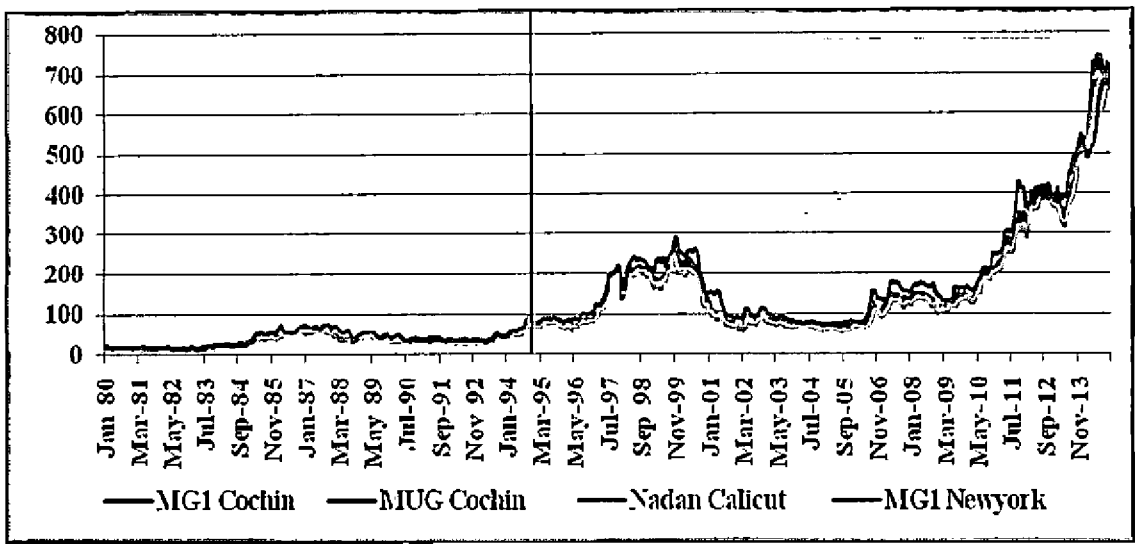
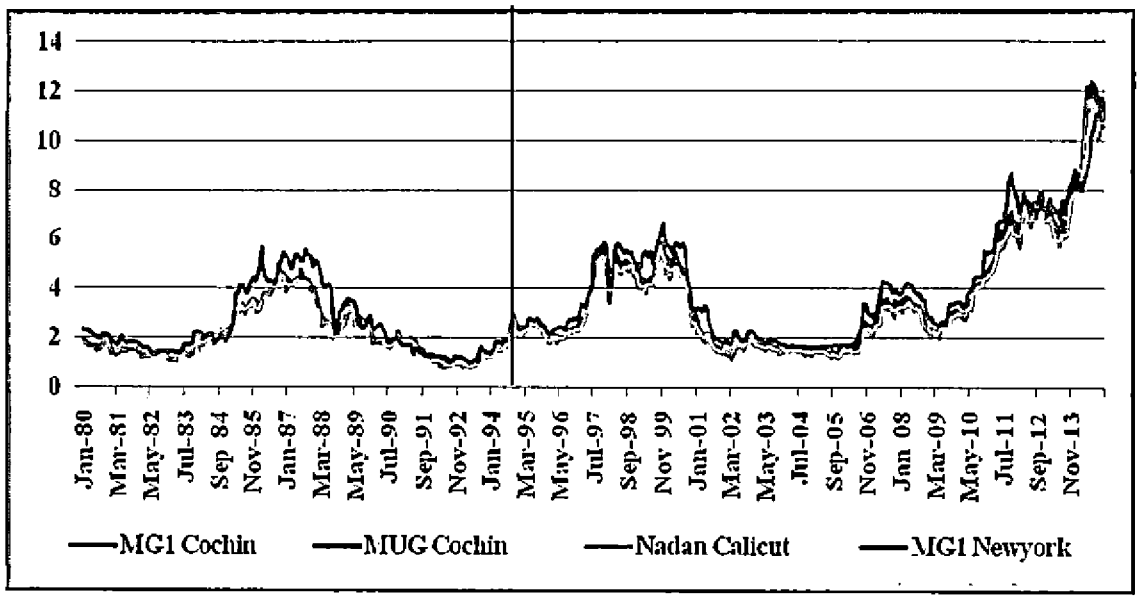


Figure 21 Movements in monthly prices of black pepper (in dollar per kilogram)



4.1.3.2.2 Seasonality in prices of black pepper

As any other agricultural commodity, black pepper is also seasonal in production. In Kerala, the harvest season extends from November to January in the plains and January to March in the hills. The seasonal indices for Malabar Garbled and Malabar Ungarbled pepper in Cochin market were estimated separately for the pre-WTO and post-WTO periods and are given in Table 4.16. It could be observed from the table that the prices of pepper exhibited considerable seasonality. The increasing phase for garbled pepper prices in Kochi market in the post-WTO period was observed from July to October with the peak price in October while for ungarbled prices August and October showed the highest prices. The fall in price occurs from November to March, coinciding with the harvesting and months of peak arrivals. The Coefficent of Variation in seaonal indices have declined in the post-WTO period for both Ungarbled and Garbled pepper prices and this reduction in variation in monthly prices within a particular year could be the major factor responsible for decreasing intra-annual volatility indices in the post-WTO period.

Table 4.16 Seasonal index for black pepper prices in Cochin market

Month	Cochin Malabar Ungarbled			Cochin Malabar Garbled		
	Pre	Post	Overall	Pre	Post	Overall
January	93.63	96.17	95.17	93.63	96.41	95.35
February	96.91	93.62	94.93	96.91	94.98	95.14
March	95.10	95.58	95.19	95.10	95.83	95.50
April	96.99	99.94	99.05	96.99	99.29	99.00
May	96.66	101.10	99.15	96.66	99.89	98.74
June	100.62	100.60	100.19	100.62	99.62	100.25
July	99.71	101.45	100.46	99.71	100.98	100.72
August	100.87	104.28	102.98	100.87	102.15	103.26
September	105.39	103.56	105.18	105.39	103.26	105.19
October	107.84	104.11	105.92	107.84	105.13	105.57
November	105.91	100.07	102.34	105.91	102.76	101.91
December	100.35	99.52	99.43	100.35	99.70	99.37
CV of Seasonal indices (%)	4.48	3.39.	3.70	4.48	3.11	3.58

Figure 22 Seasonal indices for prices of Ungarbled pepper in Cochin

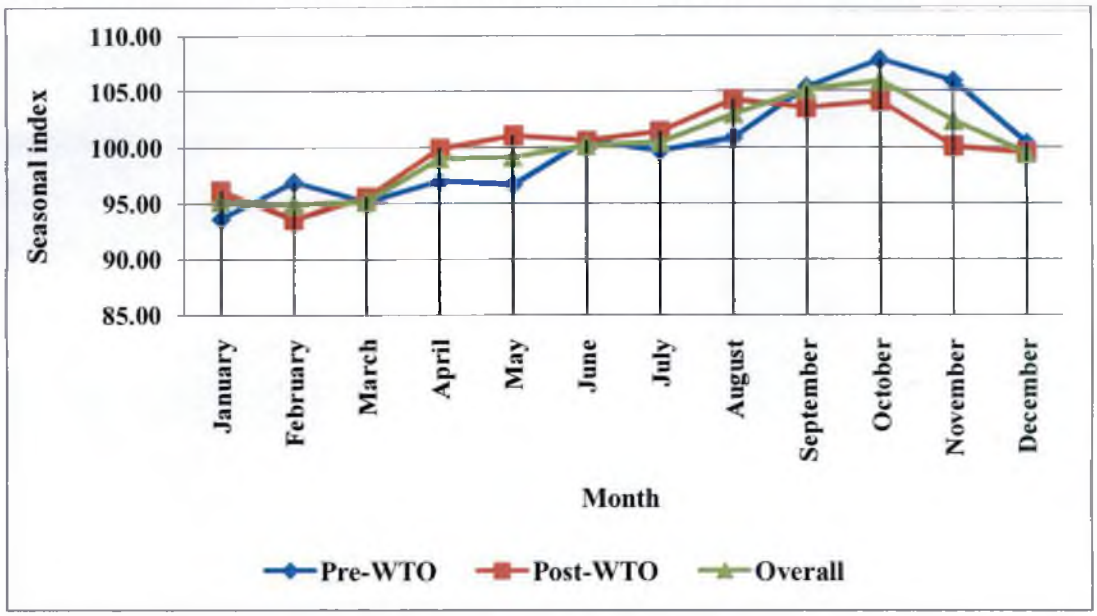
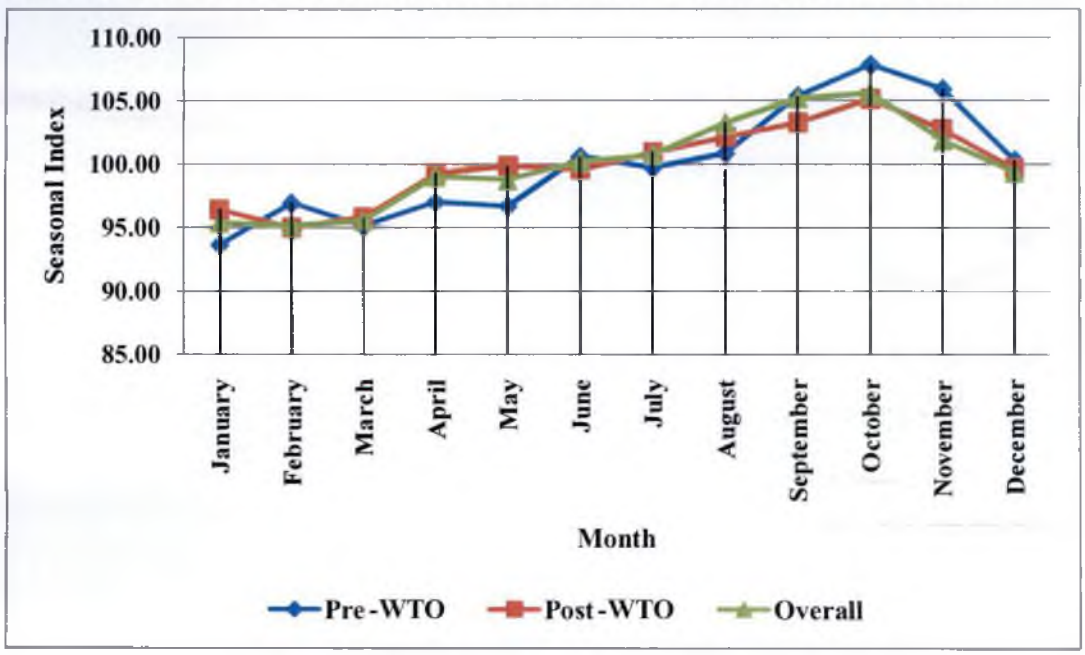


Figure 23 Seasonal indices for prices of Malabar Garbled pepper in Cochin



4.1.3.2.2 Cyclicality in prices of black pepper

Price cycles represent deviations in price levels from the average trend due to business sequences of booms and recession that appear in an economy. Cyclical movements are of longer duration, usually extending to a few years and are of different periodicity. The cyclical pattern of pepper prices could be observed in Figures 20 and 21. The cyclical pattern of pepper prices was clearly demonstrated when the prices were plotted in US dollar per kilogram. The first 11 year cycle was from 1983 to 1993 and the second cycle from 1993, showed some fluctuation near the peak values and reached the lowest value in 2004. The third cycle started from 2005 when the prices started increasing, crossed the eight dollar mark in 2011 reached the peak value of Rs 743 in July 2014 and then has shown a declining pattern. The third cycle has shown an expansion in duration in the boom phase to almost nine years and now the slump phase of the cycle is in its beginning.

4.1.3.3 Changes in international trade in black pepper

It could be observed from Table 4.17 that the share of export in production has declined in India. India exported almost three-fourth of the production in TE 1972-73 while it declined to one-third share in TE 2002-03, which further increased to 42 per cent in TE 2012-13. This could be attributed to the increasing domestic consumption of black pepper in India and increasing competition from other producers, especially, Vietnam. As per IPC estimates about 50 to 60 per cent of Indian production is consumed in the country itself. The share of India in world exports declined from more than 20 per cent in 1989 to about 10 per cent in 1991 which, further increased to about 25 per cent in 1993. From 1996 onwards the share has shown a continuously declining trend from about 24 per cent to as low as six per cent in 2004. It again increased to 15.8 per cent in quantity terms in 2007 and again declined and started increasing from 2010 and in 2011 India exported about 19 per cent of world exports in quantity terms and the value of exports was 15 per cent of the world export value.

Table 4.17 Export intensity of production of black pepper in India

Trienniums	Production (tonnes)	Export quantity (tonnes)	Percentage share of export in production
TE 1972-73	26170	19059	73
TE 1982-83	28443	23188	82
TE 1992-93	50240	24780	49
TE 2002-03	65043	22105	34
TE 2012-13	48667	20517	42

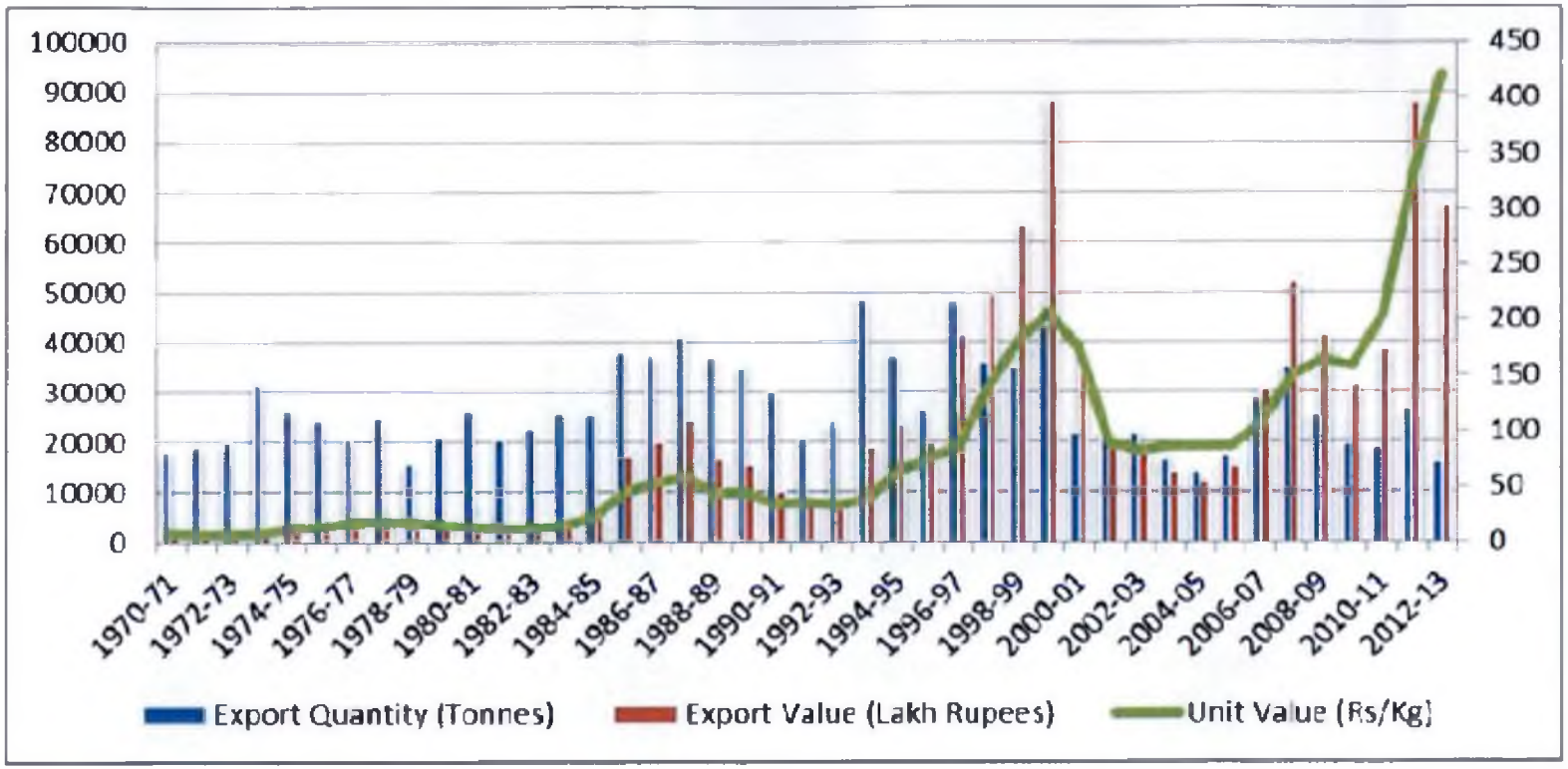
Source: Calculations based on data published by Spices Board
Note: TE denotes Triennium Ending

Table 4.18 Export of black pepper from India

Export/ triennium	Export quantity (tonnes)	Export Value (lakh rupees)	Unit Value (Rs/kg)
TE 1972-73	19059	1479	8
TE 1982-83	23188	3211	14
TE 1992-93	24780	8522	34
TE 2002-03	22105	25446	115
TE 2012-13	20517	64463	318

Source: Calculations based on data published by Spices Board
Note: TE denotes Triennium Ending

Figure 24 Export of black pepper from India



It could be observed from Figure 24 and Table 4.18 that the unit value of black pepper exports were very low in the 1970s and it remained low upto mid 1980s, because of that the value of exports were very low when compared to the quantity of exports from India. After 1985, the unit value of pepper exports strated increasing and because of that the value of exports also increased and this trend continued utpo 1998-99. This increase could be atrributed to the devaluation of rupee and liberalisation policies implemented in India. From 2000 onwards the exports declined in both value and quantity terms upto 2005 and the unit value was less than ₹100 in some of the years. From 2006-07, the unit value started increasing whereas the quantity of exports exhibited a declining pattern and consequntly the value of exports increased. The export unit value of black pepper crossed the ₹700 mark in 2014-15

4.1.3.4 Futures trading

The volume and value of black pepper traded in futures market is presented in Table 4.19.

Table 4.19 Volume and value of black pepper trading in futures market

Year	Volume (lakh tonnes)	Value (Rs. in crore)
2004-05	11.63	8334.28
2005-06	11.56	8029.83
2006-07	76.26	90727.61
2007-08	71.97	105323.7
2008-09	-	-
2009-10	19.61	27705.73
2010-11	42.25	84786.09

Source: Reports of the Forward Market Commission

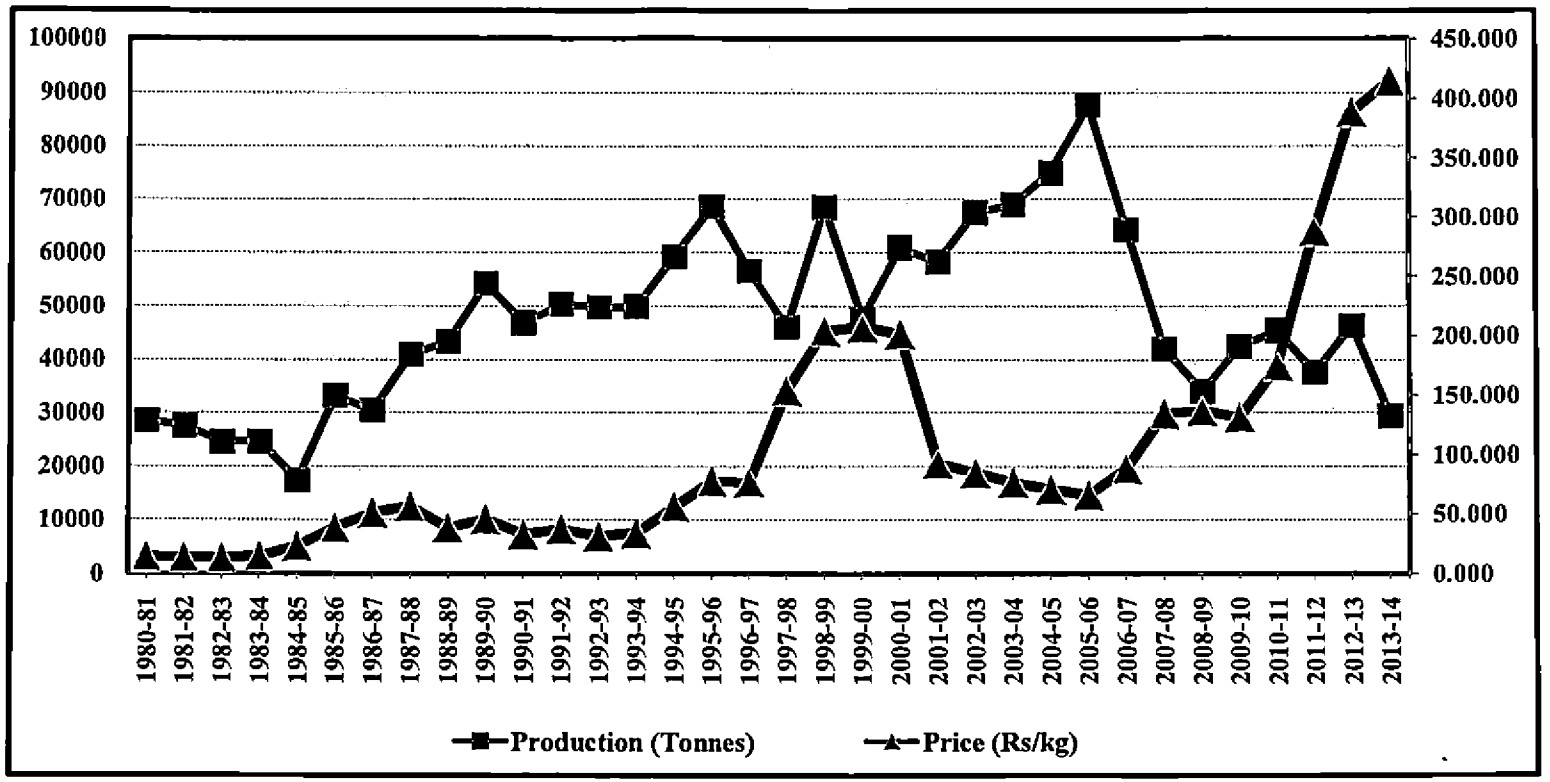
Futures trading is permitted for pepper at the National Exchanges, National Commodity and Derivatives Exchange Limited (NCDEX); and National Multi

Commodity Exchange of India Limited (NMCE) and in The Indian Pepper and Spice Trade Association Exchange, Kochi. Even though there is substantial increase in the quantity and value of pepper traded in futures market, the direct benefit to the small farmers or farmer groups from futures trading is very limited as the actual delivery in the market is very much limited. The quantity trade is many times the actual production and hence there is a criticism that the speculation is contributing to price volatility in spot markets of black pepper. Mostly, the beneficiaries in futures trading are large farmers, exporters and traders and even if it has helped, it has helped only in price discovery.

4.1.3.5 Variation in production

Pepper production is influenced by the price movements. The movement of production and price of black pepper in India is depicted in Figure 25. An inverse relationship between production and price could clearly be detected from the figure. Since pepper is a perennial crop the production response by increase in area to rise or fall in price in a particular year will be at a lag of three to four years. When world pepper prices are high, new vines are planted and fertilizer usage goes up. The pepper exporters also try to reduce their stocks during the periods of high price. Then, as the newly planted vines start to yield, production increases and the prices fall. When world pepper prices are low, pepper vines are neglected and fertilizer usage decreases. Because producers neglect management, pepper production stagnates or even declines, tightening the supply situation until pepper prices increase again. This cycle of pepper production and prices continues.

Figure 25 Movements in production and price of black pepper in India



4.1.3 Significance and persistence of volatility - GARCH Model

Even though the estimation of volatility using various volatility indices gives measurements on the magnitude of volatility, it will not provide any evidence on whether the estimated volatility is statistically significant and also regarding the persistence of volatility. The estimates of the GARCH (1,1) model fitted for the nominal rupee and dollar prices of black pepper in domestic markets are presented in Table 4.20. The estimates of the GARCH (1,1) model for nominal pepper prices turned out to be significant in the post-WTO period. The volatility as indicated by the summation of the ARCH (αi) and GARCH (βi) terms for most of the price series were high in the post-WTO period. With the exception of dollar prices for Cochin Malabar Ungarbled, all the other price series in rupee as well as dollar terms showed an increase in volatility in the post-WTO period. The volatility was found to be moderate for Calicut Nadan in the pre- and post-WTO periods. The Cochin Ungarbled pepper prices in dollar also exhibited a medium volatility and it also declined slightly in the post-WTO period. Though the volatility has increased in the post-WTO period in the domestic markets, none of them turned out to be very high or there was no evidence of the persistence volatility for any of price series.

The estimates of the GARCH (1,1) model fitted for the nominal rupee and dollar prices of black pepper in international markets are presented in Table 4.21. In the case of international market prices, it could be observed that the volatility has declined in the post-WTO period. The volatility as indicated by the summation of the ARCH (αi) and GARCH (βi) terms have exhibited a reduction in magnitude within the medium volatility category or decreased from persistence in volatility to high or medium volatility, clearly indicating reduction in significance as well as persistence of price volatility for black pepper prices in international markets during the post-WTO period. This pattern of behaviour in price volatility could be observed for both nominal rupee and dollar prices of black pepper in the international market.

The estimates of the GARCH (1, 1) model fitted for the real prices of black pepper in domestic market is presented in Table 4.22 and that for the international pepper prices is presented in Table 4.23. For domestic market, the volatility of real prices in rupee was found to be very low or low in the post-WTO period. The volatility was found to be high for real dollar prices of Cochin Malabar Garbled in the post-WTO period while it was moderate for Cochin Ungarbled and Calicut Nadan. In the international markets, the volatility declined for the real pepper prices in rupee and dollar terms in the post-WTO period as indicated by low or medium values for summation of the ARCH (αi) and GARCH (βi) terms.

The analysis using GARCH models revealed that even though the magnitude as well as significance of volatility in black pepper prices has increased in the post-WTO period in the Indian markets, there was no evidence of persistence in volatility in the domestic markets. The GARCH models for real prices showed very low volatility in the post-WTO period in the domestic market. The increase in volatility in the domestic market was clearly identifiable in the case of Cochin Malabar Garbled prices. In the case of international prices, the magnitude, significance and persistence of volatility substantially declined in the post-WTO period.

The reduction in tariff and removal of non-tariff barriers and other measures in international trade as part of the liberalisation policies in economic reforms and the subsequent WTO and proliferating Free Trade Agreements have made the transmission of international price signals to domestic markets much faster. Hence, the increase in volatility in domestic markets could be attributed to the trade openness as part of the liberalisation policies and also to the quick transmission of international market developments to Indian markets due to the developments in information and communication technologies. When the international price volatilities are getting transmitted to various consuming and producing countries at faster rates, there could be corresponding decline in the price volatility in the international markets.

Table 4.20 Estimates of the fitted GARCH model for nominal black pepper prices in domestic market

	Cochin Malabar Garbled			Cochin Malabar Ungarbled			Calicut Nadan		
	Pre-WTO	Post-WTO	Overall Period	Pre-WTO	Post-WTO	Overall Period	Pre-WTO	Post-WTO	Overall Period
Prices in rupee									
Constant	2.69 (0.89)	4.25 (9.63)	2.69*** (2.28)	2.66 (0.48)	4.22 (10.11)	2.66* (1.93)	2.61 (0.51)	4.18 (7.21)	2.61 (1.44)
Estimates of ARCH term (α_i)	0.22 (1.76)	0.12*** (2.35)	0.13*** (2.56)	0.26** (2.96)	0.10** (2.08)	0.16* (3.92)	0.22 (2.65)	0.21** (2.42)	0.19* (3.75)
Estimates of GARCH term (β_i)	0.04 (0.13)	0.70* (5.56)	0.53* (3.03)	0.25 (0.91)	0.75* (5.52)	0.6* (5.17)	0.19 (0.96)	0.39** (2.10)	0.34** (2.35)
Log likelihood	214.83	292.3	504.57	178.53	274.86	450.63	166.87	242.61	408.90
$\alpha i + \beta i$	0.26	0.82	0.66	0.51	0.85	0.76	0.41	0.60	0.53
Volatility	Low	High	High	Medium	High	High	Medium	Medium	Medium
Prices in dollar									
Constant	0.68 (1.27)	0.80 (1.79)	0.68 (0.78)	0.64 (1.03)	0.77 (0.83)	0.64** (1.03)	0.59 (1.62)	0.74* (0.93)	0.59* (0.11)
Estimates of ARCH term (α_i)	0.07 (0.92)	0.13*** (2.31)	0.12 (2.29)	0.20 (2.59)	0.21* (2.71)	0.23* (3.92)	0.16 (1.95)	0.23* (2.68)	0.21* (3.58)
Estimates of GARCH term (β_i)	0.06 (0.06)	0.67* (4.89)	0.45* (2.11)	0.29 (0.95)	0.19* (2.28)	0.36* (2.65)	0.26 (0.98)	0.33*** (1.92)	0.29*** (2.09)
Log likelihood	208.11	281.66	486.11	174.96	243.98	418.22	164.05	237.21	399.34
$\alpha i + \beta i$	0.13	0.80	0.57	0.49	0.40	0.59	0.42	0.56	0.50
Volatility	Low	High	Medium	Medium	Medium	Medium	Medium	Medium	Medium

Note: * denotes significant at one per cent level, ** denotes significant at five per cent level, *** denotes significant at ten per cent level

Table 4.21 Estimates of the fitted GARCH model for nominal black pepper prices in international market

	New York Brazil			New York Lampong			New York Sarawak			New York MG1		
	Pre-WTO	Post-WTO	Overall Period	Pre-WTO	Post-WTO	Overall Period	Pre-WTO	Post-WTO	Overall Period	Pre-WTO	Post-WTO	Overall Period
Prices in rupee												
Constant	2.65 (1.49)	4.34 (6.02)	2.65 (1.69)	2.71 (1.22)	4.34 (6.89)	2.71 (1.74)	2.69* (0.42)	4.34* (5.77)	2.69** (1.53)	2.89 (0.42)	4.34* (5.88)	2.89 (1.48)
Estimates of ARCH term (α_i)	0.39* (2.68)	0.14** (2.52)	0.23* (3.92)	0.54* (3.26)	0.21* (2.94)	0.33* (4.42)	0.59* (4.30)	0.15* (2.62)	0.20* (5.95)	0.39* (3.19)	0.17* (2.61)	0.28* (4.41)
Estimates of GARCH term (β_i)	0.24** (2.10)	0.29 (1.34)	0.25** (2.74)	0.22** (2.43)	0.18 (1.13)	0.21** (2.98)	0.45* (6.21)	0.28*** (1.35)	0.74 (21.68)	0.25 (2.15)	0.23 (1.42)	0.23 (2.81)
Log likelihood	197.13	294.18	490.1	200.28	301.97	500.03	209.97	297.25	505.05	193.4	298.1	488.99
$\alpha i + \beta i$	0.55	0.43	0.48	0.76	0.39	0.54	1.04	0.43	1.02	0.64	0.40	0.51
Volatility	Medium	Medium	Medium	High	Medium	Medium	Persistence	Medium	Persistence	High	Medium	Medium
Prices in dollar												
Constant	0.64 (0.45)	0.89 (1.67)	0.64 (0.9)	0.69 (1.44)	0.89** (1.94)	0.69 (1.49)	0.68 (1.62)	0.89** (1.81)	0.68 (1.68)	0.87 (0.69)	0.89 (1.68)	0.87 (1.15)
Estimates of ARCH term (α_i)	0.35* (2.82)	0.22* (2.81)	0.31* (4.21)	0.73* (3.49)	0.28* (3.25)	0.44* (5.05)	0.60* (4.00)	0.25* (3.02)	0.30* (6.79)	0.34* (3.30)	0.26* (2.96)	0.31* (4.66)
Estimates of GARCH term (β_i)	0.21** (2.05)	0.18 (1.30)	0.19* (2.66)	0.15* (2.37)	0.13 (1.16)	0.15* (2.98)	0.54* (6.86)	0.15** (1.29)	0.72 (25.77)	0.21** (1.98)	0.14** (1.44)	0.18* (2.72)
Log likelihood	203.7	293.8	496.5	210.02	302.54	510.4	221.86	298.50	520.46	195.06	298.9	491.77
$\alpha i + \beta i$	0.56	0.4	0.5	0.88	0.41	0.59	1.14	0.4	0.94	0.55	0.4	0.49
Volatility	Medium	Medium	Medium	Very High	Medium	High	Persistence	Medium	Very High	Medium	Medium	Medium

Note: * denotes significant at one per cent level, ** denotes significant at five per cent level, *** denotes significant at ten per cent level

Table 4.22 Estimates of the fitted GARCH model for real black pepper prices in domestic market

	Cochin Malabar Garbled			Cochin Malabar Ungarbled			Calicut Nadan		
	Pre-WTO	Post-WTO	Overall Period	Pre-WTO	Post-WTO	Overall Period	Pre-WTO	Post-WTO	Overall Period
Prices in rupee									
Constant	4.44 (109.37)	4.44 (271.56)	4.43 (326.98)	4.25 (511.27)	4.31 (149.45)	4.27 (296.26)	4.24 (638.07)	4.24 (174.26)	4.25 (376.80)
Estimates of ARCH term (α_i)	0.33 (3.17)	0.07 (0.75)	0.06*** (2.89)	0.21** (2.59)	0.16 (2.00)	0.18* (2.66)	0.13*** (2.96)	0.00 (0)	0.16* (2.43)
Estimates of GARCH term (β_i)	0.00 (0)	0.32 (0.41)	0.89* (21.01)	0.80* (11.33)	0.00 (0)	0.56* (4.64)	0.84* (18.22)	0.0006	0.48* (2.86)
Log likelihood	216.93	370.85	579.4	246.76	390.15	618.14	242.98	314.19	539.67
$\alpha i + \beta i$	0.33	0.39	0.95	1.09	0.16	0.74	0.97	0.0006	0.64
Volatility	Low	Low	Very high	Persistence	Low	High	Very high	Low	Medium
Prices in dollar									
Constant	0.62 (1.11)	0.83 (1.29)	0.61 (0.42)	0.58 (0.81)	0.80 (0.20)	0.58 (0.34)	0.54 (1.08)	0.76 (0.09)	0.54 (0.60)
Estimates of ARCH term (α_i)	0.00 (0)	0.13** (2.47)	0.09** (2.26)	0.13** (1.82)	0.21** (2.47)	0.18* (3.36)	0.07* (1.45)	0.24** (2.37)	0.16* (2.89)
Estimates of GARCH term (β_i)	0.01 (-)	0.72* (6.93)	0.73* (6.56)	0.51 (1.23)	0.39** (1.88)	0.46** (2.45)	0.68** (1.89)	0.35 (1.74)	0.44** (2.20)
Log likelihood	192.23	277.13	465.87	164.08	238.03.	400.88	153.7	231.56	382.58
$\alpha i + \beta i$	0.01	0.85	0.82	0.64	0.6	0.64	0.75	0.59	0.60
Volatility	Low	High	High	Medium	Medium	Medium	High	Medium	Medium

Note: * denotes significant at one per cent level, ** denotes significant at five per cent level, *** denotes significant at ten per cent level

Table 4.23 Estimates of the fitted GARCH model for real black pepper prices in international market

	New York Brazil			New York Lampong			New York Sarawak			New York MG1		
	Pre-WTO	Post-WTO	Overall Period	Pre-WTO	Post-WTO	Overall Period	Pre-WTO	Post-WTO	Overall Period	Pre-WTO	Post-WTO	Overall Period
Prices in rupee												
Constant	4.36 (135.7)	4.43 (266.63)	4.41 (328.61)	4.40 (208.43)	4.44 (271.99)	4.42 (368.67)	4.39 (194)	4.43 (266.04)	4.42 (361.59)	4.44 (109.37)	4.44 (271.56)	4.43 (326.98)
Estimates of ARCH term (α_i)	0.24 (2.51)	0.04 (0.39)	0.086* (3.00)	0.17* (2.65)	0.19 (1.76)	0.13* (3.59)	0.24** (1.98)	0.04 (0.40)	0.17* (2.76)	0.33 (3.17)	0.07 (0.75)	0.06* (2.89)
Estimates of GARCH term (β_i)	0.00 (0)	0.40 (0.30)	0.84* (14.81)	0.74* (9.12)	0.05 (0.17)	0.77* (13.23)	0.58* (3.07)	0.46 (0.34)	0.61* (4.83)	0.00 (0)	0.32 (0.41)	0.89 (21.01)
Log likelihood	207.42	365.02	562.77	212.24	374.58	578.60	216.96	367.50	576.62	216.93	370.85	579.39
$\alpha i + \beta i$	0.24	0.44	0.926	0.92	0.24	0.9	0.82	0.5	0.78	0.33	0.39	0.95
Volatility	Low	Medium	Very High	Very High	Low	Very High	High	Medium	High	Low	Low	Very High
Prices in dollar												
Constant	0.58 (0.44)	0.92 (0.43)	0.57 (0.18)	0.63 (0.02)	0.92 (1.14)	0.62 (0.59)	0.61 (0.43)	0.91 (0.24)	0.61 (0.13)	0.80 (0.90)	0.92 (1.78)	0.81 (0.12)
Estimates of ARCH term (α_i)	0.32* (3.03)	0.17** (2.47)	0.24* (4.11)	0.45* (3.27)	0.23* (2.90)	0.32* (4.49)	0.39* (3.51)	0.17 (2.43)	0.25* (4.42)	0.37* (3.41)	0.19* (2.48)	0.27* (4.30)
Estimates of GARCH term (β_i)	0.34** (1.91)	0.23 (1.17)	0.27** (2.45)	0.27** (2.07)	0.17 (1.04)	0.22* (2.65)	0.54* (4.28)	0.20 (1.08)	0.35* (3.11)	0.32 (2.00)	0.20 (1.23)	0.24* (2.48)
Log likelihood	191.13	270.14	459.37	196.64	276.12	470.56	200.72	270.85	465.42	187.32	274.07	458.79
$\alpha i + \beta i$	0.66	0.4	0.51	0.72	0.4	0.54	0.93	0.37	0.6	0.69	0.39	0.51
Volatility	High	Medium	Medium	High	Medium	Medium	Very High	Low	Medium	High	Medium	Medium

Note: * denotes significant at one per cent level, ** denotes significant at five per cent level, *** denotes significant at ten per cent level

4.2 PRICE TRANSMISSION AND MARKET INTEGRATION

4.2.1 Cointegration analysis using monthly prices

The nature and extent of price transmission between the domestic and international markets of black pepper during different time periods were analysed in both pair-wise and multiple cointegration frame works. Integration among different markets in India and between Indian and international markets were analysed for the pre-WTO, post-WTO and overall period using monthly data. The cointegration analysis was done separately for prices in nominal rupee and dollar terms. Before attempting cointegration tests, the univariate time series properties of the price data were examined using Augmented Dickey Fuller (ADF) tests and they were performed to confirm that all the price series were non-stationary at levels and integrated of the same order. All the price series in rupee as well dollar terms were transformed into natural logarithm before testing for stationarity as well as cointegration. The estimated test statistics from the ADF tests for nominal as well as real prices, in different domestic and international markets, at levels and first difference in different time periods are presented in Table 4.24. The null hypothesis of non-stationary could be rejected for most of the prices after first differencing and the exceptions to this were the real prices of black pepper in most of the domestic markets as well as the international market which were found to be stationary at levels. Hence, the real prices were not considered for the cointegration analysis. The results of the stationarity tests implied that the nominal price series (rupee as well as dollar) in the pre-WTO, post-WTO and overall periods, contained a single unit root and were integrated of order one.

Cointegration analysis was carried out for the price series which were of the same order of integration. For all the three pair-wise cointegration between nominal Indian and international prices in rupee, (Table 4.25) i.e., Cochin Malabar Garbled with New York prices of Malabar Garbled pepper (New York MG1), Cochin Ungarbled with New York MG1 and Calicut Nadan with New York MG1, the null

hypothesis of no cointegration was rejected for Pre-WTO, post-WTO and overall periods, while the null hypothesis of r<=1 was confirmed. Similarly, ail the pair-wise cointegration using domestic prices *viz.*, Cochin Malabar Garbled, Cochin Ungarbled and Calicut Nadan, proved the existence of one cointegrating relationship among each of the pair in all the time periods which proved the co-movement of prices in different markets of black pepper within the country.

The results of the pair-wise cointegration analysis for prices in dollar is presented in Table 4.26. The null hypothesis of r<=1 could be confirmed for all the combinations of dollar prices in all the periods. The cointegration analysis thus proved that the markets were cointegrated or the nominal rupee and dollar prices in the Indian markets move together with international prices even before liberalization and liberalization *per se* has not much improved or affected the co-movement of prices between the domestic and international markets. The analysis also proved the existence of strong co-movement of prices between the markets of black pepper within the country.

As the four market price series for pepper, *viz.*, Cochin garbled, Cochin ungarbled, Calicut Nadan and New York Malabar Garbled 1, were integrated of the same order, the test for cointegration among multiple markets was attempted using the Maximum Likelihood Estimation procedure (Johansen and Juselius, 1990) as it provides most efficient estimate of the cointegrating vectors and also identifies the number of cointegrating relationship among the non-stationary variables. The multivariate cointegration tests for prices of pepper in four markets in rupee and dollar terms in pre-WTO, post-WTO and overall time periods (Table 4.27) confirmed that the null hypothesis of no cointegration (r=0), at least one cointegration (r=1), at least two cointegrations (r=2), could be rejected at one per cent level of significance for all the periods. But the null hypothesis of r<=3 was accepted confirming that there are three or less than three cointegrating vectors among the different price series (three Indian and one international) in all the periods. Since the number of price

series included in the cointegration test for pepper was four (n=4), the number of common stochastic trends turned out to be one. Similar results were obtained in the case of multiple cointegration analysis with three domestic market prices viz., Cochin Malabar Garbled, Cochin Ungarbled and Calicut Nadan. In this case also the null hypothesis of no cointegration and at least one cointergration (r=0, r=1) could be rejected at one per cent level of significance for all the periods. But the null hypothesis of r<=2 was accepted confirming that there are two or less than two cointegrating vectors among the different domestic price series (three Indian) in all the periods. Since the number of price series included in the cointegration test for pepper was three (n=3), the number of common stochastic trends turned out to be one. The finding of n-1 cointegrating vectors in multiple cointegration analyses using three domestic prices alone as well as three domestic prices and one international price in different time periods, implies that all the prices contain the same stochastic trend and therefore are pair-wise cointegrating. It could be seen that the number of markets that were cointegrated in all the periods were the same and all the markets were cointegrated even before liberalization. The cointegration analysis carried out for black pepper suggests that even in the pre-WTO period there was transmission of price signals between the domestic and the international markets of pepper. Thus, the cointegration analysis proved co-movement of prices, even before the liberalization era.

Table 4.24 Results of the stationarity tests for monthly nominal and real prices of black pepper

	Market/Price Series	Pre WTO (1980 - 1994)				Post WTO (1995 - 2014)				Overall Period (1980 - 2014)			
		Price in rupee		Price in dollar		Price in rupee		Price in dollar		Price in rupee		Price in dollar	
		Rho	Tau	Rho	Tau	Rho	Tau	Rho	Tau	Rho	Tau	Rho	Tau
Nominal Prices													
Levels	Cochin Malabar Garbled	-6.95	-1.95	-5.01	-1.41	-1.94	-0.74	-3.01	-1.04	-7.04	-1.73	-6.46	-1.59
	Cochin Ungarbled	-3.84	-1.46	-2.97	-1.27	-2.02	-0.81	-1.58	-0.89	-5.82	-1.80	-3.50	-1.36
	Calicut Nadan	-4.33	-1.57	-3.38	-1.40	-1.49	-0.69	-2.20	-0.91	-5.13	-1.63	-4.40	-1.42
	New York Malabar Garbled 1	-5.49	-1.48	-3.26	-1.64	-1.25	-0.98	-1.61	-1.19	-6.47	-1.60	-5.18	-1.5
First Difference	Cochin Malabar Garbled	-209.1*	-9.53*	-200.1*	-10.75*	-191.46*	-12.47*	-184.86*	-12.11*	-387.35*	-15.84*	-312.71*	-15.72*
	Cochin Ungarbled	-218.2*	-11.73*	-205.9*	-11.77*	-1089*	-12.86*	1041.86*	-14.75*	-1595.79*	-17.45*	1560.82*	-18.63*
	Calicut Nadan	-594.6*	-13.39*	-551.1*	-13.09*	-963.18*	-12.56*	-951.07*	-12.15*	-1536.19*	-19.72*	-1685.7*	-19.17*
	New York Malabar Garbled 1	-421.3*	-9.98*	-343.2*	-10.43*	-508.15*	-11.49*	-468.64*	-11.13*	1287.32*	-14.71*	1230.03*	-14.01*
Real Prices													
Levels	Cochin Malabar Garbled	-57.95*	-5.60*	-4.45	-1.31	-25.78	-3.57	-3.46	-1.06	-55.3*	-5.27*	-7.97*	-1.84*
	Cochin Ungarbled	-99.49*	-8.19*	-3.53	-1.56	-49.48	-3.77	-6.16	0.86	-77.5*	-5.7*	-4.69*	-1.54*
	Calicut Nadan	-119.64*	-10.19*	-3.79	-1.21	-47.65	-3.11	-2.67	-0.88	-87.05*	-5.13*	-6.57	-1.62
	New York Malabar Garbled 1	-45.30*	-5.25*	-3.83	-1.35	-76.32*	-5.13*	-2.08	-1.49	-113.0*	-7.69*	-8.38	-2.04
First Difference	Cochin Malabar Garbled	-284.47*	-14.56*	-205.4*	-10.23*	-260.9*	-16.81*	181.3*	-11.94*	-456.8*	-22.37*	-308.26*	-15.59*
	Cochin Ungarbled	-260.88*	-13.09*	-181.3*	-6.99*	-1156.6*	-17.38*	-892.3*	-14.66*	-2138.1*	16.20*	-1379.7*	-18.61*
	Calicut Nadan	-8180.5*	-10.38*	-954.8*	-12.47*	-1407.2*	-15.62*	-937.9*	12.12*	-2143.1*	-17.07*	-1637.2*	-19.14*
	New York Malabar Garbled 1	-1345.6*	-10.61*	-490.4*	-10.64*	-1555.0*	-11.07*	-937.9*	-10.69*	-1780.5*	-13.89*	-721.07*	-13.7*

Note: * denotes significant at one per cent level, ** denotes significant at five per cent level, *** denotes significant at ten per cent level

Table 4.25 Results of pair-wise cointegration tests between Indian and international monthly prices of black pepper in rupee

Pairs of markets	Pre-WTO (1980 - 1994)			Post-WTO (1995-2014)			Overall (1980-2014)		
	Eigen Value	Trace Test		Eigen Value	Trace Test		Eigen Value	Trace Test	
		Null	λ-trace		Null	λ-trace		Null	λ-trace
Cochin MG and New York MG 1	0.106	r = 0	20.63.	0.141	r = 0	36.59	0.11	r = 0	51.01
	0.003	r<=1	0.54	0.0008	r<=1	0.188	0.00	r<=1	0.00
Cochin Ungarbled and New York MG 1	0.209	r = 0	42.87	0.138	r = 0	35.69	0.167	r = 0	76.72
	0.005	r<=1	0.84	0.0004	r<=1	0.107	0.00	r<=1	0.021
Calicut Nadan and New York MG 1	0.203	r = 0	41.48	0.153	r = 0	39.98	0.155	r = 0	70.81
	0.005	r<=1	0.89	0.0009	r<=1	0.205	0.00	r<=1	0.0001
Cochin MG and Cochin Ungarbled	0.574	r = 0	153.79	0.222	r = 0	60.08	0.41	r = 0	219.7
	0.006	r<=1	1.04	0.0004	r<=1	0.094	0.0001	r<=1	0.46
Cochin MG and Calicut Nadan	0.624	r = 0	175.9	0.386	r = 0	116.82	0.368	r = 0	192.67
	0.005	r<=1	0.97	0.001	r<=1	0.25	0.00	r<=1	0.018
Cochin Ungarbled and Calicut Nadan	0.381	r = 0	86.57	0.418	r = 0	129.39	0.396	r = 0	211.06
	0.004	r<=1	0.76	0.001	r<=1	0.155	0.00	r<=1	0.011

Critical value for r=0 is 15.34 and r<=1 is **3.84** at 5 per cent significance level

Table 4.26 Results of pair-wise cointegration tests between Indian and International monthly prices of black pepper in dollar

Pairs of markets	Pre-WTO (1980 - 1994)			Post-WTO(1995-2011)			Overall (1980-2014)		
	Eigen Value	Trace Test		Eigen Value	Trace Test		Eigen Value	Trace Test	
		Null	λ-trace		Null	λ-trace		Null	λ-trace
Cochin MG 1 and New York MG 1	0.097	r = 0	19.49	0.14	r = 0	36.01	0.11	r = 0	46.95
	0.0066	r<=1	1.18	0.00	r<=1	0.006	0.00	r<=1	0.06
Cochin Ungarbled and New York MG 1	0.104	r<=0	26.75	0.18	r = 0	46.3	0.163	r = 0	74.5
	0.002	r<=1	0.43	0.00	r<=1	0.004	0.0004	r<=1	0.148
Calicut Nadan and New York MG 1	0.185	r = 0	38.27	0.15	r = 0	39.26	0.149	r = 0	67.78
	0.009	r<=1	1.63	0.00	r<=1	0.003	0.0003	r<=1	0.11
Cochin MG 1 and Cochin Ungarbled	0.47	r = 0	117.62	0.46	r = 0	145.39	0.344	r = 0	176.49
	0.0139	r<=1	2.49	0.00	r<=1	0.008	0.0001	r<=1	0.0537
Cochin MG 1 and Calicut Nadan	0.499	r = 0	125.97	0.39	r = 0	117.27	0.317	r = 0	159.5
	0.0117	r<=1	2.11	0.00	r<=1	0.002	0.0001	r<=1	0.029

Critical value for r=0 is 15.34 and r<=1 is 3.84

Table 4.27 Results of multiple cointegration tests between Indian and international monthly prices of black pepper in rupee and dollar

Pairs of markets	Pre-WTO (1980 - 1994)			Post-WTO (1995-2011)			Overall period (1980-2014)		
	Eigen Value	Trace Test		Eigen Value	Trace Test		Eigen Value	Trace Test	
		Null	λ-trace		Null	λ-trace		Null	λ-trace
Nominal prices in rupee									
Cochin MG 1, Cochin Ungarbled and Calicut Nadan	0.63	r = 0	262.23	0.445	r = 0	190.05	0.44	r = 0	435
	0.38	r<=1	85.57	0.186	r<=1	49.32	0.37	r<=1	192.58
	0.006	r<=2	1.02	0.0006	r<=2	0.14	0.0001	r<=2	0.039
Cochin MG 1, Cochin Ungarbled, Calicut Nadan and New York MG 1	0.64	r = 0	295.06	0.45	r = 0	230.31	0.45	r = 0	491.92
	0.401	r<=1	111.94	0.22	r<=1	87.77	0.369	r<=1	239.62
	0.102	r<=2	20.08	0.115	r<=2	29.45	0.104	r<=2	46.24
	0.005	r<=3	0.903	0.0006	r<=3	0.135	0.0001	r<=3	0.029
Nominal prices in dollar									
Cochin MG 1, Cochin Ungarbled and Calicut Nadan	0.503	r = 0	210.33	0.463	r = 0	238.25	0.36	r = 0	341.15
	0.369	r<=1	85.03	0.313	r<=1	89.79	0.31	r<=1	154.19
	0.014	r<=2	2.506	0.00	r<=2	0.002	0.0002	r<=2	0.064
Cochin MG 1, Cochin Ungarbled, Calicut Nadan and New York MG 1	0.52	r = 0	238.01	0.47	r = 0	275.99	0.37	r = 0	394.13
	0.38	r<=1	107.64	0.33	r<=1	125.04	0.31	r<=1	201.99
	0.105	r<=2	21.82	0.114	r<=2	28.83	0.103	r<=2	45.85
	0.0113	r<=3	2.03	0.00	r<=3	0.002	0.0002	r<=3	0.093

Critical value for r=0 is 47.21, r<=1 is 29.38, r<=2 is 15.34 and r<=3 is 3.84

4.2.2 Cointegration analysis using weekly prices

The price transmission and integration among different markets in India and between Indian and international markets were also analysed for the pre-WTO, post-WTO and overall period using weekly data. The univariate time series properties of the price data were examined using Augmented Dickey Fuller (ADF) tests and they were performed to confirm that all the price series were non-stationary at levels and integrated of the same order. All the price series in rupee as well dollar terms were transformed into natural logarithm before testing for stationarity as well as cointegration. The estimated test statistics from the ADF tests for nominal as well as real prices, in different domestic and international markets, at levels and first difference in different time periods are presented in Table 4.28. The null hypothesis of non-stationary could be rejected for most of the prices after first differencing and the exceptions to this were the real prices of black pepper in most of the domestic markets as well as the international market which were found to be stationary at levels. Hence, the real prices were not considered for the cointegration analysis. The results of the stationarity tests implied that the nominal price series (rupee as well as dollar) in the pre-WTO, post-WTO and overall periods, contained a single unit root and were integrated of order one.

In the pair-wise cointegration analysis using weekly data (Table 4.29), the cointegration between domestic and international markets were analysed using the nominal rupee and dollar prices. Both the pairwise cointegration analysis, the one between Cochin Garbled and Malabar Garbled 1 prices in New York market and other one between Cochin Ungarbled and Malabar Garbled 1 prices in New York market in both rupee and dollar terms, confirmed the null hypothesis of $r<=1$, thus proving that the two markets were cointegrated or the weekly nominal rupee and dollar prices in the Indian markets move together with international prices.

Table 4.28 Results of the stationarity tests for weekly prices of black pepper

Market/Price Series		Pre WTO (1980 - 1994)				Post WTO (1995 - 2011)				Overall Period (1980 - 2014)			
		Price in rupee		Price in dollar		Price in rupee		Price in dollar		Price in rupee		Price in dollar	
		Rho	Tau	Rho	Tau	Rho	Tau	Rho	Tau	Rho	Tau	Rho	Tau
Nominal price													
Levels	Calicut Nadan	-4.33	-1.44	-3.38	-1.28	-1.49	-0.61	-2.20	-0.84	-6.15	-1.59	-5.46	-1.43
	Calicut Wyanadan	-5.10	-1.58	-3.81	-1.37	-1.62	-0.64	-2.42	-0.89	-5.63	-1.52	-5.01	-1.35
	Cochin Ungarbled	-2.97	-1.36	-3.84	-1.20	-2.02	-0.76	-2.96	-1.04	-6.95	-1.72	-5.30	-1.42
	New York MG 1	-4.61	-1.51	-3.26	-1.28	-1.75	-0.69	-2.29	-0.87	-6.47	-1.69	-5.18	-1.41
First Difference	Calicut Nadan	-711.6*	-25.5*	-719.1*	-25.8*	-981.39*	-30.37*	-963.6*	-29.93*	-1685.68*	-39.71*	-1693.7*	-39.52*
	Calicut Wyanadan	-721.3*	-25.8*	-726.1*	-26.1*	-1039.5*	-32.09*	-1023*	-31.63*	-1762.2*	-41.23*	-1751.1*	-40.96*
	Cochin Ungarbled	-721.4*	-25.8*	-723.6*	-25.9*	-855.5*	-26.85*	-830.3*	-26.19*	-1369.57*	-26.14*	-1560.8*	-36.88*
	New York MG 1	-628.3*	-22.9*	-600.1*	-22.0*	-763.76*	-19.48*	-723.1*	-18.96*	-1287.32*	-25.34*	-1230.0*	-24.76*
Real price													
Levels	Calicut Nadan	-123.02*	-7.24*	-99.59	-1.22	-54.37*	-5.14*	-2.67	-0.89	-99.59*	-6.72*	-8.38	-1.50
	Calicut Wyanadan	-103.43*	-6.74*	-3.09	-1.26	-80.84*	-6.26*	-2.76	-0.91	131.56*	-7.72*	-6.02	-1.56
	Cochin Ungarbled	-98.89*	-6.56*	-2.59	-1.15	-46.39*	-4.76*	-3.17	-1.01	-81.07*	-6.11*	-6.19	-1.59
	New York MG 1	-47.45*	-4.96*	-2.64	-1.19	-76.32*	-6.25*	-4.59	-1.51	-4.97*	-7.89*	-3.52	-2.09
First Difference	Calicut Nadan	-4207.8*	-23.8*	-726.1*	-26.0*	-3569.8*	-20.0*	-993.3*	-30.76*	-10237.7*	-27.78*	-1729.3*	-40.29*
	Calicut Wyanadan	-4480.1*	-23.9*	-724.6*	-25.9*	-1949.72*	-22.38*	-1029*	-31.81*	-7739.06*	-23.41*	-1754.9*	-41.07*
	Cochin Ungarbled	-6246.7*	-24.9*	-953.8*	-26.1*	-1156.62*	-35.94*	-892.3*	-27.86*	-5275.49*	-32.80*	-1624.8*	-38.23*
	New York MG 1	-817.8*	-29.3*	-640.5*	-23.3*	-1126.5*	-34.93*	-358.6*	-10.82*	-1941.77*	-45.51*	-721.07*	15.02*

Note: * denotes significant at one per cent level, ** denotes significant at five per cent level, *** denotes significant at ten per cent level

Table 4.29 Pair wise cointegration tests between Indian and international weekly prices of black pepper in rupee and dollar

Pairs of markets	Pre-WTO (1980 - 1994)			Post-WTO (1995-2011)			Overall (1980-2014)		
	Eigen Value	Trace Test		Eigen Value	Trace Test		Eigen Value	Trace Test	
		Null	λ-trace		Null	λ-trace		Null	λ-trace
Nominal Prices in rupee									
Cochin Ungarbled and New York MG 1	0.0446	r = 0	36.028	0.057	r = 0	61.897	0.048	r = 0	90.406
	0.0005	r<=1	0.378	0.0004	r<=1	0.433	0.000	r<=1	0.034
Nominal Prices in dollar									
Cochin Ungarbled and New York MG 1	0.0404	r = 0	33.09	0.0618	r = 0	66.621	0.048	r = 0	90.69
	0.0011	r<=1	0.866	0.000	r<=1	0.0289	0.000	r<=1	0.0009

Critical value for r=0 is 15.34 and r<=1 is 3.84

Table 4.30 Results of multiple cointegration tests between Indian and international weekly prices of black pepper in rupee and dollar

Pairs of markets	Pre-WTO (1980 - 1994)			Post-WTO (1995-2011)			Overall (1980-2014)		
	Eigen Value	Trace Test		Eigen Value	Trace Test		Eigen Value	Trace Test	
		Null	λ-trace		Null	λ-trace		Null	λ-trace
Nominal Prices in rupee									
Calicut Nadan, Calicut Wayanadan and Cochin Ungarbled	0.325	r = 0	349.39	0.223	r = 0	429.41	0.237	r = 0	657.00
	0.052	r<=1	42.44	0.147	r<=1	166.49	0.0858	r<=1	163.81
	0.0007	r<=2	0.545	0.0001	r<=2	0.083	0.000	r<=2	0.000
Calicut Nadan, Calicut Wayanadan, Cochin Ungarbled and New York MG 1	0.333	r = 0	393.88	0.225	r = 0	495.52	0.239	r = 0	750.89
	0.057	r<=1	76.907	0.155	r<=1	229.14	0.089	r<=1	251.16
	0.039	r<=2	31.145	0.0501	r<=2	53.94	0.0434	r<=2	81.134
	0.0005	r<=3	0.374	0.0003	r<=3	0.309	0.000	r<=3	0.026
Nominal Prices in dollar									
Calicut Nadan, Calicut Wayanadan and Cochin Ungarbled	0.327	r = 0	379.36	0.224	r = 0	443.72	0.229	r = 0	706.85
	0.083	r<=1	69.683	0.158	r<=1	179.61	0.118	r<=1	229.79
	0.002	r<=2	1.498	0.000	r<=2	0.025	0.0001	r<=2	0.2005
Calicut Nadan, Calicut Wayanadan, Cochin Ungarbled and New York MG 1	0.336	r = 0	420.911	0.228	r = 0	515.98	0.234	r = 0	805.61
	0.086	r<=1	100.951	0.166	r<=1	245.82	0.123	r<=1	318.84
	0.037	r<=2	30.551	0.052	r<=2	56.19	0.042	r<=2	78.72
	0.001	r<=3	0.881	0.000	r<=3	0.0053	0.000	r<=3	0.0025

Critical value for r=0 is 47.21, r<=1 is 29.38, r<=2 is 15.34 and r<=3 is 3.84

As the four weekly price series for black pepper, *viz*., Cochin garbled, Calicut Wyanadan, Calicut Nadan and New York Malabar Garbled 1, were integrated of the same order, the test for cointegration among multiple markets was attempted using the Maximum Likelihood Estimation procedure (Johansen and Juselius, 1990) as it provides most efficient estimate of the cointegrating vectors and also identifies the number of cointegrating relationship among the non-stationary variables. The multivariate cointegration tests for prices of pepper four markets in rupee and dollar terms in pre-WTO, post-WTO and overall time periods (Table 4.30) confirmed that the null hypothesis of no cointegration (r=0), at least one cointegration (r=1), at least two cointegrations (r=2), could be rejected at one per cent level of significance for all the periods. But the null hypothesis of r<=3 was accepted confirming that there are three or less than three cointegrating vectors among the different price series (three Indian and one international) in all the periods. Since the number of price series included in the cointegration test for pepper was four (n=4), the number of common stochastic trends turned out to be one. Similar results were obtained in the case of multiple cointegration analysis with three domestic market prices viz., Cochin Malabar Garbled, Cochin Ungarbled and Calicut Nadan. In this case also the null hypothesis of no cointegration and at least one cointergration (r=0, r=1) could be rejected at one per cent level of significance for all the periods. But the null hypothesis of r<=2 was accepted confirming that there are two or less than two cointegrating vectors among the different domestic price series (three Indian) in all the periods. Since the number of price series included in the cointegration test for pepper was three (n=3), the number of common stochastic trends turned out to be one. The finding of n-1 cointegrating vectors in multiple cointegration analyses using three domestic prices alone as well as three domestic prices and one international price in different time periods, implies that all the prices are pair-wise cointegrating. The cointegration analysis using weekly prices also prove that same number of were cointegrated in all the periods and all the markets were cointegrated even before liberalization. The cointegration analysis carried out for black pepper suggests that

even in the pre-WTO period there was transmission of price signals between the domestic and the international markets of pepper and transmission of prices between Indian and international markets of black pepper is not a neo-liberal phenomenon.

4.2.3 Price Transmission -Granger Causality Tests

The cointegration analysis proved that the prices moved together and there is transmission of price signals between the domestic market as well as the domestic and international markets and that there is causality at least in one direction. But it does not provide information regarding the direction of flow of prices, i.e. whether it is from international to Indian markets or from Indian to international markets or in both directions. The Granger causality tests provide additional evidence as to whether and in which direction, price transmission is occurring between two price series. The tests carried out on monthly prices in both rupee and dollar terms (Table 4.31 and 4.32) proved that the Cochin MG, Cochin Ungarbled and Calicut Nadan prices caused the MG1 New York prices in the pre-WTO period, thus suggesting unidirectional causality from domestic to international market for Malabar garbled pepper and not from MG1 New York to domestic markets. In the case of post-WTO period, in addition to causality from domestic to international markets as in the pre-WTO period, causality from MG1 New York to Calicut Nadan in the case of nominal rupees and MG1 New York to Cochin Ungarbled in dollar prices were significant, indicating bidirectional causality in the post-WTO period. When monthly prices were considered in rupee terms for the overall period, the null hypothesis that MG1 New York does not Granger cause Calicut Nadan was rejected at one per cent level of significance and the null hypothesis of Calicut Nadan does not Granger cause Cochin Ungarbled was rejected at ten per cent level of significance. In the causality tests using dollar prices for the overall period, bidirectional causality was found in most of the cases with the exception of New York to Cochin and Calicut Nadan to Cochin prices. While using weekly price data for the Granger causality tests (Table 4.33 and 4.34), similar results as in the case of analysis using monthly data were obtained.

Table 4.31 Results of the Granger causality test for monthly prices of black pepper in rupee

Null hypothesis	Pre WTO		Post WTO		All periods	
	F Stat	Probability	F Stat	Probability	F Stat	Probability
New York MG1 does not granger cause Cochin MG	0.166	0.847	0.517	0.596	0.312	0.732
Cochin MG does not granger cause New York MG1	9.84*	0.008	12.8*	0.005	22.934	3.589
Calicut Nadan does not granger cause Cochin MG	32.9*	0.007	2.93***	0.055	17.889	3.53
Cochin MG does not granger cause Calicut Nadan	0.0075	0.992	57.15*	0.0064	36.021	3.80
Cochin Ungarbled does not granger cause Cochin MG	68.1*	0.001	0.137	0.871	43.901	5.757
Cochin MG does not granger cause Cochin Ungarbled	0.980	0.377	0.935	0.393	1.180	0.803
Calicut Nadan does not granger cause New York MG1	6.87*	0.001	4.5**	0.011	22.180	7.08
New York MG1 does not granger cause Calicut Nadan	0.691	0.501	17.9*	0.005	6.084*	0.002
Cochin Ungarbled does not granger cause New York MG1	23.37*	0.001	10.48*	0.004	35.388	6.52
New York MG1 does not granger cause Cochin Ungarbled	1.049	0.352	0.799	0.450	0.818	0.441
Cochin Ungarbled does not granger cause Calicut Nadan	3.62**	0.028	55.61*	0.001	53.318	2.521
Calicut Nadan does not granger cause Cochin Ungarbled	0.897	0.409	3.47**	0.032	2.53***	0.0804

Note: * denotes significant at one per cent level, ** denotes significant at five per cent level, *** denotes significant at ten per cent level

Table 4.32 Results of the Granger causality test for monthly prices of black pepper in dollar

Null hypothesis	Pre WTO		Post WTO		All periods	
	F Stat	Probability	F Stat	Probability	F Stat	Probability
New York MG1 does not granger cause Cochin MG	1.084	0.340	0.08	0.932	0.663	0.515
Cochin MG does not granger cause New York MG1	7.45*	0.0008	12.69*	0.005	20.52*	0.006
Calicut Nadan does not granger cause Cochin MG	38.19*	0.001	2.9***	0.056	32.15*	0.001
Cochin MG does not granger cause Calicut Nadan	0.026	0.973	57.67*	0.004	16.20*	0.001
Cochin Ungarbled does not granger cause Cochin MG	60.08*	0.001	6.51*	0.002	27.21*	0.007
Cochin MG does not granger cause Cochin Ungarbled	0.631	0.533	56.92*	0.007	24.3*	0.001
Calicut Nadan does not granger cause New York MG1	14.89*	0.001	4.45**	0.012	19.48	8.28
New York MG1 does not granger cause Calicut Nadan	1.468	0.233	19.47*	0.001	7.17*	0.0008
Cochin Ungarbled does not granger cause New York MG1	18.95*	0.003	9.22*	0.0001	27.92*	0.004
New York MG1 does not granger cause Cochin Ungarbled	1.914	0.150	16.53*	0.001	49.3*	0.007
Cochin Ungarbled does not granger cause Calicut Nadan	10.76*	0.003	7.11*	0.001	14.85*	0.005
Calicut Nadan does not granger cause Cochin Ungarbled	0.453	0.836	3.59**	0.028	1.456	0.234

Note: * denotes significant at one per cent level, ** denotes significant at five per cent level, *** denotes significant at ten per cent level

Table 4.33 Results of the Granger causality test for weekly prices of black pepper in rupee

Null Hypothesis	Pre-WTO		Post-WTO		Overall Period	
	F-Stat	Probability	F-Stat	Probability	F-Stat	Probability
Calicut Nadan does not Granger Cause New York MG1	21.9*	0.006	42.8*	0.001	63.1*	0.003
New YorkMG1 does not Granger Cause Calicut Nadan	3.63**	0.026	15.28*	0.002	16.2*	0.001
Cochin Ungarbled does not Granger Cause New York MG1	18.9*	0.009	46.48*	0.004	61.2*	0.001
New YorkMG1 does not Granger Cause Cochin Ungarbled	4.09*	0.017	11.78*	0.008	13.9*	0.009
Calicut Wayanadan does not Granger Cause New York MG1	21.5*	0.008	30.65*	0.001	52.8*	0.004
New YorkMG1 does not Granger Cause Calicut Wayanadan	2.8***	0.061	20.3*	0.002	18.6*	0.001
Cochin Ungarbled does not Granger Cause Calicut Nadan	52.65*	0.003	133.1*	0.003	180.8*	0.002
Calicut Nadan does not Granger Cause Cochin Ungarbled	2.14	0.118	4.65*	0.009	5.32*	0.0049
Calicut Wayanadan does not Granger Cause Calicut Nadan	4.03**	0.018	6.16*	0.002	10.3*	0.003
Calicut Nadan does not Granger Cause Calicut Wayanadan	5.97*	0.003	30.16*	0.001	31.2*	0.004
Calicut Wayanadan does not Granger Cause Cochin Ungarbled	4.40**	0.012	0.062	0.939	1.7	0.182
Cochin Ungarbled does not Granger Cause Calicut Wayanadan	26.56*	0.007	138.7*	0.004	151.0*	0.002

Note: * denotes significant at one per cent level, ** denotes significant at five per cent level, *** denotes significant at ten per cent level

Table 4.34 Results of the Granger causality test for weekly prices of black pepper in dollar

Null Hypothesis	Pre-WTO		Post-WTO		Overall Period	
	F-Stat	Probability	F-Stat	Probability	F-Stat	Probability
Calicut Nadan does not Granger Cause New York MG1	19.28*	0.006	47.77*	0.001	64.8*	0.006
New YorkMG1 does not Granger Cause Calicut Nadan	5.033*	0.006	15.94*	0.001	18.9*	0.007
Cochin Ungarbled does not Granger Cause New York MG1	17.07*	0.005	56.38*	0.005	67.7*	0.004
New YorkMG1 does not Granger Cause Cochin Ungarbled	5.49*	0.004	12.91*	0.002	16.7*	0.006
Calicut Wayanadan does not Granger Cause New York MG1	18.82*	0.001	33.06*	0.001	51.7*	0.001
New YorkMG1 does not Granger Cause Calicut Wayanadan	5.51*	0.004	21.33*	0.008	22.7*	0.001
Cochin Ungarbled does not Granger Cause Calicut Nadan	53.8*	0.001	138.3*	0.005	181.7*	0.001
Calicut Nadan does not Granger Cause Cochin Ungarbled	1.39	0.249	3.88**	0.020	3.1**	0.046
Calicut Wayanadan does not Granger Cause Calicut Nadan	3.35**	0.035	5.64*	0.003	8.7*	0.0002
Calicut Nadan does not Granger Cause Calicut Wayanadan	10.93*	0.001	32.4*	0.002	40.1*	0.008
Calicut Wayanadan does not Granger Cause Cochin Ungarbled	3.58**	0.028	0.022	0.977	1.24	0.29
Cochin Ungarbled does not Granger Cause Calicut Wayanadan	35.12*	0.002	148.6*	0.001	172.4*	0.002

Note: * denotes significant at one per cent level, ** denotes significant at five per cent level, *** denotes significant at ten per cent level

4.3 RELATIONSHIP BETWEEN SPOT AND FUTURES PRICES

4.3.1 Cointegration analysis using spot and future price

The nature and extent of price transmission between the spot and future prices of black pepper during different time periods were analysed in a pair-wise cointegration framework. Since there were two breaks in the data in 2011 and 2012, the analyses were carried out separately for different periods as well as the pooled data. The univariate time series properties of the daily price data on spot and future prices were examined using Augmented Dickey Fuller (ADF) tests and they were performed to confirm that all the price series were non-stationary at levels and integrated of the same order. The future and spot prices were transformed into natural logarithm before testing for stationarity as well as cointegration. The estimated test statistics from the ADF tests for future and spot prices at levels and first difference in different time periods are presented in Table 4.35. The null hypothesis of non-stationary could be rejected after first differencing. The results of the stationarity tests implied that the future and spot prices in different periods contained a single unit root and were integrated of order one. In the pair-wise cointegration analysis using spot and future market prices, (Table 4.36), the cointegration between these two markets were analysed. The pairwise cointegration analysis confirmed the null hypothesis of r<=1 for the price series from 16/04/03 to 14/06/11 and the overall data from 16/04/03 to 10/04/14, thus proving that the two markets were cointegrated or the future and spot prices move together. This could only be proved for a sufficiently larger set of price observations and not for a smaller series of data with fewer observations.

4.3.2 Price Transmission - Granger causality tests for spot and future prices

The cointegration analysis proved that the spot and future prices moved together in the long run and there is transmission of price signals between spot and future market prices indicating that there is causality at least in one direction. The result of the granger causality test for spot and future prices in Rupee is presented in Table 4.37. The results of the analysis proved that the existence of bidirectional causality between spot and future prices in the long run.

Table 4.35 Results of the stationarity tests for future and spot prices of black pepper

Market/Price Series	Levels				First Difference			
	Spot price		Future price		Spot price		Future price	
	t value	P	t value	P	t value	P	t value	P
16/04/03 to 14/06/11	-2.18	0.5	-2.05	0.57	-20.7	0.0001	-53.2*	0.001
16/12/11 to 24/04/12	-1.96	0.6	-1.94	0.62	-4.9	0.0001	-4.58*	0.0004
28/12/12 to 10/04/14	-1.56	0.8	-2.68	0.24	-22.6	0.000	-9.57*	0.000
Overall period 16/04/03 to 10/04/14	-1.71	0.7	-1.78	0.71	-22.6*	0.0001	-56.6*	0.0001

Note: * denotes significant at one per cent level

Table 4.36 Results of cointergation analysis between spot and future prices

Period	Eigen Value	Trace Test	
		Null	λ-trace
16/04/03 to 14/06/11	0.014	r = 0	33.99*
	0.00017	r<=1	0.041
16/12/11 to 24/04/12	0.1127	r = 0	10.63
	0.0276	r<=1	2.02
28/12/12 to 10/04/14	0.0142	r = 0	4.29
	0.0006	r<=1	0.023
Overall period 16/04/03 to 10/04/14	0.014	r = 0	40.45*
	0.0003	r<=1	0.85

Note: * denotes significant at one per cent level

Table 4.37 Results of the Granger causality test for spot and future prices in rupee

Null Hypothesis	16/04/03 to 14/06/11		Overall period 28/12/12 to 10/04/14	
	F-Stat	P	F-Stat	P
Spot price does not Granger Cause future price	17.4*	0.000	12.78*	0.00003
Future price does not Granger Cause spot price	182.2*	0.000	148*	0.000

Note: * denotes significant at one per cent level

4.4 MICRO-LEVEL IMPLICATIONS OF PRICE VOLATILITY

4.4.1 Socio-economic profile of the sample farmers

A brief description of the general and socio-economic particulars of the respondent farmers with regard to age, gender, education, experience in farming, family size, land holdings, annual income and sources of income, which could help in providing the necessary background information for a proper understanding of the farm as well as the farming situation has been included in this section. The discussions have been made after categorizing the respondents into two groups, *viz.*, PDS farmers and non-PDS farmers.

4.4.1.1 Peermade Development Society (PDS)

PDS is a Non-Governmental Organization (NGO) working for the integrated and sustainable development of the rural poor in Idukki district of Kerala state. It was established in 1980 and is one of the social service divisions of the Catholic Diocese of Kanjirapally. Over the last two decades, PDS as one of the leading NGOs in Kerala, is actively engaged in various socio-economic development activities like integrated tribal development, agricultural development, community health, community organization, environmental sanitation, promotion of indigenous medicines, ecological farming, production and export of organic spices, watershed management, human resource development and development of women and children.

4.4.1.1.1 PDS Organic Spices

'PDS Organic Spices', a unit of Peermade Development Society, is promoting cultivation, processing and marketing of quality organic spices to help marginal farmers achieve sustainable livelihoods. It is an exporter of certified organic spices from India since 1998 to countries like USA, Japan, Germany, U.K, The Netherlands, France, Belgium, Australia etc. They have 2000 certified organic farmers and these farmers are being monitored by an Internal Control System (ICS). The ICS monitors and verifies the activities of farmers as per the stipulated standards, identifies new areas and farmers, conduct trainings and

motivates the farmers, acts as an intermediary between the government departments and farmers, arranges external inspection and certification, maintains all documents and relevant data for individual farms with regard to the farming activities. The ICS consists of nine executive officers and for each executive officer around 250 farmers were being allotted. Farmers are inspected and certified by control union as per NPOP/EU, Demeter, NOP, Bio-Suisse and JAS regulations. The products exported include black pepper, white pepper, green pepper, turmeric, ginger, clove, cardamom, nutmeg and mace.

Pepper farmers could sell their produce to PDS only after a conversation period of three years required for a farm to be considered as fully organic. PDS was giving premium price to farmers, which was based on the prevailing market price and during 2014-15, an additional amount of ₹25-30 per kg over the market price was paid as premium to the member farmers who were selling organic black pepper to PDS. Once the commodity was sold to PDS, the full amount was not settled on that day and the farmers had freedom regarding price settlement. Only 50 per cent of the amount was settled based on the price of black pepper prevailing on that day and the price of the remaining 50 per cent of the produce could be settled on any day within six months as per the request of the farmers at the prevailing market price on that day.

4.4.1.2 Age

The age-wise distribution of the sample respondents is presented in Table 4.38. It could be observed from the table that majority of the farmers in both the categories were aged between 45 and 60 years. More than 15 per cent of the farmers in two groups were above 60 years. There were no farmers aged less than 30 years in any of the groups, indicating the lack of enthusiasm among youngsters in taking up farming as a profession, which is one of the major problems confronting the agricultural sector in Kerala state.

Table 4.38 Age-wise distribution of sample respondents

Category of farmers	Age profile (Years)				Total
	Less than 30	30-45	45-60	Greater 60	
PDS farmers	0 (0)	6 (15)	26 (65)	8 (20)	40 (100)
Non-PDS farmers	0 (0)	6 (15)	27 (67.5)	7 (17.5)	40 (100)
Total	0 (0)	12 (15)	53 (66.25)	15 (18.75)	80 (100)

Note: Figures in parentheses indicate per cent to row totals

4.4.1.3 Gender

The gender-wise classification of the sample farmers are presented in Table 4.39. It could be observed from the table that almost all the pepper growers in two categories were male farmers *i.e.,* 95 per cent of farmers were male and only 2 per cent were female farmers.

Table 4.39 Gender-wise classification of sample respondents

Category of farmers	Gender		Total
	Male	Female	
PDS farmers	38 (95)	2 (5)	40 (100)
Non-PDS farmers	38 (95)	2 (5)	40 (100)
Total	76 (95)	4 (5)	80 (100)

Note: Figures in parentheses indicate per cent to row totals

4.4.1.4 Educational background

The classification of respondents according to educational status is presented in Table 4.40. All the sample farmers were literate and majority of them in both the sample categories were having education up to SSLC. As evident from the table, 7.5 per cent of the farmers in both the categories were degree holders.

Table 4.40 Distribution of sample respondents according to educational status

Category of farmers	Educational status of farmers				Total
	Primary	Up to SSLC	HSC	Degree	
PDS farmers	1 (2.5)	25 (62.5)	11 (27.5)	3 (7.5)	40 (100)
Non-PDS farmers	0 (0)	28 (70)	9 (22.5)	3 (7.5)	40 (100)
Total	1 (1.25)	53 (66.25)	20 (25)	6 (7.5)	80 (100)

Note: Figures in parentheses indicate per cent to row totals

4.4.1.5 Experience in farming

The details on the experience of sample respondents in farming are presented in Table 4.41. The farmers were divided into three categories based on their experience in farming as having less than 10 years, 10 to 30 years and more than 30 years. It could be observed that 80 per cent of the non-PDS farmers were having more than 30 years of experience in farming and the corresponding percentage in the case of PDS farmers was 55 per cent. The PDS farmers were having less years of experience in farming when compared to the non-PDS farmers.

Table 4.41 Distribution of sample respondents according to farming experience

Category of farmers	Year of experience			Total
	Less than 10	10-30	Greater than 30	
PDS farmers	0 (0)	18 (45)	22 (55)	40 (100)
Non-PDS farmers	0 (0)	8 (20)	32 (80)	40 (100)
Total	0 (0)	26 (32.5)	54 (67.5)	80 (100)

Note: Figures in parentheses indicate per cent to row totals

4.4.1.6 Family size

The sample respondents were classified on the basis of their family size and the details are presented in Table 4.42. The availability of family labour for farming operations increases with the size of the family. It could be observed from

the table that the majority of the PDS farmers (60 per cent) were having four to six members in their families and in the category of non-PDS farmers, 70 per cent of them were having families with one to three members.

Table 4.42 Distribution of sample respondents according to family size

Category of farmers	Family size (numbers)			Total
	1-3	4-6	Greater than 7	
PDS farmers	16 (40)	24 (60)	0 (0)	40 (100)
Non-PDS farmers	28 (70)	12 (30)	0 (0)	40 (100)
Total	44 (55)	36 (45)	0 (0)	80 (100)

Note: Figures in parentheses indicate per cent to row totals

4.4.1.7 Land holding pattern

The classification of sample respondents on the basis of size of land holding is given in Table 4.43. The majority of the non-PDS farmers were having marginal land holdings of less than one hectare. In the case of PDS farmers, only 20 per cent were having holdings of less than one hectare and majority of them owned holdings of larger size. Even though PDS was not having any criterion on minimum holding size requirement for a farmer to become a member, the distribution of the sample respondents showed a bias towards farm holdings of comparatively larger size in the case of members of PDS.

Table 4.43 Distribution of respondents according to size of land holding

Category of farmers	Area in hectares				Total
	Less than 1	1 to 2	2 to 4	Greater than 7	
PDS farmers	8 (20)	19 (47.5)	11 (27.5)	2 (5)	40 (100)
Non-PDS farmers	22 (55)	16 (40)	2 (5)	0 (0)	40 (100)
Total	30 (37.5)	35 (43.75)	13 (16.25)	2 (2.5)	80 (100)

Note: Figures in parentheses indicate per cent to row totals

4.4.1.8 Annual income

Classification of respondents according to their annual income is presented in Table 4.44. It could be observed from the below table that 37.5 per cent of the

PDS farmers were having annual income above five lakh rupees and farmers with average annual income in the range of two to five lakh rupees accounted for 35 per cent. More than 60 per cent of the non-PDS farmers were having annual income above one lakh rupees.

Table 4.44 Classification of respondents according to their annual income

Category of farmers	Annual Income (in rupees)					Total
	Less than 50,000	50,000 to 1 lakh	1 lakh to 2 lakh	2 lakh to 5 lakh	Greater than 5 lakh	
PDS farmers	1 (2.5)	1 (2.5)	9 (22.5)	14 (35)	15 (37.5)	40 (100)
Non-PDS farmers	7 (17.5)	8 (20)	13 (32.5)	12 (30)	-	40 (100)
Total	8 (10)	9 (11.25)	22 (27.5)	26 (32.5)	15 (18.75)	80 (100)

Note: Figures in parentheses indicate per cent to row totals

4.4.1.9 Occupational status

Distribution of respondents according to the source of income is presented in Table 4.45. As evident from the table, agricultural and allied sectors formed the major source of income for both the categories of farmers. 95 per cent and above of both PDS and non-PDS farmer members were deriving their income from farming.

Table 4.45 Distribution of sample respondents according to the source of income

Category of farmers	Income source				Total
	Farm income	Public sector	Private sector	Self employed	
PDS farmers	39 (97.5)	0 (0)	0 (0)	1 2.5	40 (100)
Non-PDS farmers	38 (95)	2 (5)	0 (0)	0 (0)	40 (100)
Total	77 96.25	2 (2.5)	0 (0)	1 (1.25)	80 (100)

Note: Figures in parentheses indicate per cent to row totals

4.4.1.10 Consumption expenditure

The details of the consumption expenditure incurred by the sample respondents are presented in Table 4.46.

Table 4.46 Details on the consumption expenditure of sample respondents

Category of farmers	Expenditure				Total
	Less than 50,000	50,000 to 1 lakh	1 lakh to 2 lakh	Greater than 2 lakh	
PDS farmers	4 (10)	17 (42.5)	17 (42.5)	2 (5)	40 (100)
Non-PDS farmers	7 (17.5)	22 (55)	11 (27.5)	0 (0)	40 (100)
Total	11 (13.75)	39 (48.75)	28 (35)	2 (2.5)	80 (100)

Note: Figures in parentheses indicate per cent to row total

It could be observed from the table that majority of the PDS as well non-PDS farmers spent on an average between ₹ 50,000 and 1 lakh for meeting their family consumption expenditure. The percentage of farmers incurring higher consumption expenditure of ₹1 lakh and above was found to more in the PDS category.

4.4.2 Welfare implications of price volatility

4.4.2.1 Comparative analyses of the implications of price volatility on input use, production, income and employment

The impact of price volatility of black pepper on producer households was studied by comparing the price, production, employment, income and number of replanting in two years (2014 and 2015) for PDS and non-PDS farmers and the results are presented in Table 4.47.

It is evident from the table that there was slight reduction in price in 2015 when compared to 2014 for both PDS and non-PDS farmers. The decline in price of black pepper received by the non-PDS farmers was found to be marginally higher than the decline for the PDS farmers, which could be attributed to the additional amount of ₹25-30 per kg paid as premium in addition to the market price to the PDS farmers. Even though the average production of black pepper has increased in PDS as well as non-PDS farms, the growth in production was slightly high in the case of PDS farms. Hence, the non-PDS farms experienced a higher decline in income between 2014 and 2015 when compared to the PDS farmers. Consequent to the reduction in price, the number of pepper plants replanted per

farm decreased for PDS and non-PDS but there was higher percentage decline in the case of non-PDS farmers (29.58 per cent). When the replanting of black pepper per hectare was considered, it was found that the number of plants replanted increased by 53 in 2015 as compared to 2014 in the case of PDS members whereas it decreased by 30 in non-PDS farms. Thus, it could be observed that for a decline in price of a similar nature, there was differential impact on PDS and non-PDS farms and the replanting decisions per hectare varied for the two groups of sample farmers. For the PDS members while the replanting per hectare increased by about 27 per cent, for the non-PDS farmers it decreased by 13 per cent. Consequently, the cost incurred on labour and inputs also showed a similar nature of increasing pattern in PDS farms and a decreasing pattern in non-PDS farms. Even though the membership in PDS and the contractual agreement for purchase of black pepper did not insulate the farmers from price volatility, the implications of price volatility reflected as a reduction in input use or a fewer number of replanting or neglect of the crop were found to be comparatively minimal in the case of PDS farms. This could be attributed to the effective monitoring as well as extension by the executive officers involved in the Internal Control System (ICS) developed by the PDS.

Table 4.47 Implications of price volatility on input use, production, employment and income of PDS and Non-PDS farmers

Particulars	2014		2015		Change		Percentage change	
	PDS	Non-PDS	PDS	Non-PDS	PDS	Non-PDS	PDS	Non-PDS
Average price (Rs./kg)	683	658	625	595	-58	-63	-8.5	-9.55
Average production (kg/ha)	528	473	569	487	41	14	7.75	3.03
Average income (Rs./ha)	359109	311849	352092	302607	-7017	-9242	-1.95	-2.96
Average replanting (No./farm)	201	124	186	88	-15	-37	-7.34	-29.6
Average replanting (No./ha)	198	233	251	203	53	-30	26.65	-13
Average labour cost (Rs./ha)	75753	77296	78335	77115	-2582	181	3.41	-0.23
Average input cost (Rs./ha)	17532	16930	18932	16231	-1400	699	7.98	-4.13

Plate 1 Survey of PDS farmers

Plate 2 Survey of non-PDS farmers

4.4.3 Vulnerability of PDS and non-PDS farmers to price volatility

The vulnerability of black pepper farmers to price volatility was studied using a linear regression model and the estimates of the fitted regression model are presented in Table 4.48.

Table 4.48 Estimates of the regression model on vulnerability to price volatility

Variable	Coefficient	Std. Err.	t value	P>|t|	Significance
Constant	8.975	2.744	3.270	0.002	
Age (Years)	-0.139	0.074	-1.880	0.065	*
Total Area (Hectares)	0.076	0.416	0.180	0.856	
Experience in farming (Years)	0.102	0.062	1.660	0.103	
Number of family members	0.357	0.211	1.690	0.095	*
Share of income from pepper (%)	0.018	0.010	1.750	0.086	*
Membership in PDS (Dummy)	-0.288	0.695	-0.410	0.680	
Period of storage (Months)	0.004	0.046	0.090	0.925	
Non-Crop income (Rupees)	-0.004	0.0000	-1.030	0.306	
Transportation cost (Rupees)	0.001	0.003	0.420	0.679	
Gender (Dummy)	-2.250	0.628	-3.580	0.001	***
Education (Dummy)	-1.244	0.654	-1.900	0.062	*

Note: *** indicates significant at 1 % level, * indicates significant at 10 % level

Dependent Variable - Volatility in Price (Coefficient of variation in black pepper price)

Number of observations = 80, Probability of F = 0.0324

Adjusted R-squared = 0.47

The dependent variable in the linear regression model was the volatility in price of black pepper estimated as the Coefficient of Variation in price. The adjusted R squared value of 0.47 indicated that 47 per cent of the variation in the dependent variable, vulnerability to price volatility, was explained by the included

explanatory variables. The F value which indicates the overall significance of regression was found to be significant. The variables like age, gender and education were found to reduce the vulnerability to price volatility whereas number of family members and share of income from pepper increased the vulnerability. With increase in age, the experience in farming as well as marketing and the knowledge on coping strategies could possibly increase and hence cause a reduction in vulnerability to price volatility. Gender was influencing the vulnerability to price volatility and the male headed farm households could have responded to price volatility in a better manner in terms of coping strategies. Education also could increase the knowledge on strategies to overcome risk and also coping mechanisms. When there is an increase in the number of family members, the urgency to sell black pepper at the available prices is more as the family expenditure requirements would be more. Hence, there will be only limited tendency among the farmers with large family size to store black pepper and they might be forced to sell the commodity at the available prices, thus becoming more vulnerable to price volatility. Crop and income diversifications are strategies to cope with price volatility and therefore with increase in the share of income from a particular crop (black pepper) in total income of a farm household, the vulnerability to price fluctuations could increase. It was also found that the membership in PDS was not a significant factor reducing the vulnerability to price fluctuations. The prices that were paid to the PDS farmers also varied with the market price and they were only paid ₹ 25-30 as premium in addition to the prevailing market price. They had the flexibility regarding the settlement of price for 50 per cent of the produce sold to PDS which could be settled on any day within six months of handing over the commodity to PDS at the prevailing market price on that day.

4.4.4 Constraints in the production of black pepper

The PDS and non-PDS farmers' face several constraints in the production of black pepper. The major constraints were listed and then ranked based on the responses of the pepper growers during the sample survey. The ranks were then

converted to mean scores (Garett ranking) for getting a real picture of the constraints prevailing in the study area. The constraints in production of black pepper as identified by the respondent farmers were ranked and are presented in Table 4.49. Disease and pest incidence was identified as the major constraint in black pepper production by both PDS and non-PDS farmers. The mean score for this constraint was 51.55 and 61.1 respectively for PDS and non-PDS farmers. Climate change was identified as the second major constraint by both the groups of farmers. The other constraints identified were labour shortage, price variability and high wage rate. Variability in prices was identified only as the fourth major constraint by the farmers and could possibly be due to the reason that they were used to this problem even from the earlier days, whereas the first three constraints were more of recent origin. Price variability could be increasing or decreasing prices and since the prices were on the higher side of price cycle in the preceding years, farmers could not have perceived it as a major problem in the present context.

Table 4.49 Constraints faced by farmers in black pepper production

Problems	PDS farmers		Non-PDS farmers	
	Garett score	Rank	Garett score	Rank
Disease and pest incidence	51.55	1	61.1	1
Climate change	43.35	2	45.75	2
Labour shortage	41.27	3	30.17	3
Price variability	28.78	4	21.28	4
High wage rate	7.53	5	10.02	5

Summary and Conclusion

5. SUMMARY AND CONCLUSION

The study entitled "Price volatility of black pepper and its implications in Kerala" aimed at assessing the magnitude and determinants of volatility in prices of black pepper in the pre-liberalization and post-liberalization periods. The transmission of price volatility between Indian and international markets as well as spot and futures prices of black pepper were also analysed in the study. The implications of price volatility on input use, production, employment and income of farmers who were members of Peermedu Development Society (PDS), an NGO organising organic black pepper farmers and having a contractual agreement for purchase of pepper and non-PDS farmers without any contractual arrangement, were studied on a comparative framework.

The results of the intra-annual and inter-annual volatility indices of black pepper prices brought out the following results. The intra-annual volatility of monthly nominal prices in rupee as well as dollar declined marginally in the post-WTO period. A similar pattern was observed for real prices with the exception of Cochin Malabar Garbled in rupee, for which it increased in the post-WTO period. In the case of international prices, the decline in intra-annual volatility was comparatively more when compared to the Indian prices. The difference between the values of the intra-year volatility indices for Malabar Garbled pepper in both Cochin (domestic) and New York (international) markets decreased in the post-WTO period. The intra-annual volatility indices for monthly prices were less than 10 per cent for all the periods under consideration.

The magnitudes of the estimated intra-annual volatility indices for weekly black pepper prices were larger in comparison with those computed for the monthly prices indicating that the weekly prices were more volatile. The weekly real and nominal prices in domestic as well as international markets showed decrease in intra-annual volatility in the post-WTO period. The intra-annual volatility for weekly international nominal prices was comparatively lower than

that for the domestic prices in pre-WTO and post-WTO periods. In the case of weekly real prices, the magnitude of within the year price fluctuations was lower for Newyork Malabar Garbled 1 in comparison with Cochin Malabar Garbled in the post-WTO period.

The inter-annual volatility, as indicated by the Parkinson's index, for monthly domestic market prices in rupee showed a mixed pattern. While the inter-annual volatility increased for Malabar Garbled Cochin prices that of Cochin Ungarbled decreased for both nominal and real monthly prices in the post-WTO period. In the international markets, the year to year variability in real and nominal rupee and dollar prices decreased in the post-WTO period. The inter-annual volatility of weekly nominal prices increased in the post-WTO period in the domestic and international markets, where as it decreased for real prices in the international market. The inter-annual volatility of weekly nominal prices was found to be higher in the domestic market when compared to the international market; on the other hand for real prices in rupee, the volatility was greater for the international prices.

The results of the analysis of instability in annual prices showed that the magnitude of the volatility indices of nominal as well as real prices in both rupee and dollar increased in the post-WTO period. The annual price instability of nominal and real prices in the international market was higher than the domestic price instability in the pre-WTO period, where as in the post-WTO period, the instability in domestic prices was higher. For nominal pepper prices in dollars, the instability in the pre-WTO period itself was higher than that for the prices in rupees. In the case of real prices, the instability was comparatively higher in pre-WTO period and decreased slightly in the post-WTO period.

The determinants of price volatility identified were, (i) variations in US dollar-rupee exchange rate (ii) behaviour of black pepper prices including the seasonal and cyclical components (iii) changes in international trade (iv) futures trading, and (v) variations in domestic and world production as well as consumption.

The degree of persistence and significance of volatility in black pepper prices were studied using GARCH model. The estimates of the GARCH (1,1) model revealed that even though the magnitude as well as significance of volatility in black pepper prices has increased in the post-WTO period in the Indian markets, there was no evidence of persistence in volatility in the domestic markets. The GARCH models for real prices showed very low volatility in the post-WTO period in the domestic market. The increase in volatility in the domestic market was clearly identifiable in the case of Cochin Malabar Garbled prices. In the case of international prices, the magnitude, significance and persistence of volatility substantially declined in the post-WTO period. The increase in volatility in domestic markets could be attributed to the trade openness as part of the liberalisation policies and also to the quick transmission of international market developments to Indian markets due to the developments in Information and Communication Technologies. When the international price volatilities are getting transmitted to various consuming and producing countries at faster rates, there could be corresponding decline in the price volatility in the international markets.

The nature and extent of price transmission between the domestic and international markets of black pepper for the pre-WTO and post-WTO periods were analysed using both pair-wise and multiple cointegration analyses. The markets were found to be cointegrated and hence, it could be established that the Indian prices moved in unison with the international prices even before liberalization and liberalization *per se* has not much improved or affected the co-movement of prices between the domestic and international markets. The analysis also proved the existence of strong co-movement of prices between the markets of black pepper within the country.

The cointegration analysis proved the transmission of price signals and that there was causality at least in one direction between the domestic and international markets. The Granger causality tests carried out on monthly prices proved that there was unidirectional causality from domestic to

international market in pre-WTO period and it developed into bidirectional causality in the post-WTO period. In the case of weekly prices, the existence of bidirectional causality between domestic and international markets was found in both the periods. The spot and future markets prices were also found to be cointegrated and bidirectional causality could be established between them in the long-run.

For assessing the implications of price volatility at the farm level in terms of input use, production, employment and income, primary data was collected from Idukki district as it accounted for the largest share of the area under pepper in Kerala. Two blocks in the district having largest area under the crop were purposively selected. From each of the block, purposive selection of two panchayats was made. 40 farmers each were randomly selected from the PDS and non-PDS categories, making the total sample size to 80. Data was collected from the same 80 farm households at two points of time in an interval of ten months.

The impact of price volatility of black pepper on producer households was studied by comparing the price, production, employment, income and number of plants replanted in two years (2014 and 2015) for PDS and non-PDS farmers. The results showed that there was slight reduction in price in 2015 when compared to 2014 for both PDS and non-PDS farmers. The decline in price of black pepper received by the non-PDS farmers was found to be marginally higher than the decline for the PDS farmers. Even though the average production of black pepper has increased in PDS as well as non-PDS farms, the growth in production was slightly high in the case of PDS farms. Hence, the non-PDS farms experienced a higher decline in income between 2014 and 2015 when compared to the PDS farmers. Consequent to the reduction in price, the number of pepper plants replanted per farm decreased for PDS and non-PDS farmers, but there was higher percentage decline in the case of non-PDS farmers (29.58 per cent). When the replanting of black pepper per hectare was considered, it was found that the number of plants replanted increased in the case of PDS members, whereas it

decreased in non-PDS farms. The cost incurred on labour and inputs also showed a similar nature of increasing pattern in PDS farms and a decreasing pattern in non-PDS farms.

Linear regression model fitted to study the vulnerability of farmers to price volatility revealed that the variables like age, gender and education reduced the vulnerability to price volatility, whereas number of family members and share of income from pepper increased the vulnerability. It was also found that the membership in PDS was not a significant factor reducing the vulnerability to price fluctuations. The prices that were paid to the PDS farmers also varied with the market price and they were only paid ₹ 25-30 as premium in addition to the prevailing market price. They had the flexibility regarding the settlement of price for 50 per cent of the produce sold to PDS, which could be settled on any day within six months of handing over the commodity to PDS at the prevailing market price on that day.

Various constrains in production of black pepper were identified and ranked using Garett ranking technique. Among the various constraints faced by pepper farmers, disease and pest incidence and climate change were ranked as the major ones. The other constraints identified were labour shortage, price variability and high wage rate.

Policy implications

The policy recommendations are as follows:

- Proper implementation of the warehouse receipt system for a storable commodity like black pepper could enable the farmers to borrow from banks using the warehouse receipt as collateral. This will help the farmers to meet their immediate cash needs and reduce the vulnerability of farmers to price volatility by preventing distress sales.
- Dissemination of timely market intelligence and training the farmers on the use of market intelligence for making suitable selling decisions based on the price movements are very important for a commodity like black

pepper which is characterised by volatile prices. Most of the farmers lack in understanding and capacity to use market intelligence in guiding their production and marketing decisions. Hence, dissemination of market intelligence and equipping the farmers on the use of market intelligence are very important..

- As the price volatility dynamics are different for different crops, a practically implementable, black pepper specific price stabilisation mechanism which could adjust for changes in cost of cultivation as well as guarantee a stable and minimum income for the farmers need to be developed.
- The benefits of futures trading with regard to coverage of price risk should be extended to small and marginal farmers by ensuring their participation. Actual delivery of the commodity should also be made obligatory so as to prevent illegitimate speculation and the resultant volatility transmission from futures to spot markets.

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Appendices

APPENDIX I

Survey questionnaire

KERALA AGRICULTURAL UNIVERSITY

COLLEGE OF HORTICULTURE, VELLANIKKARA, THRISSUR

Department of Agricultural Economics

Price volatility of black pepper and its implications in Kerala

Interview Schedule

Farmer PDS /Non PDS:

District: Block: Panchayath:

1 Name of the Farmer :

2 Address, Phone Number :

3 Age :

4 Educational Level :

5 Experience in farming (Years)/Crop :

6 Annual Income :

7 Family Details :

Sl No	Member	Age	Education	Occupation		Annual Income	
				Primary	Secondary	Primary	Secondary

8. Number of members engaged in agriculture as full time/part time occupation:

9. Alternate sources of income:

10. Is this crop the sole source of income?

11. Any family members who are students living away at college or school?
(at present or past)

1 Yes (ask how many) 2 No

If yes; 1 Within Kerala 2 Other states 3. Other countries

12. What is your consumption expenditure – What are the recent changes?

13. Details of non crop/Allied activities:

Sl No	Activities	Area/No	Annual maintenance expenses	Gross returns
1	Dairy			
2	Poultry			
3	Fish farming			
4	Self-employment			
5	Others			

14. Details of the Operational Holding:

I	Area of Operational Holding (ha)	Wetland	Garden land
(i)	Owned – with patta		
(ii)	Owned – without patta		
(iii)	Leased-in (From which year)		
(iv)	Leased-out (From which year)		
	Total		

When leased out /leased in (year)

15. Cropping Pattern:

Sl. No.	Crop	Variety Local/HYV	Area/ No.	Main Product		By-product	
				Quantity	Value	Quantity	Value
I	Perennial Crops						
Mono-crop – Specify Pre-bearing / Peak-bearing / Over-aged – denote age							
Mixed –crop							
II Annual Crops							

If replanting of over-aged plants not done, reasons for that

16. Production and Price of Pepper

Year / Crop	Current Year 2014	Previous Year 2013	Year before previous 2015
Quantity Produced / Sold Average Price Peak Price Lowest Price			
Quantity Produced / Sold Average Price Peak Price Lowest Price			
Quantity Produced / Sold Average Price Peak Price Lowest Price			

17. Cost of Cultivation of pepper

Age of plantation

Wage Rates: Male..... Female..... Special wages: .....

Change wages in last few years from memory:

Change in input prices in last few years:

Changes in cultivation cost:

Area: Production: 2012 ql. 2013 ql. 2014 ql.
Price: 2012 Rs./ql. 2013 Rs./qtl. 2014 Rs./ql.

Wage rate (Rs/day): By product:

Particulars	Input		Human labour					
			Hired labour		Family Labour		Total	
	No./unit	Cost	No.	Amount	No.	Amount	No.	Amount
Land preparation								
Digging of pits, Filling up of pits								
Planting material								
Planting/staking								
Mulching								
Pruning/Training								
Manures								
Fertilizers								
Plant protection measures								
Intercultural operation								
Others/Live hedge/Intercropping								
Harvesting								
Cleaning, drying, packing								
Land tax/cess								
Other expenses								
Total								

17. Details on contact with developmental agencies:

Sl. No	Agencies	Type of Assistance			
		Planting materials	Technology	Subsidy	Marketing
1	Department of Agriculture				
2	Spices Board				
3	KAU				
4	Co-operatives				
5	NGO				
6	Others				

18. Details of credit:

Have you availed any credit? Yes / No (Specify year also)

Sl. No.	Sources of Finance	Type of Loan			Loan Amount	
		ST	MT	LT	Taken	Outstanding
1	Nationalised bank					
2	Co-operative bank					
3	Gold Loan					
4	Money lender					
5	Friends & relatives					
6	Others					

19. Replanting, land improvement and others (last five years)

Activity	Extent of coverage	Total expenditure	Amount of subsidy & Source	Year
Replanting (No. of plants)				
Replanting (No. of plants) – Shift to other crops				
Land improvement (area)				
Irrigation (area)				
Farm machinery				
Any other investment				

20. Any transaction

Sl.No.	Transaction	Year	Amount
1	Selling of land		
2	Any other property		
3	Buying of land		
4	Buying of any property		
5	Cutting down of trees/selling		
6	Selling of Animals		
7	Any other		

21. Details on Marketing:

1	Main mode of Disposal (Code)	
2	Total Marketed Quantity	
3	When do you sell the produce?	
4	To whom do you sell the produce? (Code)	
5	Reason for sales to local dealer	
6	Distance to the market	
7	Any market charges	
8	Mode of Transport	
9	Price received per kg:	
10	Mode of Payment	
11	Storage	
(i)	Time period of storage	
(ii)	Method of storage	
(iii)	Cost of Storage	
(iv)	Other remarks	
11	Loading and unloading charges	
12	Transport charges	
13	Source of information on price	

22. Marketing Constraints

Ranking of Constraints		
Sl No	Problems	Rank
1	Disease and pest incidence	
2	Climate change	
3	Labour shortage	
4	Price variability	
5	High wage rate	
6	Non availability of planting material	
7	Lack of government support	

23. Are you member of any producer organization / Cooperative / SHG (PDS)

Any contractual agreement of selling of the produce?

If yes, since which year?

How the price is determined?

Is there any incentive/bonus?

24. Suggestions for improvement of cultivation of this crop

25. What support do you expect from the institutions to withstand price volatility?

26. Coping mechanisms

Pre coping (Ex – ante)	Post Coping (Ex-post)	Implications
Crop Diversification	Crop Diversification	Reduced marketable surplus
Income Diversification	Income Diversification	Employment Consumption Income Standard of living
	Borrowing of credit	Repayment of loans Renewal of loans
	Crop management – Low input use	Resource use efficiency Productivity variations
	Leasing of land	No long term investment
	Selling of land	Loss of Asset or ownership
	Migration	Employment Income Consumption Standard of living
	Contractual agreement	Assured price
	Reducing consumption	Livelihood security Food security Nutritional security

APPENDIX II

Details of secondary data with source and duration

Particulars	Period	Sources
Annual and monthly domestic and international price of black pepper	1980-81 to 2013-14	Spices Board (www.indianspices.com), Journal of Arecanut, Spices and Medicinal plants, Statistical book of International Pepper Community (IPC)
Weekly domestic and international price of black pepper	1980-81 to 2013-14	Spices board (www.indianspices.com), Journal of arecanut, spice and medicinal plants
Daily spot and future price of black pepper	2002 to 2015	Spices market weekly
Annual, monthly and weekly domestic and international wholesale price index	1980 to 2014	World Bank (Pink sheet), Department of industrial policy and promotion (www.eaindustry.nic.in)
Country wise area, production, export and consumption of black pepper	1980 to 2013	Statistical book of International Pepper Community (IPC)
District wise area, production and productivity of black pepper in Kerala	1980-81 to 2013-14	Spices board (www.indianspices.com), Directorate of economics and statistics

PRICE VOLATILITY OF BLACK PEPPER AND ITS IMPLICATIONS IN KERALA

By

SACHU SARA SABU
(2013-11-206)

ABSTRACT OF THE THESIS

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ABSTRACT

Black pepper, the "King of spices", is one of the oldest and best known spices in the world. India, with an area of 1.23 lakh ha and a production of 65,000 tonnes in 2012-13, is one among the leading producers of pepper. The area under pepper in Kerala has declined from 1.08 lakh ha in 1980-81 to 0.85 lakh ha in 2013-14, while the corresponding decline in production was from 36,670 tonnes to 28,519 tonnes. As an internationally traded commodity, black pepper is highly prone to price fluctuations.

The study entitled "Price volatility of black pepper and its implications in Kerala" aimed at assessing the magnitude and determinants of volatility in prices of black pepper in the pre-WTO and post-WTO periods. The transmission of volatility between Indian and international markets as well as spot and future markets of black pepper were studied. The implications of price volatility on input use, production, employment and income of farmers, who were members of Peermedu Development Society (PDS), an NGO organising organic pepper farmers, with a contractual agreement for purchase and non-PDS farmers, were also studied on a comparative framework.

The study was based on both secondary and primary data. The main observations were annual, monthly, weekly and daily prices in domestic and international markets of black pepper from 1980 to 2014. The micro-level study was undertaken in Idukki district. 40 farmers each were randomly selected from the PDS and non-PDS categories, making the total sample size to 80. For the assessment of implications of price volatility, data was collected from the same 80 farm households at two points of time at an interval of ten months, using a pretested interview schedule.

The intra-annual volatility of monthly nominal prices in rupee as well as dollar declined marginally in the post-WTO period. In the case of international prices, the decline in intra-annual volatility was comparatively more when

compared to the Indian prices. The magnitudes of the estimated intra-annual volatility indices for weekly black pepper prices were larger in comparison with those computed for the monthly prices indicating that the weekly prices were more volatile. The intra-annual volatility for weekly international nominal prices was comparatively lower than that for the domestic prices in pre-WTO and post-WTO periods.

While the inter-annual volatility for monthly prices increased for Malabar Garbled Cochin prices that of Cochin Ungarbled decreased for both nominal and real monthly prices in the post-WTO period. In the international markets, the year to year variability in real and nominal rupee and dollar prices decreased in the post-WTO period.

The results of the analysis of instability in annual prices showed that the magnitude of the volatility indices of nominal as well as real prices in both rupee and dollar increased in the post-WTO period. The determinants of price volatility identified were, (i) variations in US dollar-rupee exchange rate (ii) behaviour of black pepper prices including the seasonal and cyclical components (iii) changes in international trade (iv) futures trading, and (v) variations in domestic and world production as well as consumption.

The nature and extent of price transmission between the domestic and international markets of black pepper for the pre-WTO and post-WTO periods were analysed using both pair-wise and multiple cointegration analyses. The markets were found to be cointegrated and hence, it could be established that the Indian prices moved in unison with the international prices even before liberalization and liberalization *per se* has not much improved or affected the co-movement of prices between the domestic and international markets.

The Granger causality tests carried out on monthly prices proved that there was unidirectional causality from domestic to international market in pre-WTO period and it developed into bidirectional causality in the post-WTO period. In the case of weekly prices, the existence of bidirectional causality

between domestic and international markets was found in both the periods. The spot and future markets prices were also found to be cointegrated and bidirectional causality could be established between them in the long-run.

The implications of price volatility of black pepper on producer households was studied by comparing the price, production, employment, income and number of plants replanted in two years (2014 and 2015) for PDS and non-PDS farmers. The results showed that there was slight reduction in price in 2015 when compared to 2014 for both PDS and non-PDS farmers. Even though the average production of black pepper has increased in PDS as well as non-PDS farms, the growth in production was slightly high in the case of PDS farms. Hence, the non-PDS farms experienced a higher decline in income between 2014 and 2015 when compared to the PDS farmers. Consequent to the reduction in price, when the replanting of black pepper per hectare was considered, it was found that the number of plants replanted increased in the case of PDS members, whereas it decreased in non-PDS farms. The cost incurred on labour and inputs also showed a similar nature of increasing pattern in PDS farms and a decreasing pattern in non-PDS farms. The vulnerability of farmers to price volatility was studied and it was found that age, education and experience in farming reduced the vulnerability, while the family size and share of income from pepper were found to increase the effect of price volatility. It was found that a contractual agreement alone could not protect the farmers from price variations.

The policy recommendations include proper implementation of warehouse receipt system so as to enable the farmers to borrow from banks to meet their immediate needs and prevent distress sales, dissemination of timely market intelligence and training the farmers on suitable selling decisions based on price movements, an implementable black pepper price stabilization mechanism which could adjust for changes in the cost of cultivation as well as ensure a stable income for the farmers and ensuring participation of small and marginal farmers in futures markets.