Spatial Market Integration of Wheat and Rice in Pakistan and South Asia

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Erklärung

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Jam Ghulam Murtaza Sahito

Gießen

Abbreviations

ADF	Augmented Dickey Fuller
$AMSL$	Agricultural Marketing and Storage Limited
$APCOM$	Agricultural Price Commission
AIC	Akaike Information Criterion
AR	Autoregressive
$ARIMA$	Autoregressive Integrated Moving Average
$ASEAN$	Association of Southeast Asian Nations
BBS	Bangladesh Bureau of Statistics
$CECP$	Cotton Export Corporation of Pakistan
DF	Dickey Fuller
FAO	Food and Agriculture Organization
$FATA$	Federally Administered Tribal Areas
FCT	Federal Capital Territory
FOB	Freight On Board
GDP	Gross Domestic Product
GCP	Ghee Corporation of Pakistan
$GIEWS$	Global information and Early Warning System
GOB	Government of Bangladesh
GOI	Government of India
GOP	Government of Pakistan
$HIES$	Household Integrated Economic Survey
$IFPRI$	International Food Policy Research Institute
IMF	International Monetary Fund
KPK	Khyber Pukhtunkhaw
$LLHR$	Logged Wholesale Prices of Lahore Market
$LHYD$	Logged Wholesale Prices of Hyderabad Market
LM	Lagrange Multiplier
$LMLTN$	Logged Wholesale Prices of Multan Market
$LPINDI$	Logged Wholesale Prices of Rawalpindi Market
$LPSHWR$	Logged Wholesale Prices of Peshawar Market
$LQUETTA$	Logged Wholesale Prices of Quetta Market
$LSUKKUR$	Logged Wholesale Prices of Sukkur Market
MT	Metric Tonnes
PBM	Parity Bounds Model
$PASSCO$	Pakistan Agriculture Storage and Supplies Corporation
$RECP$	Rice Export Corporation of Pakistan
Rs	Pakistani Rupees
$SAARC$	South Asian Association of Regional Cooperation
$SAFTA$	South Asian Free Trade Area

SAM	Social Accounting Matrix
$SAPTA$	South Asian Preferential Trade Arrangement
$SBIC$	Shwarz's Bayesian Information Criterion
$SupLM$	Supreme Lagrange Multiplier
TCP	Trading Corporation of Pakistan (Private) limited
$TSLS$	Three Stage Least Squares
$TVECM$	Threshold Vector Error Correction Model
UN	United Nations
US	United States
$US\$$	United States Dollar
$USHRW$	United States Hard Red Winter Wheat
VAR	Vector Autoregressive
$VECM$	Vector Error Correction Model
WFP	World Food Program
$WSFS$	World Summit on Food Security
WTO	World Trade Organization

Executive Summary

Wheat and rice are important staple food crops of South Asian countries including Pakistan. Wheat and rice trade across South Asian countries takes place not only to earn foreign exchange but to ensure food security also. Market integration and transmission of price information flow is required to facilitate the process of trade among South Asian countries. Understanding market integration in developing countries is an important issue in current research. The governments of South Asian countries have been working for sharing economic opportunities under SAARC (South Asian Association of Regional Cooperation) and SAFTA (South Asian Free Trade Area) frameworks. The present study, therefore, was designed to see the extent of market integration of wheat and rice in Pakistan and among South Asian countries particularly Bangladesh, India, and Pakistan. This study also aims to assess the degree of market integration from international markets to domestic markets of these countries.

Previous research on the subject has attempted at analyzing market integration in Pakistan's south and north Punjab regions, mainly relying on cointegration only and not considering advanced dynamic models and transaction costs to analyze the degree of integration. Therefore, this study is a first attempt to analyze the extent of market integration in the whole country using a TVECM model. Monthly wholesale price data of five regional markets of wheat and seven markets of rice from January 1988 to April 2011 were used for this study. Price series were tested for stationarity with the augmented Dickey-Fuller (ADF) test and it was found that all prices are integrated of order one, commonly written as I(1). Cointegration was also identified in all the price series pairs of wheat and rice using the Johansen's cointegration test. The Threshold Vector Error Correction Model (TVECM) with a band of non-adjustment was applied to incorporate transaction costs, without relying on observations for these costs, which were not available for the study. Hence, the TVECM was preferred over a simple VECM.

For a complete analysis and comparison, VECM results are also presented and discussed. Results of the analysis revealed that wheat and rice markets of Pakistan are quite integrated in the long run as well as in the short run. It was found that linear ECMs or VECMs provide misleading results as compared to TVECMs. Short-run adjustments in the TVECM model provide mixed results depending on regimes as well as markets. Strong adjustments were found in the upper regime, which shows that when price differences are above the second threshold markets tend to adjust significantly.

Market integration analysis of South Asia includes monthly wholesale prices of Bangladesh, India and Pakistan only, because of the unavailability of data for other countries in the region. Along with that, wheat export price series of the United States of America (US-HRW) and Thailand and Vietnam rice export prices were used to investigate market integration of South Asian countries with the world markets. Time series for South Asian wheat markets and for US-HRW price series starts from January 2000 and it ends to June 2011. Monthly prices of rice, from January 2000 to December 2013 were used for Bangladesh, India, Pakistan, Thailand and Vietnam.

The ADF test results of the South Asian and international wheat and rice markets revealed that all the price series are first difference stationary, in other words integrated of order one I(1). The Johansen's cointegration test revealed long-run integration for almost all the pairs of wheat and rice markets. The VECM estimates showed that Indian domestic market prices do not adjust significantly with any of the other market under study. Pakistan and Bangladesh wheat markets have shown slow but significant adjustment with the changes in the US-HRW wheat export prices. Wheat market prices of Pakistan have also revealed significant adjustment to the shock appeared in Bangladesh or Indian market prices while adjustment from Bangladesh wheat market has been noticed only in response to the shock in Indian wheat prices. Overall, the coefficient of the adjustment parameter has been very low.

Estimation results obtained from the application of the TVECM depicted a different story. Statistically significant adjustment parameters were found in the case of wheat markets of Pakistan and India also. Along with that Pakistani wheat markets have shown significant adjustment to the changes in Bangladesh wheat prices as well as to the international prices. Whereas, Bangladesh markets have shown significant and higher adjustment in response to the changes in Indian wheat prices. No significant adjustment of Bangladesh and Indian wheat markets can been seen in result of the changes in the international wheat market.

The TVECM estimations show that the Indian market is less integrated with the international markets, mainly because of their government interventions in the rice sector. For instance, they imposed a ban on the trade of wheat and rice after 2007 for couple of years. The degree of adjustment of Bangladesh and Pakistani rice markets was observed between 20 to 30 percent, as the rice sector of both the countries is less restrictive, and private traders are more involved. Hence, they are not only integrated in the long run, but in the short run as well.

A higher degree of integration can be achieved with extended cooperation and by facilitating trade within the region, which will reduce the costs of trade, stabilize the prices in the region and will also be helpful in ensuring food security in the region. These objectives can be achieved by an efficient functioning of markets, by reducing government interventions and by encouraging private traders to participate actively.

Contents

1 Introduction **1**
- 1.1 Purpose and Objectives 6
- 1.2 Conceptual Approach 8

2 Contextual Background **10**
- 2.1 Overview of the Economy of Pakistan 11
- 2.2 Overview of the Economies of other Selected Countries 14
  - 2.2.1 Bangladesh 16
  - 2.2.2 India 17
- 2.3 Structure of Wheat and Rice Markets in Pakistan 18
- 2.4 Available Production and Growth of Wheat and Rice in Pakistan 21
  - 2.4.1 Production and Growth of Wheat 21
  - 2.4.2 Production and Growth of Rice 23
- 2.5 Government Interventions 25
  - 2.5.1 Support Price Policy of Pakistan 25
  - 2.5.2 Government Procurement 28
  - 2.5.3 Government Interventions in South Asia 29
- 2.6 International Trade of Wheat and Rice in South Asia 31
- 2.7 Food Security in South Asia 36

3 Review of Literature **43**
- 3.1 Historical Development of Market Integration Studies 44
- 3.2 Market Integration Research on Pakistan 51
- 3.3 Market Integration Research Studies on South Asian Countries 56

4 Data **62**
- 4.1 Data Collection 62
  - 4.1.1 Domestic Wheat Markets 63
  - 4.1.2 Domestic Rice Markets 65
  - 4.1.3 South Asian and the World markets 68
- 4.2 Sources of Data 70

4.3 Data Problems and Handling 71

5 Data Analysis and Estimation Method 73
5.1 Unit Root Tests 74
5.2 Cointegration 76
5.3 Vector Error Correction Model 78
5.4 Threshold Vector Error Correction Model 80

6 Results 85
6.1 Market Integration Analysis of Pakistan 85
6.1.1 Domestic Wheat Market Integration Analysis 86
6.1.2 Cointegration Test Results for Wheat Markets 88
6.1.3 Vector Error Correction Model Results of Wheat Markets of Pakistan 90
6.1.4 TVECM Analysis of Domestic Wheat Markets 92
6.1.5 Domestic Rice Market Integration Analysis 94
6.1.6 Vector Error Correction Model Results of Rice Markets of Pakistan 97
6.1.7 TVECM Analysis of Domestic Rice Markets 100
6.2 Market Integration Analysis of South Asian Markets 102
6.2.1 Cointegration Test Results of Wheat and Rice Markets of South Asia 103
6.2.2 TVECM Results of Wheat Markets of South Asia . . . 110
6.2.3 TVECM Results of Rice Markets of South Asia 113

7 Conclusion and Recommendations 117

A Appendices 123

List of Figures

2.1 Flowchart of Marketing Channels of Wheat in Pakistan 19
2.2 Flowchart of Marketing Channels of Rice in Pakistan 20
2.3 Province-wise Area Sown Under the Wheat Crop in Pakistan . 22
2.4 Province-wise Production of Wheat in Pakistan 22
2.5 Province-wise Area Sown Under the Rice Crop in Pakistan . . 23
2.6 Province-wise Production of Rice in Pakistan 24
2.7 Intra-regional Trade Share of South Asia and ASEAN 35
2.8 Wheat Production and Shortfall Province-wise for the Year 2007-08 40

4.1 Map of Pakistan Indicating Wheat Markets of the Country . . 63
4.2 Wholesale Wheat Prices of Pakistan 64
4.3 Map of Pakistan Indicating Rice Markets of the Country . . . 66
4.4 Wholesale Irri Rice Prices of Pakistan 67
4.5 Wheat Prices of South Asian Countries and the USA 69
4.6 Rice Prices of South Asian Countries, Thailand and Vietnam . 70

List of Tables

2.1 Wheat and Irri-rice Procurement Prices from 1990-91 to 2011-12 (Rs. per 40 Kg) . . . 28
2.2 Trade of South Asia within the Region and with Rest of the World . . . 34

4.1 Descriptive Statistics of Nominal Monthly Wholesale Prices of Wheat Markets of Pakistan . . . 65
4.2 Descriptive Statistics of Nominal Monthly Wholesale Prices of Rice Markets of Pakistan . . . 66

6.1 ADF Test Results for Wheat Markets of Pakistan . . . 86
6.2 ADF Test Results for Rice Markets of Pakistan . . . 87
6.3 Pairwise Cointegration Test Results for Wheat Markets of Pakistan . . . 88
6.4 Joint Cointegration Test Results for Wheat Markets of Pakistan 89
6.5 VECM Results for Wheat Markets of Pakistan . . . 90
6.6 Estimates of SupLM Test Applied on Price Series of Wheat Markets of Pakistan . . . 92
6.7 Pairwise Cointegration Test Results for Rice Markets of Pakistan 94
6.8 Pairwise Cointegration Test Results for Rice Markets of Pakistan-II . . . 95
6.9 Joint Cointegration Test Results for Rice Markets of Pakistan 96
6.10 VECM Results of Rice Markets of Pakistan . . . 98
6.11 Estimates of SupLM Test Applied on Price Series of Rice Markets of Pakistan . . . 99
6.12 ADF Test Results Wheat Markets of South Asia and the USA 102
6.13 ADF Test Results Rice Markets of South Asia, Thailand and Vietnam . . . 103
6.14 Pairwise Cointegration Test Results for Wheat Markets of South Asia and the USA . . . 104

6.15 Joint Cointegration Test Results Wheat Markets of South Asia and the USA 104
6.16 VECM Results of Wheat Markets of South Asia and the USA 105
6.17 Pairwise Cointegration Test Results for Rice Markets of South Asia, Thailand and Vietnam 106
6.18 Joint Cointegration Test Results for Rice Markets of South Asia, Thailand and Vietnam 107
6.19 VECM Results of Rice Markets of South Asia, Thailand and Vietnam 108
6.20 Estimates of SupLM Test Applied on Price Series of Wheat Markets of South Asia and the USA 110
6.21 Estimates of SupLM Test Applied on Price Series of Rice Markets of South Asia, Thailand and Vietnam 114

A.1 Production, Utilization and Surplus or Deficit of Wheat in Bangladesh in Thousand Tonnes from 2001 to 2013 124
A.2 Production, Utilization and Surplus or Deficit of Wheat in India in Thousand Tonnes from 2001 to 2013 124
A.3 Production, Utilization and Surplus or Deficit of Wheat in Pakistan in Thousand Tonnes from 2001 to 2013 125
A.4 Production, Utilization and Surplus or Deficit of Rice in Bangladesh in Thousand Tonnes from 2001 to 2013 125
A.5 Production, Utilization and Surplus or Deficit of Rice in India in Thousand Tonnes from 2001 to 2013 126
A.6 Production, Utilization and Surplus or Deficit of Rice in Pakistan in Thousand Tonnes from 2001 to 2013 126
A.7 TVECM Results of Wheat Markets of Pakistan 127
A.8 TVECM Results of Rice Markets of Pakistan 129
A.9 TVECM Results of Wheat Markets of South Asia and the USA 133
A.10 TVECM Results of Rice Markets of South Asia, Thailand and Vietnam 134

Chapter 1

Introduction

Market integration describes the degree of price transmission within vertically or spatially separated markets. Spatial or vertical market integration of homogeneous commodities in developing countries has been the center of interest for economists in the last few decades. Special attention has typically been given to basic food crops such as wheat and rice, because food insecurity is a major issue for developing countries. Market integration studies in agriculture, especially for developing countries are tools to examine, evaluate, regulate and reform price polices for food security and price stability.

In the context of Pakistan, a developing country, wheat is the major food crop, providing the largest source of caloric intake, thus it is important from food security perspective. The World Trade Organization (WTO) considers Pakistan as the most food insecure among net wheat-importing developing countries (GoP, 2012b). Pakistan has not yet achieved self-sufficiency, especially in wheat production, and has remained largely a net importer of wheat. In fact, Pakistan has only exported a small amount of wheat as a result of bumper crop between the years from 2000 to 2006. Overall, the production of wheat has been volatile in Pakistan during the last two decades (GoP, 2012b).

Rice being one of the the major export products earns a valuable share via foreign exchange. Hence, Ghafoor and Aslam (2012) consider rice also as one of the potential crops to improve the food security situation in Pakistan.

Generally, if agricultural markets of a country or a region are not integrated, then local food scarcity would tend to persist, because distant markets with excess supply will not be able to benefit from arbitrage conditions and will not respond to the price signals of segmented markets.

Price transmission among food markets will enable us to understand the vulnerability of the population to food market shocks in Pakistan and in South Asia. Market integration studies provide valuable information about the efficiency of market functioning and about the dynamics of price adjustment in the markets. Information of spatial market integration infer the efficiency of pricing, effectiveness of arbitrage and competitiveness of markets, which implies the efficient market functioning (Sexton et al., 1991).

There are many hindrances to the efficient functioning of agricultural commodity markets in South Asia in general and Pakistan in particular. Some major issues include insufficient transportation infrastructure, restrictions on the movement of wheat within provinces and districts, no or sparse access to market information, market structure and changes in the costs of production (Tahir and Riaz, 1997). For example, intra-province movement restrictions of major food crops in the months of harvesting and support price policy of wheat are direct interventions of the governments. Transportation infrastructure, information and communication are other factors affecting market integration.

The government of Pakistan has been involved in interventions within the wheat sector via support prices, procurement, storage, transportation and distribution of wheat to flour millers since independence. Two major objectives of these interventions are, first, to protect consumers from higher import prices, and second, to protect producers via procurement and support prices in an effort to reduce price volatility (Ahmad et al., 2006). The government of Pakistan procures about 25 to 30 percent of total wheat production every year (GoP, 2012b). These government interventions are considered as a fiscal burden on the economy in case of higher degree of market integra-

tion (Mushtaque et al., 2007a; Dorosh and Salam, 2008). The government interventions in the rice markets in Pakistan have been reduced to a large extent since the late 1990s. A higher degree of market integration and quicker adjustment of prices to form a new equilibrium as a result of shocks to the market prices also indicate the efficient functioning of markets.

South Asian countries have a long history of extensive interventionist policies until the mid 1990s. Afterwards liberalization has replaced many of the old intervention policies of the governments, especially in Bangladesh, India and Pakistan.

It is generally assumed that markets of the protectionist economies are isolated from the world markets (John, 2013). This study tries to analyze if the markets of South Asia are as isolated from the world markets as assumed, or that is not the case with South Asian Markets. Despite high potential of trade, it is a general hypotheses that South Asian markets are not integrated with each other, due to political conflicts in the region, especially between Pakistan and India.

As market integration refers to the transmission of price movements or dissemination of price shocks between distinct markets of a region, or different regions of a country, or from world markets into local markets. In this study our focus is on spatially or geographically separated markets of wheat and rice. Price transmission studies of agricultural commodities are of particular interest to the researchers for being a complicated pattern of price dynamics, because of the fact that transportation of these commodities is quite expensive and they are produced in wide areas (Fackler and Goodwin, 2001).

The concept of market integration answers many different questions via price transmission, which is an important tool to analyze integration of spatial markets. Fackler and Goodwin (2001) posit that market integration is the best way to measure the degree of transmission of demand and supply

shocks from one region to another. Fackler and Tastan (2008) tender to raise the attention towards analyzing the impact of liberalization and intervention policies on markets, especially in developing countries.

There are only few market integration studies regarding the food markets of Pakistan. Unfortunately, most of them have focused only on one or two regions of the Punjab province and merely relied on cointegration coefficients or an error-correction mechanism. Regional food markets of India and Bangladesh have been studied previously by Ravallion (1986), Goletti et al. (1995), Dawson and Dey (2002), Basu (2010), Ghosh (2010) and some others, but surprisingly, there has been no such study to the best of my knowledge to assess the degree of market integration between food markets of the South Asian region as a whole, which comprises of almost half of the under-nourished people of the world. Further, there has been a lot of development in the last two decades regarding the methods to investigate market efficiency and integration, which has not been applied yet to food markets of Pakistan. Hence, it is worthwhile to assess the degree of market integration between different wheat and rice markets of Pakistan, as well as the integration of the domestic market with its neighboring partners and with the world's leading wheat and rice markets.

Many models and methods have been developed to analyze integration of markets. Every method has its own strengths and weaknesses. However, due to intuitive interpretation, error-correction models have gained the attention of the majority of studies. Most of these studies rely only on time-series data of prices and do not take into account transaction costs or trade flows.

Barrett (1996) and Barrett and Li (2002) state that one cannot describe spatial market relationships only by prices but by their combination with transaction costs. However, transaction costs are neither easily available nor any other proxy can be used to incorporate these costs. Threshold models estimate a neutral band linked with unobservable transaction costs and stretch explicit attention to these costs. Therefore, a threshold vector error

correction model (TVECM) will be used for analysis, by using a band of non-adjustment (Thresholds) to consider a band of no arbitrage. These models recognize the size of the band or their thresholds in response to shocks by prices on horizontally separated markets. This is, however, conditional on if the shock is substantial enough to raise price differentials between two separated markets above the transaction cost.

It is well established on the basis of past research that the food markets of the Punjab province of Pakistan are well integrated. But, it is yet to be seen if the food markets of other provinces are also integrated with the markets of Punjab province or not. As we know, market integration of wheat and rice within different regions (Provinces) of Pakistan, the degree of price adjustment in food markets of South Asian countries within the region as well as with the whole world, using advanced dynamic models, have never been estimated.

Therefore, a thorough market integration analysis of wheat and rice in Pakistan and in South Asia, based on information of the degree of market integration will assist the governments in formulating policies to provide infrastructure and information services in an effort to avoid market exploitation and will enable the countries of the region to adopt policies to have close ties regarding trade of food products. Keeping in mind the importance of market integration for an efficient marketing system in the region, this study aims to analyze the degree of market integration with the help of a threshold vector error correction model.

1.1 Purpose and Objectives

Pakistan and other South Asian countries face several and similar problems like insufficient transportation infrastructure, no or limited access to market information, government-imposed restrictions on the movement of goods between regions, changes in the costs of production, complicated market structure, natural disasters, government monopoly on trade in most cases and many more issues, which has serious effects on efficient market functioning, particularly agricultural commodity markets.

Market integration of agricultural products has retained importance in developing countries due to its potential application to policy making. The government can formulate policies of providing transportation, infrastructure and information regulatory services to avoid market exploitation, on the basis of information on the degree of market integration.

Despite the potential of trade within South Asian countries, they are reluctant to trade with each other, due to political warfare in the region. Pakistan and India are considered as rivals, while both could benefit from trade instead of importing from other countries at higher transaction costs. It is therefore worthwhile to see if the grain markets in the region are well integrated or not, as most countries in South Asia have extreme interventions by governments in the agricultural commodities particularly in food grains.

Generally, it is assumed that countries having government interventions in terms of domestic policy as well as international trade restrictions have isolated domestic markets in the region and from the world market. Pakistan and India are two major exporters of rice and have severe trade restrictions from time to time. It is of interest to empirically analyze whether the domestic markets of these two countries are really as isolated from the world market as assumed.

Wheat and rice are two major food grain crops of Pakistan and other South Asian countries. The purpose of this study is to investigate whether the wheat and rice markets of South Asia are integrated with each other and to the world markets and to what extent they are integrated. Goletti et al. (1995) explained the reasons for empirically analyzing market integration. Such as, it makes possible to identify groups of integrated markets, so as to avoid duplication of intervention. They further explain with the help of an example that if three markets A, B, and C are well integrated with each other, then the government may think of reducing its efforts to influence the price process in those markets. Moreover, market integration studies are relevant for successful implementation of market liberalization or price stabilization policies, by providing a clearer picture of the price transmission process. A balance of food availability in food-deficit and food-surplus regions can be assured with the proper information on market integration within spatial or vertical markets.

Specific objectives of the study are:

1. To develop a dynamic model of spatial market integration.

2. To analyze spatial market integration among different wheat and rice markets in Pakistan.

3. To investigate spatial market integration among South Asian countries in wheat and rice markets.

4. To asses the degree of market integration between world wheat and rice markets prices and domestic market prices of Bangladesh, India and Pakistan.

1.2 Conceptual Approach

The second chapter provides the detailed information regrading the economies of the selected countries and the structure of wheat and rice markets in Pakistan. It also provides an overview on the province-wise wheat and rice production in Pakistan and the overall situation of production and consumption in the selected countries. Distortions in the wheat and rice sector based on the policies of the concerned governments are also discussed in this chapter. In the end, the food security situation in the region as a whole and in the specific countries and impacts of market integration on food security to provide the base for the analysis of the wheat and rice markets of South Asia will be discussed.

The third chapter is composed of detailed reviews of existing literature in the field of market integration and price transmission. The historical development of market integration studies over a long time period, in terms of different methods of estimations and their strengths and deficiencies are discussed. Specific studies regarding Pakistan and other South Asian countries are also discussed in detail. This chapter will also provide the strengths and weaknesses of the studies.

Details about the data used for the study, sources of data regarding South Asian and international prices, as well as wholesale price series for different wheat and rice markets of Pakistan are provided in chapter four. Issues of data unavailability and problems within the time series available are also discussed in detail. Further, methods to deal with those issues are described in this chapter. Selection of different markets subject to data availability and suitability are provided and maps locating the markets are also provided for better understanding. Descriptive statistics of the data in this chapter provide an overview of the data and information regarding missing values. The last section of this chapter also provides the methodology to impute missing values in the existing data.

Chapter five comprises of the tests, methods and models used for the analysis. Existing models and their weaknesses are also discussed and a justification for the use of the Threshold Vector Error Correction Model (TVECM) incorporating the unobserved transaction costs via thresholds is provided. Chapter six provides the results of all the tests and linear VECMs as well as TVECMs. The comparison of the linear and non-linear model makes it easier to understand the dynamics of the markets under study. Finally, conclusions and recommendations are provided in the last chapter, based on the results obtained from the estimation.

Chapter 2

Contextual Background

This chapter comprises of the economic overview of the countries and the role of agriculture in general, and wheat and rice in particular, in the economy of the countries under study. The countries selected for the study have a major share of agriculture in the economy. Apart from this background information of the wheat and rice markets of Bangladesh, Pakistan and India, Section 2.3 will describe the structure of the wheat and rice markets in Pakistan. Section 2.4 gives an overview about the production of wheat and rice in Pakistan and its development over two decades. Details about government interventions in the wheat and rice sub-sectors in Pakistan and in other south Asian countries are discussed in Section 2.5. The next section sheds some light on the trade of south Asian countries with each other and with the rest of the world, with a focus on the necessity of further economic cooperation within the countries. In the last section, the food security situation in the region and the importance of market integration studies for the food security of the developing countries will be discussed.

2.1 Overview of the Economy of Pakistan

The economy of Pakistan largely depends on its agricultural sector. Although the percentage share of agriculture in GDP has decreased in the last few decades considerably, it still contributes 21 percent of GDP. 45 percent of the labor force of the country is employed in this sector, and agriculture is the source of livelihood for more than 60 percent of the population of Pakistan. Agriculture and agro-based industrial products contribute 75 percent to the total foreign exchange earnings from exports (GoP, 2012b).

From the beginning of the 21st Century, annual GDP growth was more than 5 percent until the crisis of 2008. Due to this financial crisis the growth slowed down but now it is getting momentum again. It is growing at an average of 4.7 percent from 2000-01 until 2011-12. The share of the industrial sector has increased rapidly, but despite a wide range of fluctuations in the growth rate of agriculture due to climate change, high rainfalls, the 2008 food crisis and heavy floods in Pakistan, the contribution of agriculture to GDP has grown at an average rate of 2.7 percent annually from 2000-01 to 2011-12 (GoP, 2012b). Despite the importance of the agricultural sector in the economy of Pakistan there is still a huge gap between food supply and food demand, because of the low performance of this sector.

The agricultural sector has four sub-sectors including: crops, livestock, fisheries and forestry. Two-third of total cropped area is covered and one third of agricultural GDP is contributed by four major crops: wheat, rice, cotton and sugarcane. These four crops contribute about 90 percent of value added in major crops, and account for 29 percent of the value added in overall agriculture out of 32 percent by all major crops. Other sub-sectors like livestock, fishing, forestry and minor crops contribute to the remaining 68 percent of the value added in agriculture (GoP, 2012b). The government of Pakistan mostly focuses on policies regarding these major crops and intervenes heavily in the crop sub-sector.

Wheat and rice play a central role in policy making and both are of high importance from the food security perspective because these two crops are major staple food crops of Pakistan. Wheat flour contributes 72 percent of Pakistan's daily caloric intake with per-capita wheat consumption of around 124 kilo gram per year, one of the highest in the world (Raza, 2014). Production of these two crops is highly concentrated in the two provinces Punjab and Sindh; they both account for more than 90 percent of total production. During the fiscal year 2011-12 wheat and rice accounted for 12.5 and 4.9 percent of value added in agriculture and 2.6 and 1 percent of GDP, respectively (GoP, 2012b). Production of both crops has almost tripled in the last three decades, due to a significant increase in yields. Population has also increased and has more than doubled in the last three decades but due to fluctuations in the production of both crops, specially in wheat, the government tends to devise policies to fulfill the food requirement of the population. Increasing wheat production through yields is one of the basic objectives of Pakistan for self-sufficiency to minimize import dependence. Wheat imports ranged from 0.5 mmt to 4.11 mmt during the last two decades, and were highest (4.11 mmt) in 1998-99 (GoP, 2011, 2012b).

The Pakistan Agriculture Storage and Supplies Corporation (PASSCO) and provincial governments procure wheat in the harvesting season, and large-scale government procurement takes place in Punjab and Sindh provinces. The federal government announces the wheat support price at the time of sowing in consultation with provincial governments although implementation of procurement policies is the responsibility of provincial governments. The government procures 20 to 30 percent of total production each year directly from producers at supported prices and provincial food departments sell a substantial portion of procured wheat to private flour mills or directly to the consumers via utility stores (Government Corporation) at an issue price or release price in lean months of the same marketing year. Meanwhile, farmers also market their product with free prices. Hence, in the current marketing system, public and private markets co-exist (Hamid et al., 1990; Dorosh and Valdes, 1990; Ahmad et al., 2006; Dorosh, 2009).

Most stakeholders are affected by these policies and the majority also tries to influence these policies. HIES (Household Integrated Economic Survey) data from 2011-2012 clearly indicated that only 5 percent of households from Pakistan, who are 20 percent of wheat producers and typically have large farms, account for almost 70 percent of total wheat sales. 45 percent of wheat sales are the contribution of only 10 percent of wheat farmers, and one fourth of all wheat farmers are net wheat buyers (HIES, 2013). Thus, a large number of farmers could not benefit from the high support and procurement price policies, because only 20 percent of farmers have surplus wheat to sell after keeping for their own consumption and seed.

Flour millers take the advantage of low issue prices of wheat which are below market prices, and they sell wheat flour to consumers at the open market price. So net consumers also enjoy the low market prices of wheat (grain as well as flour), and these net consumers are about 80 percent of total population. The government also subsidizes the sales of grains within provinces, from the wheat surplus province Punjab to other wheat-deficit provinces. As the wheat issue price to flour mills does not cover the overall expenditure on domestic or import procurement, transportation, storage, management and distribution, flour mills benefit from subsidies, economic rents and quotas (for flour mills) to purchase government wheat. As a result, the number of flour mills increased and most of them only operate while government subsidized wheat is available for flour mills. Apart from this, these flour millers also try to influence and create pressure on the government to continue these policies (Anderson and Martin, 2009; Dorosh and Salam, 2008).

Rice is the second major food crop and the third largest crop of Pakistan after wheat and cotton in terms of area sown. Pakistan is among top five rice-exporting countries of the world, with the share of around 11 percent in the world's exports of rice. Pakistan is the 11th largest rice producer in the world in terms of area sown, 12th in production and 59th in terms of yield per hectare (Ghafoor and Aslam, 2012).

Although Pakistan is a net exporter of rice, the average rice yield in Pakistan is lower than in many other rice-exporting countries. In order to obtain self-sufficiency, increase in rice yields is a need of the day. In 2008-09 and 2009-10 along with the area sown yield has also increased, but from 2010 area and production decreased significantly because of the heavy rainfall and floods in 2010 and 2011. Many varieties of rice are grown in Pakistan; two major exportable varieties are basmati- and irri-rice. More than 60 percent of irri rice is produced in the Sindh province, while basmati rice is totally produced in the Punjab province.

2.2 Overview of the Economies of other Selected Countries

Traditionally, the economy of South Asia has been dependent on agriculture. The share of agriculture in the region's economy is decreasing and performance of the service sector has been remarkable. In 1970, agriculture accounted for over 40 percent and the service sector accounted for about 38 percent of the region's total GDP. In 1980s, service sector had surpassed agriculture to become the largest sector, accounting for over 40 percent of total GDP, and the contribution of agriculture has reduced after that consecutively and considerably. By 2011, the contribution of service sector in the region had increased to more than 50 percent while the share of agriculture had reduced to less than 20 percent in the region. Even then, the agriculture sector accounts for more than 50 percent of total employment in 2011 (World Bank, 2012b).

The share of the individual countries as the percentage of total economy (GDP) of South Asia varies significantly. India, being the largest economy of the region leads with 80 percent of the total GDP of South Asia, followed by Pakistan with about 9.3 percent contribution in the year 2011. Bangladesh

and Nepal account for 4.9 and 2.6 percent, respectively. Afghanistan, Bhutan and the Maldives contributed less than 1 percent to the South Asian GDP in the same year. South Asia comprises of 24 percent of the world population, but it only accounts for 3.25 percent of the total GDP of the world (World Bank, 2012b).

South Asia is the region with the largest concentration of the poor and undernourished population in the world. Therefore, self-sufficiency in food is their major concern, especially in basic staple food crops such as wheat and rice (Ganesh-Kumar et al., 2010). About 571 million people in South Asia living with the income below 1.25 dollars per day (World Bank, 2012a).

Wheat and rice trade across South Asian countries takes place not only to earn foreign exchange but also to ensure food security. Market integration and transmission of price information flow is required to facilitate the process of trade among South Asian countries. The Governments of South Asian countries have been working for sharing economic opportunities under the SAARC (South Asian Association of Regional Cooperation) and SAFTA (South Asian Free Trade Area) frameworks.

Despite the importance of the agricultural sector in the national economies of South Asian countries, there is a wide gap between food supply and demand due to a low performance of agriculture. Agricultural market performance, especially in developing countries of South Asia is an important issue in economic development. Bangladesh, India, Nepal, Pakistan and Sri Lanka share similarities in their food sector like production, consumption and marketing patterns due to common colonial heritage. Even the problems of the sector are of similar nature, for example: post harvest losses, improper storage facilities and limited infrastructure. Wheat and rice in these countries are traded within, from and to other countries which makes the marketing system relevant for efficient trade and food security in the region.

2.2.1 Bangladesh

Agriculture is also the lifeline of Bangladesh's economy. It contributed around 20 percent in GDP in the fiscal year 2011-12. Crops only contributed for 11.2 percent of GDP. Although, overall production of food grains has increased over the last five consecutive years, production of wheat and rice has faced fluctuations in the last years. Production of wheat and rice also increased in the year 2012. According to their policy, the government announced procurement targets and procured 1.3 million metric tons (mmt) of rice against their target of 1.25 mmt and 0.099 mmt of wheat against 0.1 mmt target. Bangladesh is a net importer of wheat and rice but public as well as private sector imports of both grains were significantly lower in the fiscal year 2011-12 than in the previous fiscal year, mainly because of their available stock and higher production. Total import of rice including public and private import stood at 0.52 mmt and of wheat at 1.77 mmt in the fiscal year 2011-12. In the fiscal year 2010-11 their total imports of rice and wheat were 1.59 mmt and 3.80 mmt, respectively (GoB, 2012).

Bangladesh meets 75 percent of its wheat consumption requirements through imports. Bangladesh imports wheat from India, Russia and Ukraine, Canada, Australia and the U.S. India's export ban on wheat during the price spikes in 2007-08, forced Bangladesh to import wheat from European and South American countries, to fulfill its needs. However, as soon as India withdrew the export ban on wheat, it became the major wheat exporter to Bangladesh. About 78 percent of wheat imported by Bangladesh during the marketing year 2012-13 has been sourced from India (Hussain, 2013).

Bangladesh is the fourth largest rice producing and consuming country and an important but highly variable rice import market. Most of the rice production in Bangladesh is dependent on monsoon. Hence, it faces high fluctuations. In the late 1990s, Bangladesh was the world's second largest importer and imported about 2.5 million metric tons, but since then it has imported an average of only 0.5 mmt annually(Wailes, 2005).

2.2.2 India

Agriculture along with forestry and fishing accounted for only 14.1 percent of the GDP in the fiscal year 2011-12. But the role of agriculture is much bigger in the Indian economy keeping in view its share in employment, which is nearly 60 percent. Agriculture separately accounted for 12.0 percent of GDP followed by forestry and fishing by 1.4 and 0.7 percent respectively. After the world financial crisis in 2008-09, the Indian economy recovered quickly and achieved 8.6 and 9.3 percent GDP growth in 2009-10 and 2010-11, respectively. But the growth rate slowed down to 6.2 percent in 2011-12 and 5 percent in 2012-13 (GoI, 2013).

Although the share of agriculture has been 8 percent in GDP growth in the last decade, the services sector played an even more important role in the overall growth of the economy and accounted for 65 percent in the growth. Industry contributed 27 percent in growth in the last 10 years. Share of agriculture in real GDP has a slower growth rate than services and industry (GoI, 2013).

Agriculture in India has done remarkably well in terms of output. India is 2nd in the world for the production of rice, wheat, sugarcane, cotton, vegetables and fruits and the leading producer of milk, pulses and jute in the world. Indian production of food grains increased from 52 million tonnes to 244.78 million tonnes from 1951-52 to 2011-11. Self-sufficiency and food security has been the focus of agricultural policy in India (GoI, 2012).

The government of India views wheat and rice as strategic commodities for food security because both crops are important staple foods for majority of the population of India. Consequently, the government intervenes heavily in the market through grain procurement, price supports, export subsidies and some trade restrictions (Wailes, 2005). Due to a steady increase in the government support price and consecutively high production, food grain procurement by the government increased during 2007 to 2012 (Singh, 2014).

In September 2011, the government of India removed the ban on exports of wheat and rice, which had been enforced since 2007 (Singh, 2014). The central as well as the state governments also support farmers by subsidizing input supplies and by providing agricultural credit at low interest rates.

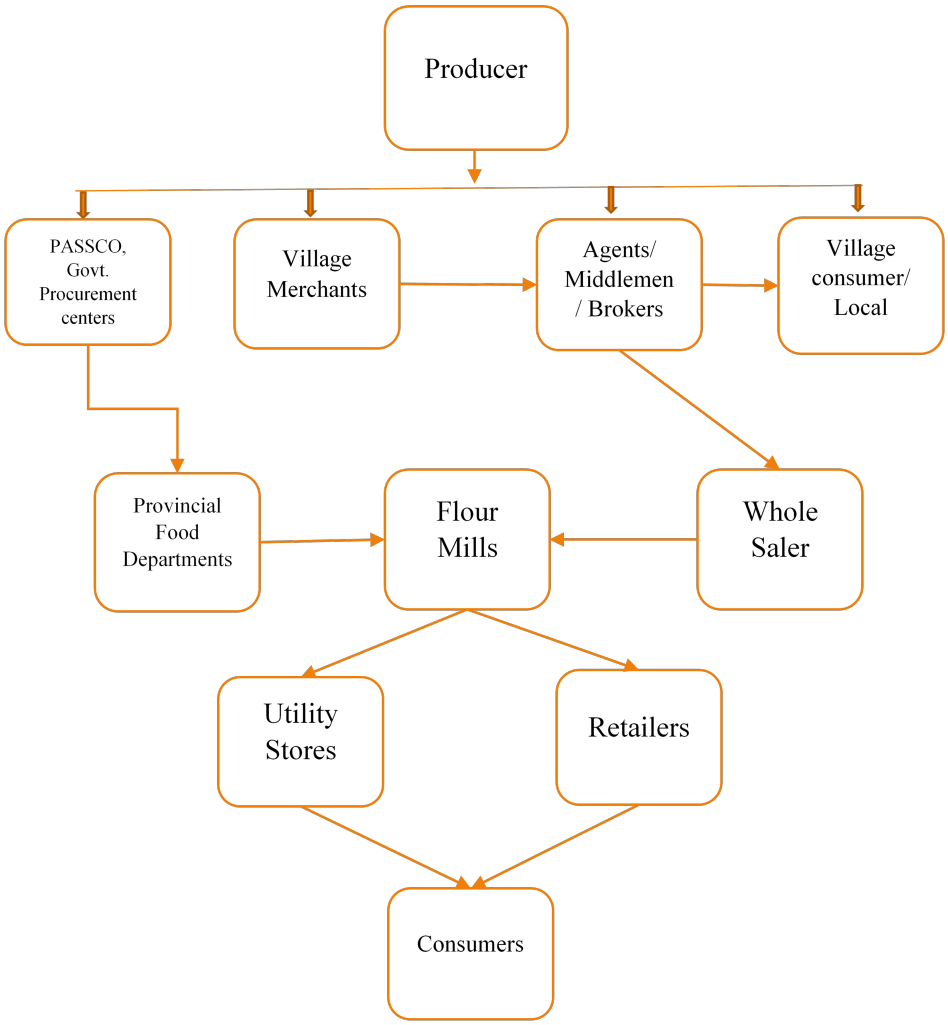
2.3 Structure of Wheat and Rice Markets in Pakistan

The present marketing system of wheat in Pakistan is complex. Along with the public sector procurement, the private sector is also allowed to sell wheat at free prices. Most of the small farmers sell wheat directly to middlemen or village merchants instead of bringing it to public procurement centers. At some times, even standing crop is being sold to these agents because the small farmers take money or inputs from these merchants during the sowing season or throughout the year and commit to these merchants that they will sell their product to them.

Merchants purchase the wheat from farmers and, then, these agents and merchants sell wheat to the procurement center or to the central wholesale markets or traders. Sometimes they also sell to registered market committee agents (locally called Arthis) and these Arthis provide wheat to flour mills and wholesale markets. To understand the complex wheat marketing system, all the marketing channels of wheat are illustrated in a flow chart, Figure 2.1.

Like wheat, there are also different channels between growers and end-users for rice marketing, such as village brokers, middlemen and commission agents (arthis). A flowchart of marketing channels in the rice sector of Pakistan, from producer to the end user enables to understand the prevailing complex marketing system in Pakistan. In the marketing of rice, processors play an important role as private exporters and Trading Corporation of Pakistan (Private) limited (TCP) are dependent on processors, as they get the largest share of exportable rice from the processors.

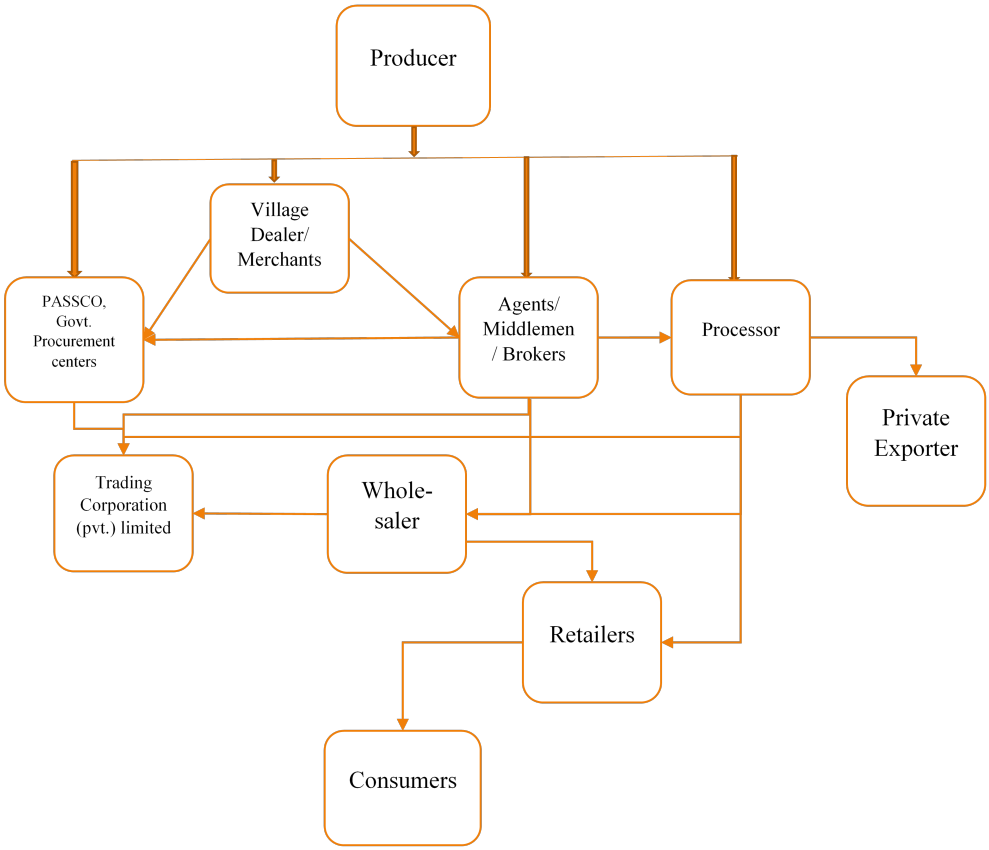
Figure 2.1: Flowchart of Marketing Channels of Wheat in Pakistan



Source: Own illustration based on Zahid et al. (2007).

Figure 2.2 describes the channels of rice marketing in Pakistan. Producers voluntarily sell some of their product at government procurement centers along with other channels like village dealers, commission agents and processors. The government procured rice is then provided to TCP for exports as well as for stockholding to stabilize the prices in periods of demand and supply shocks. Processed rice is also purchased by wholesalers and retailers.

Figure 2.2: Flowchart of Marketing Channels of Rice in Pakistan



Source: Own illustration.

2.4 Available Production and Growth of Wheat and Rice in Pakistan

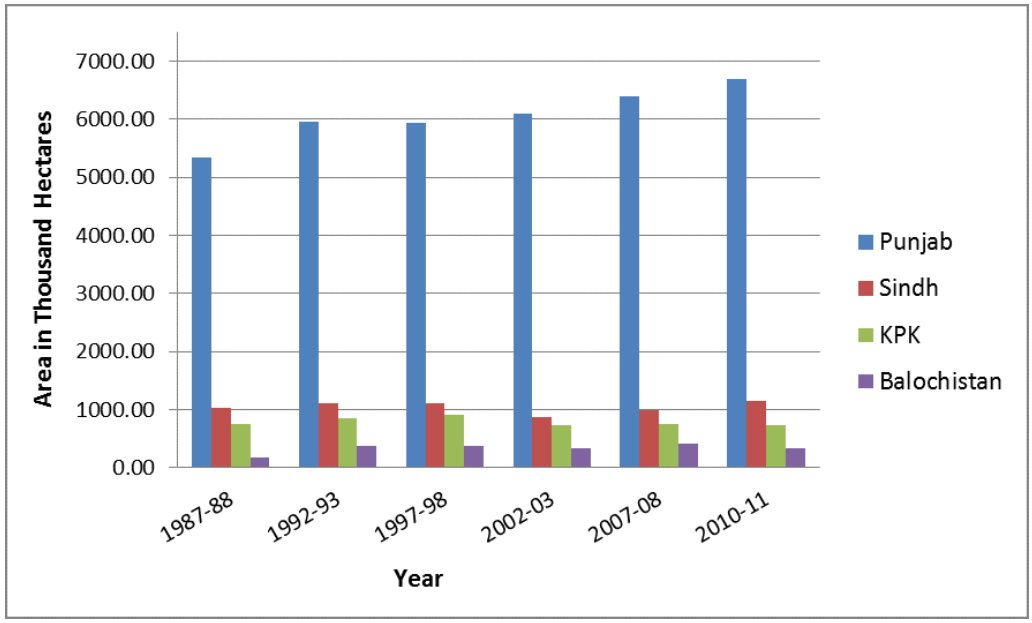
Wheat accounts for more than half of the total caloric consumption in Pakistan. Considering the higher prices of rice, poor household consume the significant share of wheat. Rice is mainly used for export because of higher production and less consumption in the country. Pakistan accounts for about 20 percent of the total wheat production of South Asia (FAOSTAT, 2014). But wheat production in Pakistan has been volatile from year to year. In some years, Pakistan is able to export wheat while in others imports. Therefore, food security is a major concern and is mainly associated with wheat production and consumption, which gives a reason for the government to intervene in the wheat market.

2.4.1 Production and Growth of Wheat

The area and production of the wheat crop in Pakistan (province-wise) are presented in Figures 2.3 and 2.4. The statistics depicted that in the year 1987-88, 7,308.4 thousand hectares were sown for producing 12,675 thousand tonnes of wheat in Pakistan. The area as well as production increased in the last twenty five years, the area increased only by 1,000 thousand hectares, while production almost doubled in the same period. Figures indicated that the area sown was 8,649 thousand hectares and production of wheat was 23,473.4 thousand tonnes in the year 2011-12 (GoP, 2012a).

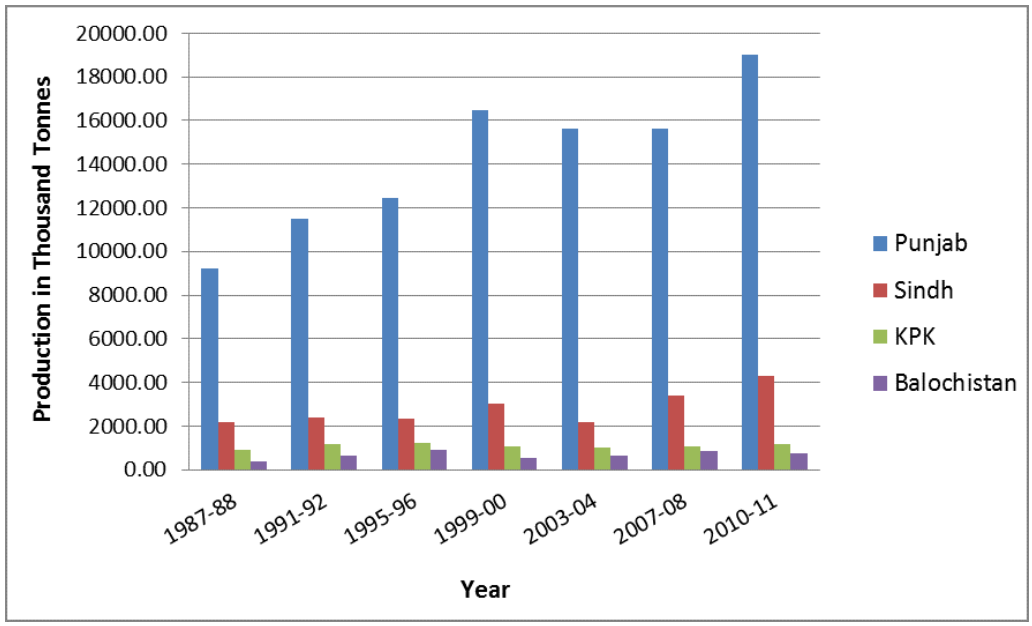
The contribution of the provinces to area and production showed that Punjab is and was the largest contributor. Punjab alone contributed 73 percent of area and production in the year 1987-88 and the share increased and became 75 percent in the year 2011-12. Area and production of Punjab in the year 2011-12 was 6,482.90 and 17,738.90, respectively. Area sown in Sindh, KPK and Balochistan in the year 2011-12 was 1,049.20, 729.30 and 388.40, respectively and production in the same year was 3,761.50, 1,130.30 and 842.70, respectively.

Figure 2.3: Province-wise Area Sown Under the Wheat Crop in Pakistan



Source: Own illustration based on Agricultural Statistics of Pakistan GoP (2012a).

Figure 2.4: Province-wise Production of Wheat in Pakistan

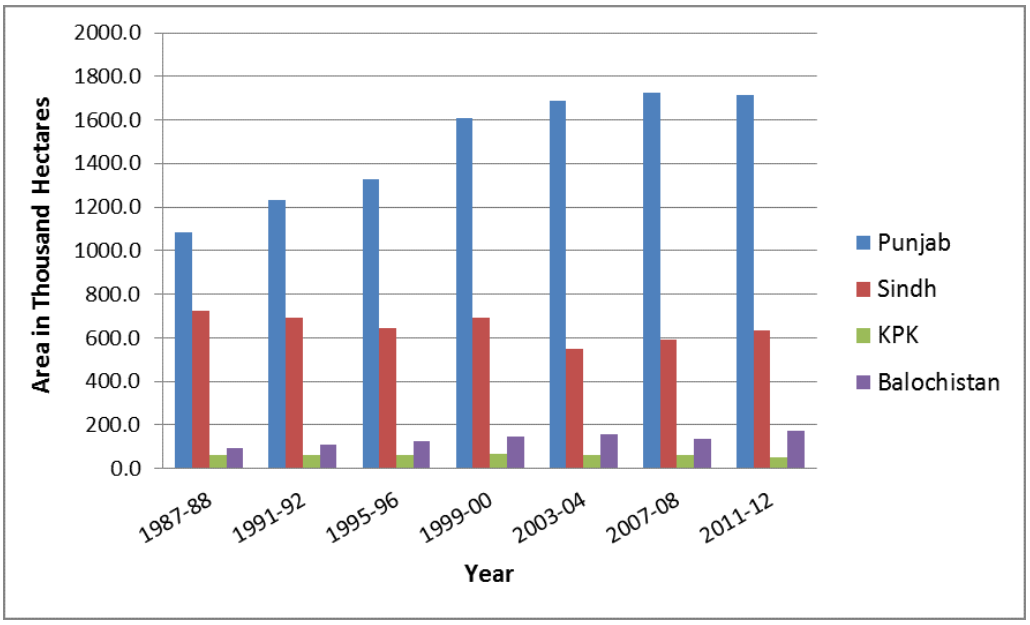


Source: Own illustration based on Agricultural Statistics of Pakistan GoP (2012a).

2.4.2 Production and Growth of Rice

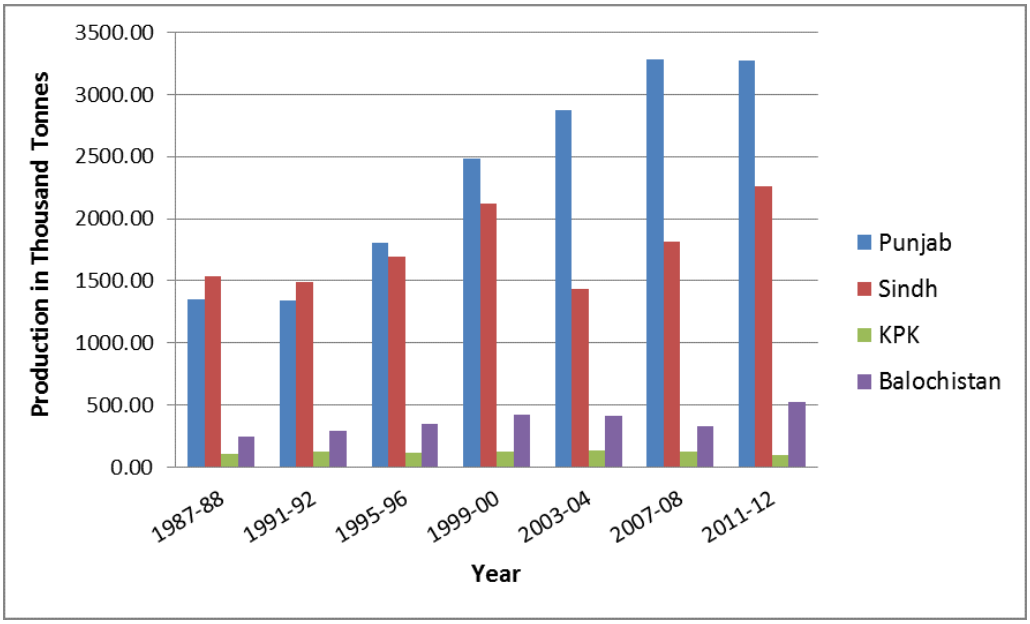
Pakistan is one of the leading producers and exporters of rice, with a share of about 9 percent of total exports of the world. Rice is grown on about 11 percent of total cropped area of Pakistan. Production of rice in Pakistan is comprised of about 40 percent of Basmati type and 60 percent of coarse types. Less than 50 percent of the total rice produced in the country is consumed domestically, the rest of the production is exported. Hence, it is an important source of foreign exchange earnings and accounted for more than 5 percent of value added in agriculture and more than 1 percent of GDP in most of the years, except for the years of heavy rainfall and floods (GoP, 2012b). The share of Punjab, Sindh, KPK and Balochistan in terms of area under the rice crop was 67, 25, 2 and 6 percent, respectively, in the year 2011-12. In the same year, the share in production was 53, 37, 1 and 9 percent, respectively. Province-wise area and production of rice from the year 1987-88 to 2011-12 is given in Figures 2.5 and 2.6.

Figure 2.5: Province-wise Area Sown Under the Rice Crop in Pakistan



Source: Own illustration based on Agricultural Statistics of Pakistan GoP (2012a).

Figure 2.6: Province-wise Production of Rice in Pakistan



Source: Own illustration based on Agricultural Statistics of Pakistan GoP (2012a).

The area under the rice crop has increased form 1,963 thousand hectares in 1987-88 to 2,571.20 thousand hectares in 2011-12 and production increased form 3,240.90 thousand tonnes to 6,160.40 thousand tonnes in the same duration of time. The pattern of growth in rice also suggests that production has increased, almost doubled, although the area increment is only one forth, which indicates the improvements in per hectare yields in rice production. The area sown as well as production in the Punjab province has increased considerably. While area sown in Sindh decreased in the last few years because of the heavy rainfall and floods in the recent past. Even then the production of rice in Sindh province has shown a significant growth because of the higher yields. Area sown in Punjab, Sindh, KPK and Balochistan in the year 2011-12 was 1,714.20, 635.80, 50.10 and 171.10, respectively, and production in the same year was 3,277.00, 2,260.10, 94.70 and 528.60, respectively.

2.5 Government Interventions

As compared to developed countries where farming communities are supported by the governments, developing countries supply food at lower prices to the urban communities by interventionist policies by hitting the farming communities (Ahmad et al., 2006). Pakistan is not an exception. Since independence, Pakistan has been intervening in agriculture, in terms of output as well as input markets. Apart from settlement issues, Pakistan faced many problems at the time of independence like food deficit, infrastructure, shortage of revenue, balance of payment problems (Hamid et al., 1990). As a result, government intervened in the domestic and the import and export market. The government induced compulsory procurement and prices were kept significantly lower than the world price for most of the agricultural commodities. Movement of agricultural commodities from one district to another was banned to ensure procurement by government agencies. As a consequence, a food crisis during the 1950s forced the government to change the policy.

2.5.1 Support Price Policy of Pakistan

The Pakistan government introduced a support price system in the 1960s and fixed the price of wheat to tackle the crisis. Within a short period of time support prices of rice, sugarcane, cotton, maize and oilseed crops were also introduced. The main purpose of the support price system was to protect the farmers against sudden price declines (shocks). Later on a voluntary procurement policy was introduced instead of compulsory procurement for most of the crops except wheat and rice, and prices were fixed above the world prices. The ban on commodity movement from one district to another and on exports was not lifted (Chaudhry and Sahibzada, 1995).

In the 1970s, the government adopted the policy to nationalize enterprises, and structural reforms were introduced along with institutional reforms to control the marketing and distribution of agricultural products, especially food grain products. Two of the major state-owned enterprises

out of many were the Pakistan Agricultural Storage and Supplies Corporation (PASSCO) and the Rice Export Corporation of Pakistan (RECP). PASSCO and provincial food departments were responsible for price stabilization and procurement of wheat, while RECP for the procurement of rice and to maintain a monopoly in rice exports. The government of Pakistan also developed some other enterprises like the Cotton Export Corporation of Pakistan (CECP), the Agricultural Marketing and Storage Limited (AMSL) for potato and onion procurement and the Ghee Corporation of Pakistan (GCP) for oilseed crops (Hamid et al., 1990; Ahmad et al., 2006; Dorosh and Salam, 2008).

State-owned entrepreneurship and control over international trade and domestic marketing and distribution policies affected the economy. The government then performed some structural adjustments in 1980 with financial support by the International Monetary Fund (IMF) and the World Bank to gradually reduce the interventions in trade, marketing and distribution of agricultural commodities (Anderson and Martin, 2009).

Apart from that, the interventions in commodity markets were minimized and compulsory rice procurement and sugar rationing discontinued and replaced with a new system of price fixation on the basis of cost of production based on the recommendations of the Agricultural Price Commission (APCOM). APCOM was formed in 1981. In the mid-1980s RECP interventions were reduced and the private sector was allowed to participate in rice trade, but its role was limited, and PASSCO was advised to implement the support price for paddy. Border protections were also reduced as a part of structural changes during that period (Anderson and Martin, 2009).

The government of Pakistan continued the policy of trade liberalization in the 1990s, the role of AMSL was transferred to PASSCO, and AMSL was closed in 1993 (Dorosh and Salam, 2008). The Trading Corporation of Pakistan private limited company, set up in July 1967, was strengthened and RECP and CECP were merged into TCP. Although, the Federal Cabinet

approved the merger of CECP and RECP in TCP, in December 1996, both the corporations were merged practically in TCP with effect from January, 2001.

The private sector was not only allowed to export other agricultural commodities along with rice, but 25 percent freight subsidy on fruits, vegetables and fish exports were also provided. In 2001, a subsidy on wheat amounting to dollar 1 million at the rate of Rs. 3,250 per tonne was also announced. In 2002-03, it was reduced to Rs. 2,500 per tonne. Imports of agricultural commodities were also allowed to the private sector by strictly following the rules and regulations given by the government of Pakistan. Tariffs were gradually reduced from 225 percent in the late 1980s to 25 percent till the late 1990s. Non-tariff barriers were also eliminated during the mid-1990s (FAO, 2000). Except the 30 items on the negative list due to religious, environmental and health grounds all of commodities were allowed for imports.

Despite the objective of increasing wheat production and reaching self-sufficiency, the government has taxed wheat producers and subsidized consumers relative to world prices, but these policy interventions have always changed with the changing market conditions. For example, in the year 2005 the government allowed the private imports of wheat and kept wholesale prices in most parts of the country close to import price, but subsidized the imports of wheat at a large scale in the years when world prices are higher, to benefit consumers. Similarly, in the years of bumper (higher) production, high support prices and net market injections by the government kept domestic prices from falling steeply, thereby protecting producers (Dorosh and Salam, 2008; Anderson and Martin, 2009).

Although substantial liberalization took place in the late 1980s to the early 1990s, however, tariffs, taxes and direct interventions have been reduced for most agricultural commodities. Nevertheless, the government support price policy for wheat and in some years for rice is still continuing, and the state is also involved in trade through the TCP. The procurement or support

prices announced by the government of Pakistan from 1990-91 to 2011-12 for wheat, irri rice, as well as for irri paddy procurement are shown in Table 2.1.

Table 2.1: Wheat and Irri-rice Procurement Prices from 1990-91 to 2011-12 (Rs. per 40 Kg)

Fiscal Year	Wheat	Rice	Paddy
1990-91	112	127	73
1991-92	124	140	78
1992-93	130	150	85
1993-94	160	157	90
1994-95	160	170	102
1995-96	173	183	112
1996-97	240	210	128
1997-98	240	-	153
1998-99	240	-	175
1999-00	300	-	185
2000-01	300	-	205
2001-02	300	-	205
2002-03	300	-	205
2003-04	350	-	215 *
2004-05	400	-	230 *
2005-06	415	-	300 *
2006-07	425	-	306 *
2007-08	625	-	-
2008-09	950	1400	700
2009-10	950	1200	600
2010-11	950	-	-
2011-12	1050	-	-

Here * represents indicative prices.
Source: Agricultural Policy Institute, Islamabad

After the trade reforms and liberalization policy adopted by the government of Pakistan rice support prices were not announced from the year 1997-98 to 2007-08. Although the government announced support price for paddy, but rice procurement was voluntary. The practice of wheat procurement by the government is still continuing.

2.5.2 Government Procurement

Procurement targets are set by the provincial governments and PASSCO with the objective of stocking enough wheat for distribution in the lean months, depending on the per-capita requirements and total production. The provincial governments and PASSCO procure about 20 percent of wheat production per year. To meet the procurement requirement of the food department the government also uses restrictions on the movement of wheat between provinces and even districts at the time of harvest. This practice was very common till the mid-1990s. It became rare over the last 15 years, and was limited to only those years in which Pakistan faced a significant shortfall in national production. For example, in 1998 and 2004 the Punjab government restricted the movement/transportation of wheat not only within provinces but also within districts to ensure target achievement of district food departments, although these restrictions were lifted within few months.

Pakistan has taken extensive reforms in all sectors of the economy during the last two decades. Deregulation policies were implemented such as lifting inter-provincial and inter-district bans on the private trade from the late 1980s onward. However, various stakeholders (specially millers and landlords) continue their pressure to influence government policies and force government to interfere in the markets directly, specially in the years of bumper crop production because of the threat of lower producer prices or in the case of crop shortfalls to cope with the increase in prices for consumers. The government then sales the procured wheat at subsidized prices to flour mills.

2.5.3 Government Interventions in South Asia

South Asia is a region where government interventions in the food markets were common. All these countries tried to protect their producers by stabilizing prices through public procurement policies with the objective to reduce the market risk for producers (Ganesh-Kumar et al., 2010). They also provided subsidies to consumers on basic food crops (grain as well as wheat

flour), through ration shops, utility stores and public sector imports. These policies were common in all these countries until the late 1970s, and then policies were liberalized to some extent (Anderson and Martin, 2009).

Among South Asian countries, liberalization policies were first adopted by Sri Lanka which replaced the rationing system with a public stamp program. Then Bangladesh started to deration and limited it to public sector employees. After a few years Bangladesh eliminated its limited rationing also in the early 1990s. Afterwards, Nepal took efforts and begun to rely on an open market. Pakistan also dissolved its rationing system in the late 1980s, and markets were liberalized (Ganesh-Kumar et al., 2010). In the rice sector private traders were allowed and encouraged to trade at open market prices. The government intervention in wheat is still continuing and the government is still providing incentives to producers through support prices and public procurement, as well as to consumers through distribution at subsidized rates. Overall liberalization policies were also adopted by India, but they still have a public procurement and distribution system via ration shops to ensure food security. India procures large shares of the total production of wheat and rice. The procurement of major cereals in India is even higher than Pakistan. About 25 to 30 percent share of the total production of both the major food crops are procured every year (Dorosh, 2009). The government of Bangladesh procures a substantially lower share of total production of both cereals, which is only 5 to 8 percent of total production. As compared to Bangladesh, Nepal and Sri Lanka, government interventions in food grains are higher in India and Pakistan.

The main objective of a large scale government intervention in the domestic food markets through procurement, storage, transportation and distribution is to stabilize the prices. However, this comes at high fiscal costs which is not sustainable in the long run, because of storage losses, costs of handling, transaction costs, subsidized sales and public distribution programs. Above all, these interventions may result in significant price distortions.

2.6 International Trade of Wheat and Rice in South Asia

In this era of globalization, it is a need of the day to coordinate with other countries of the world, specially with the neighbors through bilateral trade or through regional trade agreements. Regional collaboration creates opportunities for the partners to engage in trade, which leads to expansion of their markets and strengthening of the economy via market-led integration.

Due to the common colonial heritage most of the South Asian countries have continued the pre-independence policies of their colonizers (British), and these policies continued for decades. During that period, South Asia has been characterized by slow economic growth as well as sluggish industrialization, weak export performance leading to a low trade-to-GDP ratio (Moinuddin, 2013). Political conflicts in the region and war between Pakistan and India further aggravated the situation. As a result, Bangladesh got the status of an independent country in 1971. After independence, Bangladesh also continued the same protectionist policies.

Until few years after independence, the percentage share of trade (in terms of total trade) within the region was in double digits but gradually decreasing. This large share reflects the relatively protectionist policies regarding trade in developed countries, adopted during the 1930s and 1940s, and the South Asian region had less trade barriers in the early years of independence (Baysan et al., 2006). This higher trade share fell quickly and reached only 2 percent in the mid of the 1960s. Two major reasons described by Raihan (2012) are the political rivalry between Pakistan and India and the protectionist trade regime in the region. Subsequently, the developed countries opened their markets to trade between them and with other countries including those in South Asia. Simultaneously, South Asia became relatively closed with import-substituting industrialization, government interventions in production activities and a limited role of the private sector (Baysan et al., 2006).

Except Sri Lanka, which liberalized its economic policies significantly in the late 1970s, anti-trade policies continued in the region till the late 1980s. Baysan et al. (2006) argues that the collapse of the Soviet Union and the success of the People's Republic of China based on outward-oriented policies played an important role to convince the policy-makers of the countries of South Asia that trade openness is the only way to achieve rapid economic growth. Ultimately, policy changes started in the individual South Asian economies, by liberalizing their markets gradually and by adopting a growth model based on trade linkages with the contemporary world. This systematic change took place in the late 1980s and early 1990s, and contributed to a rapid expansion of intra-regional trade between India, Pakistan, Bangladesh, and Nepal as well as of their trade with the world.

Before that, the performance of South Asian economies in international trade was meager in terms of integration with global markets, once compared with other regions of the world. South Asia's trade to GDP ratio was less than 20 percent and intra-regional trade was only 2.9 percent in the year 1990. Protectionist policies like import-substituting policies, high tariff barriers and other trade restrictions restrained South Asia from higher integration within the region as well as with the world until that period (Moinuddin, 2013).

Afterwards, individual economies in the region realized the importance of cooperation and opening-up the economy for trade, which led to the foundation of the South Asian Association of Regional Cooperation (SAARC) in 1985 to promote dialogue and cooperation within the region (Baysan et al., 2006). Countries of the region then started to reduce tariffs gradually as per their adoption of liberalization policies and with the implementation of World Trade Organization (WTO) rules. Under the umbrella of SAARC, trade agreements at the bilateral, regional, and multilateral levels were initiated, but could not get the desired results of achieving extended economic cooperation and integration (Bandara and Yu, 2003).

In 1993, the SAARC countries signed an agreement known as South Asian Preferential Trade Arrangement (SAPTA), which became functional in December 1995. Although the exchange of preferences remained extremely limited, nevertheless, the process of negotiations kept alive the dialogues between the member countries (Baysan et al., 2006). Ultimately, result of that has been achieved after ten years of formation of SAPTA, in the form of the South Asian Free Trade Area (SAFTA). Liberalization policies and the developments regarding regional as well as multilateral cooperation has a positive impact on the growth of international trade of the region, but it was not as vivid as could have been (Table 2.2). The platform of the SAARC and the SAFTA can be further explored to strengthen cooperation in the region, because there is a large volume of informal trade (smuggling) in the region, which reflects the need of the formal trade (Chabot and Dorosh, 2007; Dorosh, 2009).

As a result of liberalization and trade openness, international trade of South Asia has shown unprecedented growth, but its trade within the region is still far less than the potential (Ganesh-Kumar et al., 2010). Intra-regional trade started to increase after 1990, with a slower growth in the trade share. Total percentage share of South Asian regional trade was only 1.9 percent in 1990, which has reached its peak to 5.1 percent in the year 2003, which has again declined to 3.2 percent in 2012 (Table 2.2).

This decline might be because of the higher trade with the rest of the world, because the intra-regional trade of South Asia recorded in the year 2012 was 28.251 billion US$, which has gradually increased from slightly over 1 billion US$ in 1990. Trade of South Asian countries with the whole world was about 52 billion US$ in 1990, which increased up to 877.839 billion US$ in the year 2012 (Table 2.2). The total trade and the intra-regional trade share depicts that South Asian countries trade more with other countries of the world than with the countries of the region.

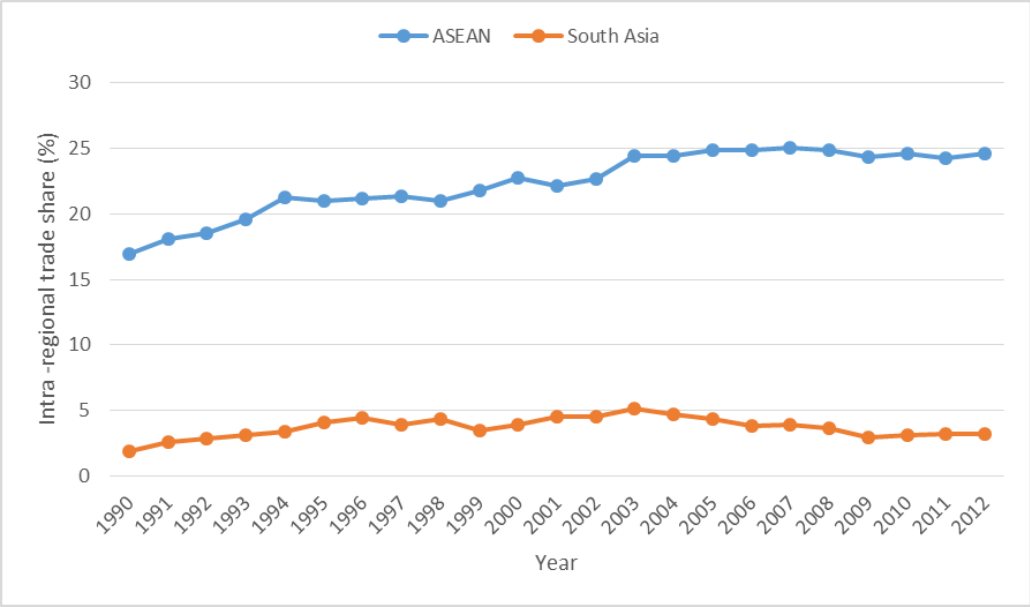
Table 2.2: Trade of South Asia within the Region and with Rest of the World

Year	Trade with World in Billion US$	Intra-region Trade in Billion US$	Intra-region Trade Share (%)
1990	52.651	1.006	1.9
1991	48.513	1.269	2.6
1992	55.506	1.568	2.8
1993	56.552	1.778	3.1
1994	65.602	2.213	3.4
1995	84.433	3.473	4.1
1996	89.510	3.980	4.5
1997	98.646	3.837	3.9
1998	100.411	4.401	4.4
1999	109.815	3.863	3.5
2000	122.457	4.823	3.9
2001	121.449	5.463	4.5
2002	135.913	6.205	4.6
2003	166.060	8.488	5.1
2004	211.497	10.003	4.7
2005	279.419	12.118	4.3
2006	346.372	13.240	3.8
2007	444.722	17.270	3.9
2008	525.485	19.144	3.6
2009	481.673	14.223	2.9
2010	646.112	20.379	3.1
2011	871.214	27.998	3.2
2012	877.839	28.251	3.2

Source: Based on ADB 2015 (Asia Regional Integration Center (ARIC) Integration Indicators Database, available at: `http://aric.adb.org/integrationindicators`, last accessed in March 2015.

In fact, all the South Asian countries trade more with advanced markets of Europe, United States of America, Japan and, more recently, with the People's Republic of China. For example in the last few years, on average, India has less than 2 percent of its trade within the region, while the rest of the trade took place with non-regional trading partners (Asian Development Bank, 2015). The situation is almost similar for other countries as well, except Afghanistan and Nepal, all other South Asian countries trade more (export/import from) outside the region, despite the requirement/availability in the neighboring country in the region.

Figure 2.7: Intra-regional Trade Share of South Asia and ASEAN



Source: Based on ADB 2015 (Asia Regional Integration Center (ARIC) Integration Indicators Database, available at: `http://aric.adb.org/integrationindicators`, last accessed in March 2015.

Regardless of higher global integration, intra-regional integration of South Asian countries in terms of trade has remained slow with a sluggish growth in regional trade. Despite of a little increment in intra-regional trade in the last decade, South Asia still stands as lowest integrated region in the world. Figure 2.7 provides an appraisal of intra-regional trade shares of the Association of Southeast Asian Nations (ASEAN) and South Asia. The figure confirms that ASEAN countries are well ahead of South Asian countries in regional integration in terms of regional trade. In the year 2012, intra-regional trade of South Asia was slightly above 3.2 percent, while intra-regional trade between ASEAN countries was above 24.5 percent. The highest percentage share in intra-regional trade was in the year 2003, but declined afterwards. The figure also shows that not only in recent years, but consistently ASEAN has a much higher share in regional trade as compared to South Asia. This implies that South Asia is less integrated than ASEAN.

Regional trade in wheat and rice has increased in South Asia. Before 1990s, Thailand was the main supplier of rice to Bangladesh, but after that India surpassed it. Nepal imports almost 10 percent of its consumption of rice from India. The share of Pakistan in world exports of rice increased after liberalization and after active participation of the private sector in rice exports. All these countries took efforts to increase trade in food grains over the last two decades by allowing private imports and exports, reducing or replacing tariffs with quotas and removing license requirements (Ganesh-Kumar et al., 2010). There is still a great need and potential to expand co-operation within the region, especially in the food sector, to assure sustainable food security in the region and in the individual countries.

2.7 Food Security in South Asia

"Food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life. The four pillars of food security are availability, access, utilization and stability. The nutritional dimension is integral to the concept of food security"(World Summit on Food Security, 2009).

The concept of food security is complex and is defined in different ways. FAO (2003) reports, more than two hundred (200) different definitions and interpretations of food security were available about a decade ago. The definition adopted by the World Summit on Food Security (WSFS) mentioned above, emphasizes the pillars of food security, which are availability, access, utilization and stability. Although food security has different dimensions that go beyond food production, demand, availability and access, the focus of this section will be more on availability and access, but it is essential to understand the four key aspects described by World Summit on Food Security (2009) to have the broader view of the complex issue of food security.

Mitra (2010) describe these elements as follows:

- The primary pillar of food security is physical availability of food. This includes domestic food production, stock available, food aid and commercial food imports, as well as the fundamental determinants of each of these factors.
- The second aspect of food security, access to food refers to capability of all households and all individuals within those households, in terms of sufficient resources, to purchase food for a nutritious diet.
- If the above two conditions are satisfied, then comes the third parameter "utilization". It is a socio-economic and a biological aspect, with a focus on nutritional requirement. If sufficient and nutritious food is both available and accessible, the household has to make decisions concerning what food to consume.
- Stability refers to the temporal dimension of nutrition availability, access and sustainability, which describes the period over which food security is being considered.

Focus here will be on the first two pillars of food security in relation to this study. Access is more relevant in terms of affordability, provided the availability. As Mitra (2010) points out that availability depends on the resources of the households and on the prices of the food. Von Braun (1992) also emphasizes access to food and availability of food being the major determinants of food security. Use of the term availability is often confused with food supplies available at both household level and at regional or national level (Mitra, 2010). However, the term is most commonly applied to food supplies at the regional or national level (Riely et al., 1999; Hahn, 2000). Von Braun (1992) argues that domestic food production, stockholding of commodities for domestic consumption and trade (particularly imports of food products) are the major determinants of regional or national availability of food.

National availability of food (self-sufficiency) was often misinterpreted as national food security, even this was not made clear whether self-sufficiency guarantees the access to food by all citizens, regardless of prices (Pinstrup-Andersen, 2009). Although access can be achieved without being self-sufficient in food production, depending on the ability of households of the country or region to generate enough income which can be used to meet food needs together with own production. This is in accordance with what Sen (2001) points out that food availability is not a guarantee to food security. He further argues that Sub-Saharan Africa despite being self-sufficient in food in general, is undernourished, because self-sufficiency is based on availability or fulfillment of the market demand. He adds that South Asia in terms of undernourishment is not better than Sub-Saharan Africa, although the former is even not self-sufficient.

Food price volatility in the last few years, specifically after the 2007-08 food price hikes, put extra burden on the national economies of developing countries especially, which are more vulnerable to food insecurity. Von Braun (1992) argues that volatility in prices or supplies may contribute to food insecurity through changes in the consumption. Price volatility, more specifically positive increment in prices, may not only effect lower income groups, but also lower-middle and upper-middle income households of the developing countries like Bangladesh and Pakistan. Hence, food insecurity may persist or to some extent increase. For example, Asian Development Bank (2008) reports that in Asia, a 20 percent increase in food prices probably increased the number of poor by 5.7 million and 14.7 million in the Philippines and Pakistan, respectively.

World Bank (2010) in a detailed report based on different studies by the World Bank, after the 2007-08 crisis, namely *"Food price increase in South Asia: National responses and regional dimensions"*, also explains that food price inflation reduces the purchasing power of a given nominal income and therefore affects consumption and investment decisions, which ultimately results in a reduction in the economic growth and welfare losses. Moreover,

households in South Asia, that presently live just above the poverty line may plunge into poverty, as a result of food price increases, because in South Asia, poor people spend a large proportion of their income to purchase food.

According to the FAO Hunger Map, out of 281.4 millions undernourished people in South Asia in the year 2015, 261.3 millions are from Bangladesh, India and Pakistan only. Bangladesh has 16.4 percent of its population, who do not have adequate food to meet the daily minimum dietary requirements, over a period of one year. In absolute numbers, there are 26.3 millions undernourished people in Bangladesh. In terms of the percentage of the population, India has 15.2 percent of its population and Pakistan with the highest percentage in these three countries with 22 percent undernourished people. Nearly 200 million people in India are undernourished.

South Asia has about 423 millions people living on less than one dollar per day. South Asia has failed to reduce the absolute number of the undernourished people, despite an annual reduction of 1.7 percent in the existing undernourishment in the region, in the past decade. Agriculture in South Asian countries faces problems like low productivity of cereals, supply deficiencies, high staple food prices and low returns to farmers (Mittal and Sethi, 2009). All these factors seem to be a threat to food security.

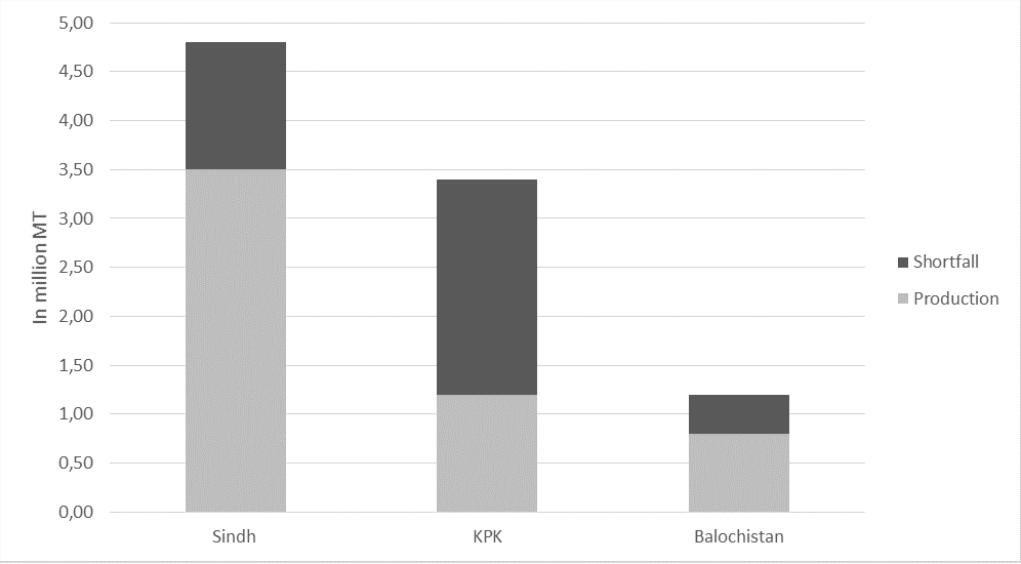
Being agricultural countries, cereals are the most important source of food for the majority of Bangladeshi, Indian and Pakistani people. Cereal's contribution is 50 to 60 percent of total caloric consumption of Pakistan (Asghar, 2011). Wheat is the staple food crop of Pakistan, rice is the staple food crop of Bangladesh, while wheat and rice both are basic sources of dietary consumption of India (World Bank, 2010). Therefore, availability, affordability and accessibility of wheat and rice in this region are necessary for ensuring food security.

Availability of wheat and rice in the countries under study can be assessed by the production of wheat and rice, its consumption, stock varia-

tions, surplus or deficiency and traded quantities. Similarly, province-wise or region-wise availability of wheat and rice can be assessed by production and consumption requirements of the area.

Unfortunately, historical data of province-wise wheat consumption are not available as readily as data on production. Province-wise consumption-requirements data are especially difficult to find. As one of the objectives focuses on regional market price series of wheat from different provinces, it is therefore necessary to have an idea of the demand in different provinces. Due to the aforementioned data availability constraint, the shortfall of wheat for the year 2008 (only) is presented here to give an idea of wheat deficient provinces (Figure 2.8). This was estimated and assessed by the United Nations inter-agency assessment mission based on a partial equilibrium simulation model using Household Integrated Economic Survey (HIES) data, and their own rapid assessment household surveys (United Nations, 2008).

Figure 2.8: Wheat Production and Shortfall Province-wise for the Year 2007-08



Source: UN Inter-Agency Assessment Report 2008. Available at: `http://www.wfp.org/content/pakistan-high-food-prices-impact-assessment-and-way-forward-july-2008`, last accessed in April 2015.

Punjab is the only province of Pakistan having a surplus in wheat production, producing about 16-17 million MT of wheat every year with a consumption requirement of 12.5 million MT in the province (United Nations, 2008). Furthermore, Sindh, Balochistan and Khyber Pakhtunkhwa (KPK) are deficient provinces in wheat production. Hence, trade takes place more from Punjab to these provinces. In most cases, government transports wheat from the stock of wheat procured during the harvest season or finances the private sector's wheat transport to the deficit areas of the country in order to offset the costs of transportation. Sindh has a wheat production shortfall mainly because its capital Karachi, which comprises of dense urban population, is also the main port where imports arrive. The urban population of Karachi are the primary wheat import consumers. KPK is the largest wheat deficit province requiring the allocation of more than two million MT annually. These provinces buy wheat either from PASSCO or from the Punjab food department. KPK shares the porous border with Afghanistan and a large share of wheat is sent to Afghanistan as informal trade rather than reaching local consumers (Chabot and Dorosh, 2007; Dorosh, 2009).

Production, consumption, surplus or deficit, imports, stock variations and export quantities of wheat and rice (in thousand tonnes) in South Asian countries under study from year 2001 to 2013 are provided in the appendices A.1 to A.6. Bangladesh is a net wheat importer among three countries under study, while, India and Pakistan are nearly self sufficient. India imported a handsome amount of wheat in the years 2006 and 2007 due to high consumption during these years and less stocks available of wheat. Pakistan was considered as net wheat importing country before 2000. After that, its production nearly met the requirements of the country in addition to stock availability. Hence, Pakistan has exported wheat in the early 2000s.

As far as rice is concerned, except Bangladesh, Pakistan and India are net rice exporting countries. In fact, India and Pakistan are among the top five rice exporting countries in the world. The area under the rice crop and its production in Pakistan is lowest in the countries under study, but due to

low consumption of rice in Pakistan almost half of its production is exported every year. Production of wheat and rice is significantly higher in India and Bangladesh; so is the consumption. Area, production and consumption of rice in Bangladesh is five times higher than in Pakistan. But, Bangladesh is still a net rice importer, because rice is the major food consumption commodity of Bangladesh.

As discussed above, food prices play an important role from the food security perspective. Higher prices of wheat and rice, or high price volatility in the region in general and in the individual countries in particular can be a threat to food security. This study will provide the idea, to what extent the prices of the basic food staples of this region are integrated with each other. Ganesh-Kumar et al. (2010) describe that geographically separated but integrated domestic markets having uniform prices, well developed physical infrastructure, which makes the transportation of goods easier, are not only vital to improve food security but also prevent domestic price spikes.

Chapter 3

Review of Literature

This chapter contains the detailed review of market integration studies in general and studies on Pakistan and South Asia in particular. Section 3.1 provides a historical overview of the methods developed over time to assess the degree of market integration, along with a detailed summary of some important studies, the methods used and their strengths and weaknesses. Sections 3.2 and 3.3 provides summary of some important studies regarding the countries under study.

Spatially or geographically separated market relationships can not only be described by prices or by trade volumes. But the relationship can be best described by prices, trade volumes and transaction or transfer cost. Market integration studies in agricultural markets especially for developing countries are the tools to examine, evaluate, regulate and reform price polices for food security and price stability. Therefore, market integration and transmission of the price information flow is required to facilitate the process of trade among South Asian countries.

Market integration can help to benefit from specialization using comparative advantage. Goletti et al. (1995) define market integration as smooth transmission of price signals and information across spatial markets and co-movements of the prices. Wyeth (1992) elaborates that market integration is

restricted to the interdependence of price changes across spatially separated markets and characterized by the degree of co-movement of prices across spatially separated markets, while, Baulch (1997) states that market integration is misleadingly judged by co-movements of prices in spatially separated markets, because of ignoring the information on transaction costs. Bekkerman et al. (2013) also agree with that and describe the difference of prices between two spatial but economically connected markets by inherent transaction costs required to trade.

The performance of the farm sector depends not just on farm production, costs and yields, but equally on marketing opportunities also. Weak marketing efficiency results all the production efforts of producer less profitable thus, marketing opportunities and better prices play an equally important role in the performance of farm sector. Sexton et al. (1991) describes that the nature of markets, working capabilities and their role in price determination is key for the allocation and optimization of resources and thus for resource productivity.

Overall market performance of agricultural products is the result of market integration (Faminow and Benson, 1990). Trading markets at two different locations are spatially integrated if price changes in one market are reflected in the prices of the other market (Goodwin and Schroeder, 1991). If the spatial markets are strongly integrated, differences between the local prices in regional markets will be equal to transportation and transaction charges only. Thus, competitiveness and efficiency of pricing are the results of spatial market linkages/ integration (Sexton et al., 1991). In case of less integrated spatial markets, the price signals could be distorted leading to an inefficient use of resources resulting in inefficiency in marketing (Goodwin and Schroeder, 1991).

3.1 Historical Development of Market Integration Studies

The history of market integration studies started way back to 100 years, but in the last 20 to 30 years the focus of research on market integration has increased tremendously and it is getting more momentum nowadays. The first market integration studies mostly relied on correlation coefficients (for details see: Jasdanwala, 1966; Cummings, 1967; Farruk, 1970; Lele, 1971; Blyn, 1973; Jhala, 1984). These techniques are criticized and rejected due to their static nature and inferences drawn from correlation coefficients. With the passage of time, market integration studies identified various measures including short and long-term tests of integration by Ravallion (1986), long-term multipliers and time to adjust by Boyd and Brorsen (1986) and Mendoza and Rosegrant (1995). Besides, cointegration coefficients were also studied by many, some of them are Ardeni (1989); Goodwin and Schroeder (1991); Wyeth (1992); Palaskas and Harriss-White (1993); Sexton et al. (1991); Gonzalez-Rivera and Helfand (2001). According to them, if spatially separated markets are integrated, there is an equilibrium relationship between markets. Causality and centrality tests were also introduced by Mendoza and Farris (1992).

Certain studies compared various measures of market integration and analyzed the structural factors affecting these measures which include Goodwin and Schroeder (1991); Faminow and Benson (1990) and Goletti et al. (1995) and linked market integration with structural factors or determinants.

Regression and cointegration based tests have also been criticized recently for their ignorance of transaction costs by Barrett (1996); Balke and Fomby (1997); Baulch (1997); McNew and Fackler (1997); Fackler and Goodwin (2001); Goodwin and Piggott (2001); Barrett and Li (2002) and Hansen and Seo (2002) who introduced threshold cointegration.

Is cointegration informative?, this interesting question is asked and analyzed by McNew and Fackler (1997) by developing a model used to simulate

prices. They suggested to be cautious in the application of cointegration models for analyzing price behavior in spatially separated markets and their interpretation. One of the major conclusion of this research was that no cointegration does not necessarily mean lack of market integration. The reason behind this was referred to forces like transportation costs and other costs of arbitrage, which may be non-stationary or these forces may cause the cointegration in the autarky prices. Prices that would occur in the absence of trade are termed as autarky prices.

A first study to consider the threshold cointegration was done by Balke and Fomby (1997). They modeled the on and off behavior of cointegration explicitly as a threshold model on the basis of the movement of cointegrated series. They concluded that the series are not cointegrated when they are close to equilibrium, but they are cointegrated when they move far away from equilibrium. In other words, once the system exceeds a certain threshold, cointegration becomes active.

Baulch (1997) developed and applied the Parity Bounds Model (PBM) to wholesale rice markets of the Philippines, and also tested the statistical reliability of this model. Recognizing the role of transaction costs, the author also criticizes the conventional tests and methods used for food market integration analysis and extends the earlier work on stochastic frontier and switching regression models by using transaction costs explicitly at a single point in time, along with nominal rice prices. The author proved the statistical reliability of the model by using Monte Carlo experiments on the data generated by a point-space spatial price equilibrium model. One advantage of this method is that PBM takes into account the discontinuous trade between markets explicitly. Drawbacks of this approach are, that lagged price adjustment are difficult to consider in this model, unlike in other models. It is also necessary to consider transfer costs information at least for a single point of time adjusted by the consumer price index, which also should be as precise as possible, otherwise, it can lead to problems in the estimation procedure by extending the transaction cost band.

Monthly wholesale maize price data of major maize markets in Ghana, over the period 1980 to 1997 were used to analyze asymmetric price transmission from the central market to local markets by Abdulai (2000). The author used threshold cointegration tests that allow for asymmetric adjustment toward a long-run equilibrium relationship and error correction models, and found the evidence of asymmetric price transmission from the central market to local markets. Results of the paper revealed rapid price transmission to local markets when there is an increase in maize wholesale prices in the central market, but the transmission is slow when prices decrease. The author further pointed out that price transmission observed in the study does not make a compelling case for government interventions in the agricultural markets.

Ejrnaes and Persson (2000) applied a threshold error correction model to wheat market prices of France in the 19th century. They developed a model which incorporates the transport-cost-adjusted law of one price. The method applied in this analysis provided the estimates for transaction or transport costs, which they report were very close to the observed transportation costs. Realizing the fact that in the threshold error correction models, adjustments take place only when price differences between spatial markets exceed transaction costs, they used this method and found precise estimates of the speed of adjustment to the differences in equilibrium price between geographically separated markets. The authors concluded that wheat markets of France were well integrated in the 19th century, unlike previous studies on French wheat markets, mainly because of the method they used for the analysis. Hence, they argued that the appropriate method to analyze integration of spatial or vertical markets is the one incorporating transport cost.

Spatial market integration was analyzed by Goodwin and Piggott (2001) using threshold effects in corn and soybean markets in North Carolina. Along with the confirmation on the presence of threshold effects, they found that threshold models estimated faster adjustments to disequilibrium than the

case where threshold behavior, exhibiting transaction costs, trade and arbitrage is ignored. The possibility of unidirectional trade flows between the markets has also been mentioned, asserting that transportation infrastructure and handling facilities may be better suited for commodity flows in one direction.

Barrett and Li (2002) introduced a new methodology to investigate spatial market integration using maximum-likelihood estimation of a mixture distribution model incorporating price, transfer costs, and trade flow data by extending the PBM model introduced by Baulch (1997). They showed that their method allows direct estimation of the probability that the relationship between two markets falls into each of the four basic conditions: perfect integration, segmented equilibrium, imperfect integration, or segmented disequilibrium, derivable from theory. This method also requires the data for transfer costs and trade flows explicitly, like the PBM model.

One of the important contributions to the literature on threshold cointegration in vector error-correction models is provided by Hansen and Seo (2002). They proposed a SupLM test for validating the presence of a threshold. The null hypothesis of this test is no threshold or linear cointegration, so the model reduces to a conventional linear VECM, against the alternate hypothesis of threshold cointegration. The performance of the test was also evaluated using Monte Carlo simulation. They also proposed the implementation method of maximum-likelihood estimation (MLE) of the threshold model, involving a joint grid search over the threshold and the cointegrating vector. An application of their method to the interest rates found strong evidence of a threshold effects in the model.

Meyer (2004) developed and applied a restricted two-threshold model to analyze market integration between pig markets in Germany and the Netherlands. He used Threshold Vector Error Correction Models keeping in mind the general criticism on the ignorance of transaction costs in the applied econometric analyses of market integration in the previous research. He

pointed out that threshold models can account for the effects of transaction costs without directly relying upon information about these costs, which are not available mostly. The author argues that a two-threshold model estimates are economically more intuitive than those of a one-threshold model. However, it is also pointed out in this study that econometric tests for threshold significance were not available for two-threshold model, but the only available tests are for one-threshold models. Hence, a restricted two-threshold model was used for the analysis, in which the inner regime is considered as band of no adjustment while the outer regimes of the band are considered as regime two.

A lot of research has been carried out regarding price transmission from international food markets to domestic markets, especially after the unprecedented increase in international prices. The most comprehensive study regarding price transmission, which came to my knowledge is conducted by Greb et al. (2012), with the aim to understand the price transmission mechanism of international cereal prices to domestic markets in developing countries, based on meta-regression analysis of an extensive data set. They used two samples for the analysis. One large sample of domestic and international wheat, maize and rice price series obtained from the FAO GIEWS data set, and the other sample for the same cereals was extracted from the estimated analysis of 31 past studies. Apart from analyzing both the samples, they tried to analyze the factors influencing the degree of price transmission, by measuring the variations in each sample via a meta-regression estimates.

Greb et al. (2012) found 79 percent of cointegrated food market price pairs in the literature sample, while, for the GIEWS sample it was 43 percent only. They argue that this might be because of the publication bias in the literature sample. Further they noted that in both the estimated samples, long-run and short-run co-efficient parameter estimates shows a similar point average of 0.75 and 0.09 to 0.11 adjustments, respectively. They also found out that except rice prices, domestic price adjustment in the long-run deviations is higher than the international prices. Whereas, rice price

series of most of the international markets show significant adjustment to deviations. Describing the cointegration shares in the different regions of the world, they argue that the prevalence of a higher or a lower share can be attributed by the data set used for the analysis. The authors based on their estimation using the GIEWS data set, reported that domestic prices of Asian food markets are less likely than average to be cointegrated with the international prices of the commodity under study.

John (2013) pointed out the very concern of rice-importing countries that domestic markets of rice-exporting countries are isolated due the interventionists policies of the countries, which is one of the causes of excessive price volatility in international rice markets. His study was restricted to Thailand mainly due to the extensive trade restrictions in other rice-exporting countries like India, Pakistan and Vietnam, such as outright bans on exports which has been already reported by Demeke et al. (2011).

John (2013) found out by testing the extent of exogeneity between domestic and export markets of Thailand through causality tests and impulse response functions that domestic rice markets of Thailand are not isolated from the export market. Further, it is revealed that price transmission is stronger in the domestic market than it is in the export market due to its relative persistence.

Bekkerman et al. (2013) also investigated price relationships in North Carolina (NC) corn and soybean markets by using a variable threshold band approach instead of the constant threshold, unlike Goodwin and Piggott (2001). Goodwin and Piggott (2001) estimated the same markets with constant thresholds and suggested that the assumption of a constant threshold (fixed neutral band) is restrictive, and a variable band should be used if the time series data is available for longer time periods. Hence, Bekkerman et al. (2013) extended their study by modeling and estimating time-dependent market linkages, conditional on changes in exogenous factors. Among many exogenous economic and biological factors, they suggested two major factors;

fuel prices and seasonality components as strong determinants of transaction costs for trade of agricultural commodities within two markets. For comparison, they estimated both constant and variable transaction cost band models and found that variable threshold models provide a better statistical fit and indicate statistically significant effects of time-dependent exogenous factors on market linkage variation than constant threshold band, because, a constant market linkage assumption may lead to incorrect inferences about the magnitude of price adjustments to shocks and the amount of time period until price relationships equilibrate. The authors also admit that measuring transaction costs explicitly is virtually impossible because these costs encompasses both observable and unobservable components. A drawback of this approach may be the selection of appropriate exogenous factors. For example, along with fuel prices, means of transportation, quantity of trade flows, production and consumption may also be equally important.

It can be concluded on the basis of studies mentioned above that threshold models with different regimes are superior than linear VECM models, because these models take into account the unobserved transaction costs, which play an important role in market integration research. The Parity Bounds Model developed by Baulch (1997) and the model developed by Bekkerman et al. (2013) have some drawbacks which are discussed earlier. Apart from some studies using the PBM model, consensus on using threshold cointegration or Threshold Vector Vector Error Correction Models with two or three regimes can be seen, apparently.

3.2 Market Integration Research on Pakistan

There are only few market integration studies regarding food markets of Pakistan. The only study coming to my knowledge is Mushtaque et al. (2007a) who studied the wheat markets of Pakistan. Other studies, including Kurosaki (1996); Tahir and Riaz (1997); Zahid et al. (2007) and Mushtaque et al. (2008) limited their studies to the Punjab province of Pakistan. Some

of them have focused either on the southern and northern regions of Punjab, or on different commodities like cotton, gram and fruits and vegetables. All of them have restrained themselves to cointegration and nobody has used dynamic or threshold models to analyze integration of markets. Lohano et al. (2005) are the one who used an error correction model to examine market integration by estimating price linkages among onion markets of Pakistan.

Kurosaki (1996) examined the spatial and inter-temporal price relations of wheat and rice in the Punjab province of Pakistan using regression analysis on three-year cross section data. Government support prices were used as a proxy variable for the farmgate prices along with the actual observed prices in the regression analysis. The author concluded that farmgate prices of wheat after harvest are mostly explained by the government support price, but basmati paddy have more unexplained variation in prices, mostly because the support price mechanism is different for both the crops. This study showed further that wholesale wheat prices increase regularly at the rate of storage costs in the first half year after harvest and the price rise is repressed by the government release of procured wheat in the second half of a normal year.

Tahir and Riaz (1997) tested integration of agricultural commodity markets of cotton, wheat, and rice in southeastern Punjab. The authors applied an analytical framework introduced by Ravallion (1986), in which it is possible to test for short-run and long-run integration or complete market segmentation. The author used Bahawalnagar, Chishtian, Fort Abbas, Hasilpur and Pakpattan markets for wheat and cotton. Fort Abbas market was not considered for rice market integration, because rice is not grown in this area particularly and generally South Punjab is not a major rice growing area but wheat-cotton area. They concluded that cotton, wheat and rice markets in southeastern Punjab are well integrated in the long run only. In a few special cases, short-run integration was significant. Further, the conclusion of the study also revealed that market size seems to play an important role in terms of integration, because price adjustments from Multan market to other markets under study showed clear indication of relationship with the size of the

market. The Multan market was considered as a central or reference market for wheat and rice market integration in this study.

The results for individual commodity markets of south Punjab revealed that four markets out of five were integrated in the long run as well as in the short run. Wheat market integration showed long-run integration only for the southeastern Punjab wheat markets. Whereas, rice markets showed mixed results, Hasilpur and Pakpattan markets were found segmented and other markets were found integrated, not only in the long run but in the short run as well (Tahir and Riaz, 1997).

Regional market integration in Pakistan for many agricultural commodities had been extensively studied by Mushtaque et al. (2006, 2007a,b) with an objective to provide information about the functioning of such markets and the dynamics of price adjustment. They argue that imperfections in the market functioning may provide the justification for extensive government intervention in the agricultural markets of Pakistan.

Mushtaque et al. (2006) used monthly wholesale prices of basmati rice from January 1995 to December 2003 to estimate the degree of market integration in basmati rice markets of Pakistan, using the law of one price (LOP) framework and cointegration analysis. They also restricted their study to rice markets from the Punjab province of Pakistan. Based on a cointegration framework, they observed a high degree of market integration in the rice markets of Punjab. Further, they utterly rejected the extensive and costly government intervention designed to improve competitiveness to enhance market efficiency.

The only relevant study of market integration regarding wheat markets of Pakistan comes from Mushtaque et al. (2007a) who studied the same wheat markets prices series of Pakistan, which are covered in this study. Using monthly wholesale prices from January 1980 to December 2001, they concluded on the basis of cointegration tests that except Peshawar, the remaining

four markets Hyderabad, Lahore, Multan and Rawalpindi are well integrated. Neither they used a dynamic model to analyze the market integration nor they have tried to examine the non-linearities or threshold cointegration. They also ignored the transaction costs which play a crucial role for identification of the degree of market integration.

Zahid et al. (2007) tested spatial market integration in different wheat markets in Northern Punjab, Pakistan, which are spatially segregated from each other. The Engle and Granger test of cointegration was applied to analyze long-run market integration between the central market of Lahore and five feeder markets namely Faisalabad, Sargodha, Gujrat, Gujranwala and Sialkot. It emerged from the analyses that the market pairs of Lahore-Faisalabad and Lahore-Gujranwala are perfectly integrated with each other in the long run because of direct and better road and rail link and common socio-economic culture. The pairs of Lahore-Sargodha, Lahore-Gujrat, and Lahore-Sialkot markets were found partially integrated having some what a long distance and different socioeconomic conditions between them and lesser information flow. This study revealed that government should develop infrastructure, especially roads and rails and improve flow of information. In addition expansion and construction of transportation system must be accorded priority.

Mushtaque et al. (2008) empirically studied the apple market integration for its implications on sustainable agricultural development of Pakistan. They used wholesale price data from January, 1996 to December, 2005 for the regional apple markets of Pakistan to examine the degree of market integration. Based on the augmented Dickey-Fuller (ADF) test and cointegration test results of nine regional markets they concluded that all price series are non-stationary and integrated in the long run. Maximum-likelihood estimation method of the vector error correction model (VECM) was then applied to asses the degree of market integration. Their results show that 37 to 53 percent of the disequilibrium is removed in each month. The authors concluded that apple markets of Pakistan are perfectly integrated with Quetta

being the dominating market. Their study confirmed that price linkages between markets and the relationships among distant markets seem to be important in economic analysis.

Dorosh and Salam (2008) analyzed the implications of Pakistan government's wheat policies, including procurement and trade policies on market forces, inflation in general and prices of wheat in particular. Price determinants were analyzed using the Social Accounting Matrix (SAM), it was witnessed that an increase of procurement price has no major effect on wheat prices or inflation in Pakistan, prices are rather determined by demand and supply in the market. On the basis of partial equilibrium model estimation of wheat markets of Pakistan, the authors pointed out that a possible reason of wheat price increase in Pakistan (during or before the price spikes in 2007-08) might be production volatility, instead of government policies. The overall conclusion of the study is that demand and supply of wheat play a dominant and significant role in determining prices of wheat and policies enhancing the participation of private sector can not only stabilize price volatility but can also minimize the fiscal costs of wheat procurement and sale by the government. Further, they also emphasized the role of private sector trade, to increase the supply and availability during the years of production shortfall, which might lead to price stability.

Mehmood (2010) analyzed price transmission in rice markets of the Punjab province of Pakistan with the objective to see the impact of trade reforms on rice farmers of the region. The author applied cointegration tests on monthly wholesales prices of rice from January, 2000 to December, 2007, and concluded that rice markets of the Punjab province are well integrated. Although, long-run integration has been established, speed of adjustment has not been estimated.

Keeping in view the importance of rice and the lack of market integration studies regarding rice markets of Pakistan, Ghafoor and Aslam (2012) investigated the degree of market integration in domestic rice markets. Fur-

thermore, they analyzed price transmission of international rice prices to domestic rice markets of Pakistan. This study was restricted to five markets (Faisalabad, Gujranwala, Lahore, Multan and Sargodha) from the Punjab province, because they used basmati rice prices. The basmati variety of rice is only produced in the Punjab province. To check the price transmission from international to domestic markets, they used FOB prices of Pakistan, prices of long grain aromatic rice of USA and fragrance rice of Thailand. Johansen's cointegration approach, the error-correction mechanism and Granger causality were applied to monthly data from January 2000 to December 2009 to analyze market integration and price transmission in the selected markets of rice.

Ghafoor and Aslam (2012) revealed on the basis of pairwise cointegration that the five markets of Punjab under study were integrated with each other. The author found no cointegration between international and domestic rice markets and concluded that price transmission from international to domestic markets does not occur, mainly because Pakistan is one of the major exporters so it depends less on international markets for price formation in Pakistan. The author also checked for Granger causality and concluded that Granger causality analysis also supported the integration of rice markets in Pakistan, as bi-directional causality was found in most of the regional market pairs. For international market prices, no causality between Pakistan FOB prices and Thailand rice prices was found, whereas, unidirectional causality between Pakistan FOB prices and USA rice market prices was found.

As discussed earlier, most of the studies either focused on local markets of a particular region, specially the Punjab province of Pakistan. Further, only cointegration, Granger causality and simple error correction models have been used for the analysis. I have not found any study regarding wheat and rice markets of Pakistan, using the latest methods to analyze the degree of market integration incorporating transaction costs. Non-linear models have not been applied to the food markets of Pakistan, which might give more insight to the efficiency of market functioning.

3.3 Market Integration Research Studies on South Asian Countries

There are a few studies on market integration regarding food markets of South Asian countries. Except Ravallion (1986) and Goletti et al. (1995) who developed a dynamic model of price transmission using rice prices from Bangladesh, most of the innovative studies on market integration are on developed economies, see for example, Spiller and Huang (1986); Ardeni (1989); Sexton et al. (1991); Goodwin and Schroeder (1991) and Goodwin and Piggott (2001).

A small number of studies on agricultural markets of India has been carried out see for example Basu (2010); Jha et al. (2005); Ghosh (2010, 2011) and Jayasuriya et al. (2007). Regional level studies on Pakistan and Bangladesh food markets by Ravallion (1986); Goletti et al. (1995); Dawson and Dey (2002); Lohano et al. (2005); Mushtaque et al. (2007a); Rabbani et al. (2009); Zahid et al. (2007); Alam and Begum (2012) and others.

There is only one study which came to my knowledge until now on the Nepalese and Indian rice market by Sanogo (2008) and one study regarding Bangladesh and Indian rice markets by Dorosh and Rashid (2013). To the best of my knowledge there is no such study of market integration on the South Asian region as a whole.

The concept of testing a hypothesis on short-run and long-run integration based on a dynamic model was proposed by Ravallion (1986). The model developed by him depends on the assumption about radial market structure. In this context, Ravallion (1986) introduced the concept of a reference or central market surrounded by a group of other (local) markets. Although, it is not necessary to have direct trade from (to) local markets to (from) central market, but there can be indirect trade i.e. trade from a local market to the central market via another local market. The author applied this model on the rice prices of Bangladesh from July 1972 to June 1975. The results

obtained from this study revealed that hypothesis for short-run integration could not be accepted. Long-run integration performed slightly better, but still the hypothesis of long-run integration was not accepted for three out of the five districts. Further, it was concluded that there were significant impediments to trade between Dhaka (the central market) and other local markets.

Goletti et al. (1995) analyzed rice markets of Bangladesh, using weekly prices of rice of more than three years for sixty-four districts of Bangladesh, and some structural variables along with prices. They emphasized on certain issues of market integration by using a two-stage approach. In the first stage, they used time-series methods and in the second stage they incorporated some structural variables such as distance within markets, strikes in the districts and production shocks. A moderate degree of market integration was established by their analysis. The major conclusion of the second stage is that different measures of market integration respond differently to the same structural factors. Implications provided by the authors, based on their analysis was that an improvement of existing infrastructure and development of new infrastructure, especially roads, will reduce the transportation costs and will enhance the integration between spatial markets. On the basis of production shocks, they suggested a reduced role for government interventions and they argue that the room for private traders to operate efficiently in the context of moderate supply and demand shocks is available.

Sarker and Sasaki (2000) evaluated the nature and extent of market integration of fruit and vegetables markets in Bangladesh, using the Ravallion model, between regional markets of Bangladesh surrounding the central market Dhaka. They used monthly wholesale price data of potato and banana, precisely. They found Ravallion's model suitable to understand the dynamics of fruit and vegetable markets of Bangladesh, because Dhaka is the central market and other markets under study were the surrounding potato and banana markets. They found that except one market for potato, all other markets under study for both potato and banana were not integrated with Dhaka market. However, their results also reveal that none of the selected

markets was segmented from the central market. The authors concluded that integration of banana markets was poorer than that of potato markets.

Dawson and Dey (2002) studied the spatial market integration empirically among 12 major rice markets in Bangladesh, including the Dhaka market, by using monthly wholesale prices from January, 1992 to December, 1997. Cointegration and a vector autoregressive (VAR) model was applied to test long-run spatial market integration between pairwise price series, to conduct the hypotheses tests for market integration, perfect market integration and causality, respectively. Results revealed perfect market integration in the rice markets of Bangladesh. As per expectation, the Dhaka market appeared to be the dominant market on the basis of a causality test, some distant markets Granger-cause Dhaka market as well.

Bangladesh initiated a structural adjustment program of trade liberalization in general, in agriculture and the rice sub-sector in particular, in the year 1992. Despite that, government intervention in the rice sector continued (Hossain and Verbeke, 2010). Hence, to assess the degree of market integration following the liberalization in the regional coarse rice markets of Bangladesh, Hossain and Verbeke (2010) conducted an study using wholesale weekly prices from January, 2004 to November, 2006, for six divisional markets. The authors used Johansen cointegration and a vector error correction model (VECM) to empirically assess the degree of market integration. Empirical results indicated three cointegrating vectors, which implies that the rice market is moderately integrated in the long run. Speed of adjustment or short-run integration has been weak. The authors explained that a lack of infrastructure and an insufficient transport network impede the flow of information and goods from one market to the other.

Market integration in 55 rice markets in India using a large data set of monthly wholesale prices from January, 1970 to December, 1999, was analyzed by Jha et al. (2005). They used methods developed by Gonzalez-Rivera and Helfand (2001) and some robust testing to determine the common fac-

tors of price integration among different markets. The results revealed a lack of market integration in rice markets of India. Excessive government interventions were found responsible for this low degree of integration or so to say market segmentation. It was found that due to control of government on the rice sector, co-ordination between deficit and excess supply markets could not be established and this became the common factor for market segmentation.

Rice markets integration in the mid-west and far-west districts of Nepal was studied by Sanogo (2008) with the objective of assessing the performance of regional markets along with the role by the neighboring markets of India in the supply of rice to contiguous Nepalese markets. The data used for the study was extracted from the World Food Program (WFP) database on Nepal. The Ravallion model was used for estimation of pairwise equations, using Three Stage Least Squares (TSLS) for this study. Results of the analysis indicated poor integration of the rice markets of the hinterland with Nepalgunj. However, short-run and medium-run integration of Nepalganj was found with contiguous Indian markets Rupedia and Jogbani. Sanogo (2008) points out that large price differences due to higher transport costs and lack of infra-structure obstruct the integration between mid-west and far-west markets of Nepal. Provided, open-door policy with India regarding trade and efforts for continuation of these policies, results in better integration with Indian markets. The study suggested that Nepal not only should maintain the trade relations with India, but should also build stronger relations to ensure food security in the country. However, substantial investment in transport infrastructure is required to improve market integration in the regional markets and with Indian markets as well, for long-run sustainability.

Basu (2010) tried to analyze the pricing efficiency through market integration of potato markets at wholesale, retail and at the village level in the Hooghly district of West Bengal, India. Application of the cointegration test developed by Johansen and Juselius (1990) on spatial and vertical chains revealed that potato markets in West Bengal were integrated and efficient.

This implies that the prices of potatoes are not only spatially integrated, but price signals are also quickly transmitted from the wholesale to retail markets. Unlike, efficiency drawn on the basis of cointegration among wholesale and retail markets, village markets did not provide evidence of efficiency. From the village level market analysis, the author found that sale in the cold storage non-concentrated zone was higher than in the cold storage concentrated zone, due to distress. He further points out that farmers had little margin of taking advantage from off-season sales. Traders and cold storage owners have more advantage and higher margin of profit in the prices paid by the consumers, than that of producers or farmers. That is why the author termed the potato marketing system of West Bengal as "arena of conflicts".

Basu (2010) concluded that the complex and non-competitive market structure of potato at the village level cannot guarantee efficiency, as it was witnessed from wholesale and retail markets. The author recommended the eradication of distortions in the supply chain to minimize the losses and to improve vertical market integration in the supply chain. Further, he emphasized that this will result in net welfare gains for producers, consumers and to the nation as well.

Ghosh (2011) applied the maximum-likelihood method of cointegration, investigated the impact of agricultural policy reforms on spatial integration of rice and wheat markets in India. He did this study both at intra- and inter-state level in different regions. The results indicated that the extent of intra- and inter-state spatial integration of these markets has improved during the post-reform period relative to the pre-reform one. The regional markets, which were either segmented or poorly integrated during the pre-reform period, were found to be strongly integrated, and in most cases to such an extent that satisfies the relative law of one price (LOP) during the post-reform period. He added that the government could promote agricultural growth and ensure stability in food grain prices by limiting its direct intervention in the agricultural markets, but increasing its attention to improve physical and institutional infrastructures. In the end, he recommended

that reliance on direct intervention of the government in the markets can be reduced significantly, if the government promotes efficient trading of agricultural commodities by liberalizing the markets, improves the transport and communication networks, and provides storage facilities and short- and long-term finances to private traders.

Almost all the studies mentioned above regarding market integration of food markets of Bangladesh and India, used cointegration, error correction mechanism or Granger-causality methods for analysis, which has been criticized in the recent literature for ignoring transaction costs or threshold effects. One of most recent and important study regarding rice markets of Bangladesh is carried out by Alam and Begum (2012). Understanding the importance of transportation costs for developing countries and the criticism on the ignorance of transaction costs, the authors used threshold cointegration and the Threshold Vector Error Correction Model (TVECM) of Hansen and Seo (2002) to consider the effects of transportation costs to analyze the market integration between international and domestic markets of rice. They have also used the SupLM test to establish the threshold effects. Based on the SupLM test, strong evidence of threshold effects has been found. The TVECM estimation results revealed that the Bangladesh rice market is partially integrated with the world market. The immediate speed of adjustment showed that one third of the change in world market prices transmits to the Bangladesh market in the long run.

Chapter 4

Data

This chapter provides the information about the data, sources and time period covered for the study. Limitations of the study, constraints regarding data collection and problems of the data set are also discussed in this chapter. Monthly wholesale price series of different wheat and irri rice markets of Pakistan are selected to analyze domestic market integration. Domestic wheat and rice market price series of Bangladesh, India and Pakistan and the export prices of US-HRW wheat, and Thailand and Vietnamese export price series for rice are used for the market integration analysis of South Asian markets with each other and with the international markets.

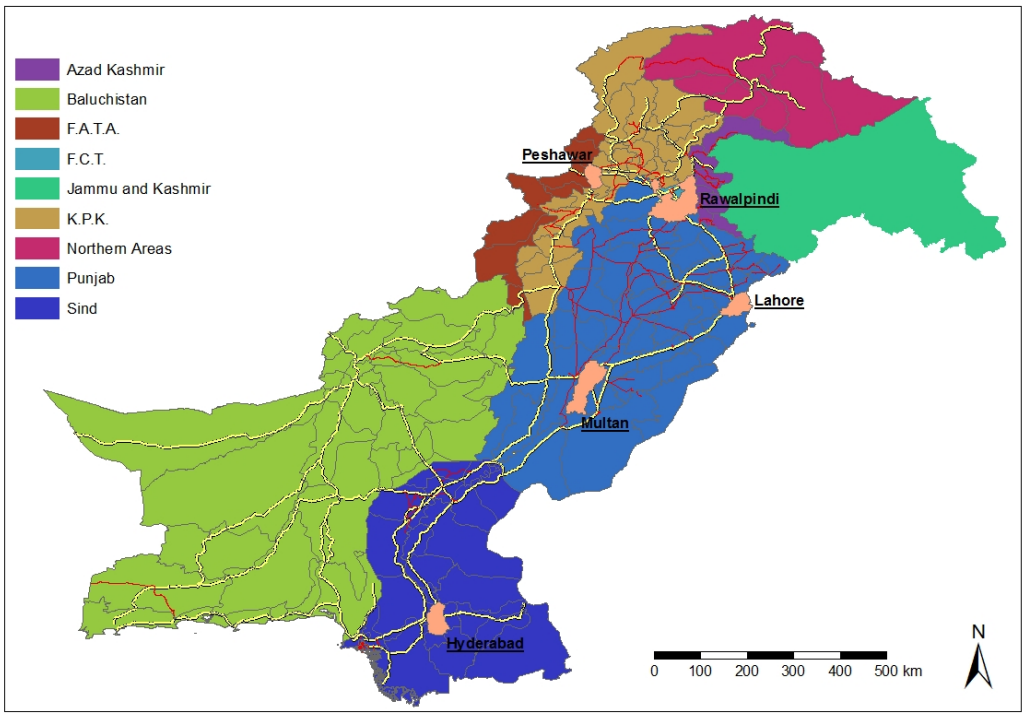
4.1 Data Collection

Selection of markets was constrained by short or long spells of poor documentation. Therefore, only the main centers of production and consumption were selected. Despite some missing value issues, a good coverage of data is realized. The time period coverage is dependent on data available so far. Monthly data available for different markets of Pakistan for wheat and irri rice are from January 1988 to April 2011 (280 observations). Due to unavailability of more recent data, estimations are restricted to wholesale prices of wheat and rice till April 2011.

4.1.1 Domestic Wheat Markets

Monthly data for nominal wholesale prices of five wheat markets are selected for the study, from January 1988 to April 2011. Selected markets include Hyderabad from Sindh Province, Lahore, Multan, and Rawalpindi from Punjab province and Peshawar form Khyber Pakhtunkhaw Province. The unit price is expressed in Pakistani Rupees per 40 kilogram. Figure 4.1 shows the map of Pakistan indicating the wheat markets selected for the study.

Figure 4.1: Map of Pakistan Indicating Wheat Markets of the Country



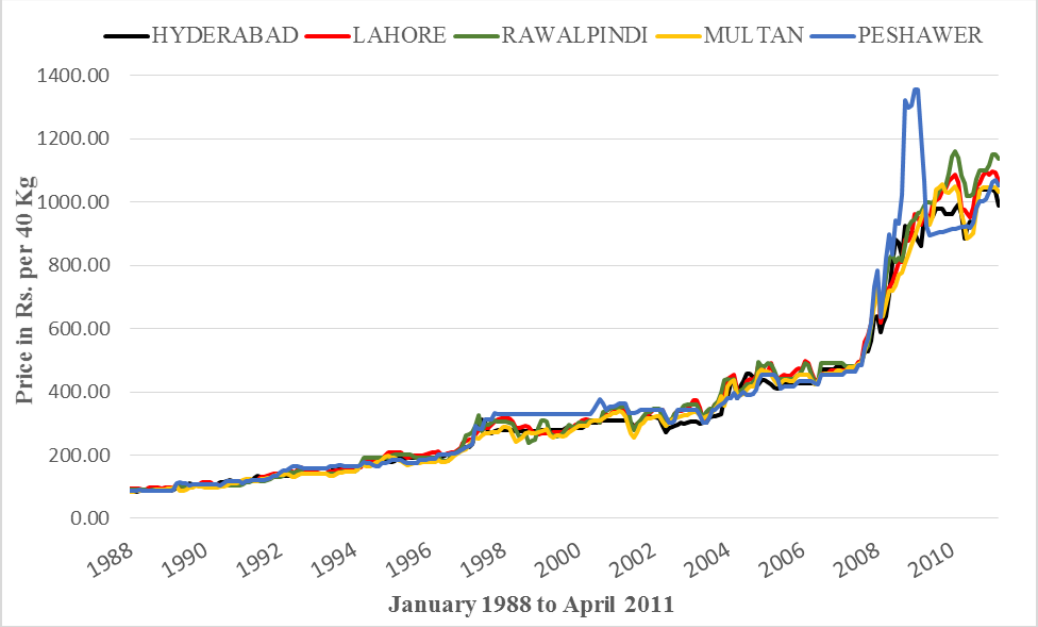
Source: Own illustration with ArcGIS program using data from the website `http://www.gadm.org/`

It can be seen in the map that three markets from the Punjab province are selected, because Punjab is the largest producer of wheat in Pakistan. Punjab contributes about 75 percent and Sindh follows with the contribution of above 15 percent of the total production of wheat in Pakistan, as of the year 2011 (GoP, 2011). No market from Balochistan is included in the

analysis of wheat markets due to non-availability of time series data and very low contribution in the production. Punjab is the largest contributor in the overall production of wheat in the country as well as the largest province in population so it is also one of the biggest consumption markets.

The difference between the prices of the wheat markets of Pakistan was negligible, and they were moving very closely in the beginning of the study period (Figure 4.2). Prices became more volatile and started to rise from the beginning of 2007. Prices reached the maximum during mid-2008, which can be explained by the food crisis and price hikes in international food markets specially for wheat, rice and maize prices.

Figure 4.2: Wholesale Wheat Prices of Pakistan



Source: Own illustration based on Agricultural Statistics of Pakistan GoP (2012a).

Descriptive statistics of price data for wheat markets are presented in Table 4.1, which shows that the arithmetic mean of wheat prices were highest in Rawalpindi, followed by Lahore. The average price in Multan market is the lowest in all. In total, there were only 31 observations missing out of the

sample of 1400 observations, about 2.5 percent, out of which, 5, 9 and 17 observations from Lahore, Multan and Peshawar market price series, respectively. The Peshawar market price was recorded highest during the period of price hike followed by the crisis in 2007 and reached its maximum with 1350 rupees per 40 kg.

Table 4.1: Descriptive Statistics of Nominal Monthly Wholesale Prices of Wheat Markets of Pakistan

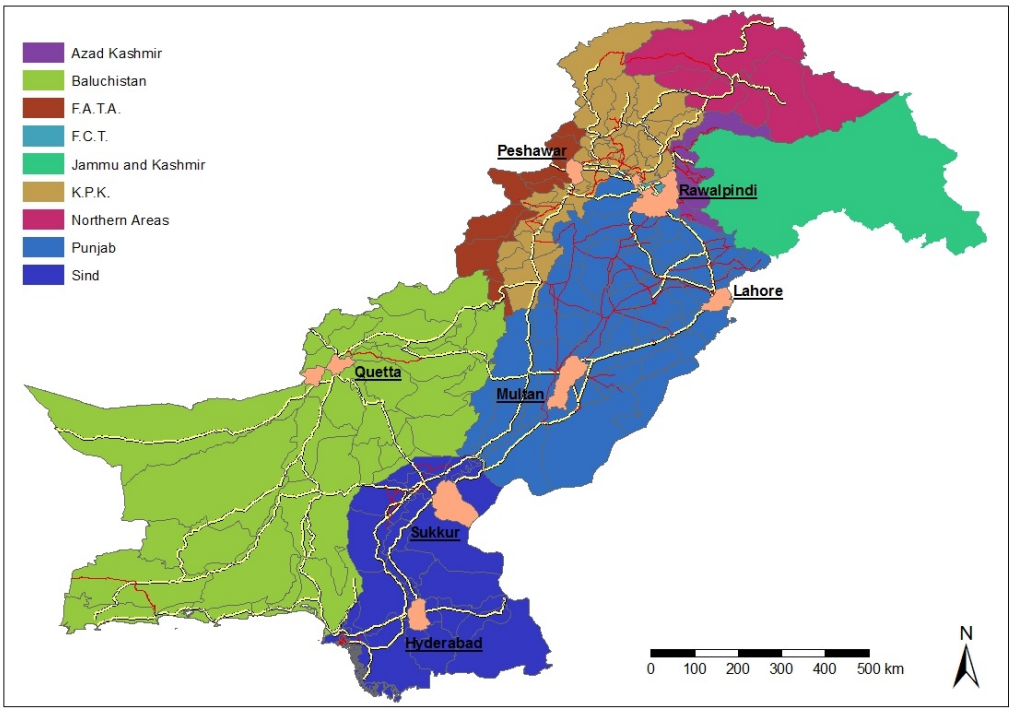
D.S/ Market	Hyd	Lhr	Pindi	Mltn	Pshwr
Mean	350.5	364.7	370.0	337.4	342.2
Maximum	1040.0	1089.7	1160.0	1054.0	1350.0
Minimum	83.0	88.5	88.0	83.5	84.0
Median	287.0	300.0	302.5	273.0	325.0
St. Dev.	259.9	270.1	284.7	254.4	259.5
No. of Obs.	280	275	280	271	263
Missing Obs. (#)	–	5	–	9	17
Missing Obs (%)	0.0	1.8	0.0	3.3	6.5

Source: Own calculations based on Agricultural Statistics of Pakistan GoP (2012a).

4.1.2 Domestic Rice Markets

Seven wholesale irri rice markets (Hyderabad and Sukkur from Sindh province, Lahore, Multan and Rawalpindi from Punjab province, Peshawar form Khyber Pakhtunkhaw (KPK) province and Quetta from Balochistan province) are selected for the study. Basmati rice markets were not selected mainly because basmati rice is produced only in the Punjab province and more than half of the total production of basmati rice is exported. Apart from that, long spells of missing observations and unavailability of time series for few important markets, basmati rice market prices are not considered for the analysis. A map of Pakistan highlighting the selected rice markets is presented in Figure 4.3.

Figure 4.3: Map of Pakistan Indicating Rice Markets of the Country



Source: Own illustration with ArcGIS program using data from the website `http://www.gadm.org/`

Table 4.2: Descriptive Statistics of Nominal Monthly Wholesale Prices of Rice Markets of Pakistan

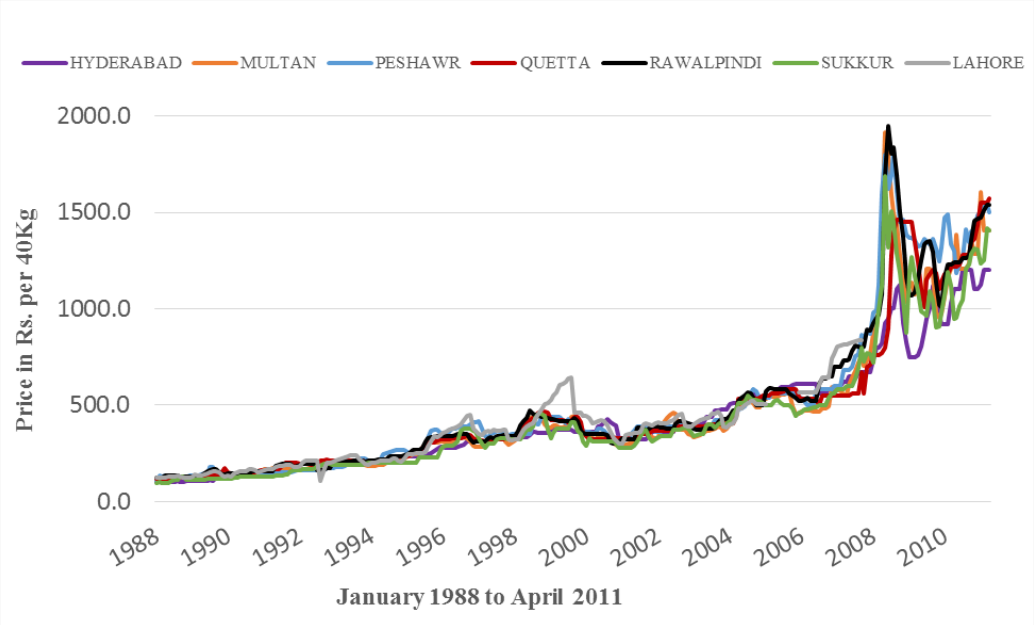
D.S/ Market	Hyd	Lhr	Pindi	Mltn	Pshwr	Queta	Sukur
Mean	423.3	445.8	485.6	447.8	494.6	459.8	428.9
Maximum	1200.0	1021.5	1949.0	1910.0	1820.0	1570.0	1690.0
Minimum	101.2	106.0	125.0	108.5	105.0	116.0	95.0
Median	357.5	349.0	366.5	330.0	380.0	349.5	334.0
St. Dev.	282.6	262.9	384.4	362.4	405.6	353.4	331.7
No. of Obs.	280	213	280	276	280	280	280
Missing Obs (#)	0	67	0	4	0	0	0
Missing Obs (%)	0	23.9	0	1.4	0	0	0

Source: Own calculations based on Agricultural Statistics of Pakistan GoP (2012a).

In irri rice prices 3.5 percent of observations were missing, most of the observations were missing for Lahore price series, see Table 4.2. Only four observations were missing in Multan and 67 in Lahore. All the observation for the remaining five markets were completely available. Missing observations were imputed using the Kalman filter, which is described in details in Section 4.3.

Imputed missing values were verified and checked, not to have outliers or any other unexpected behavior, specially for the Peshawar market price series in wheat market analysis and for the Lahore market series in rice market analysis, as large number of observations were missing in both the series. Therefore, it was checked with quite care, if the data properties have changed or if the results with reduced sample are dramatically and significantly different as compared to the full sample. Results were found not significantly different, hence, the full sample was used for final analysis.

Figure 4.4: Wholesale Irri Rice Prices of Pakistan



Source: Own illustration based on Agricultural Statistics of Pakistan GoP (2012a).

Figure 4.4 shows monthly rice prices of the selected markets from January 1988 to April 2011. Like wheat, prices of irri rice also moved very closely to each other, until the unprecedented price hike in international food prices in 2007. The arithmetic mean of prices of the selected markets show that the Peshawar market has the highest arithmetic mean of 494.6 rupees per 40 kg of rice. While, if we look at the maximum price of rice in the selected markets, it tells us that rice price in Rawalpindi market reached 1910 rupees per 40 kg, which is maximum among all the selected markets.

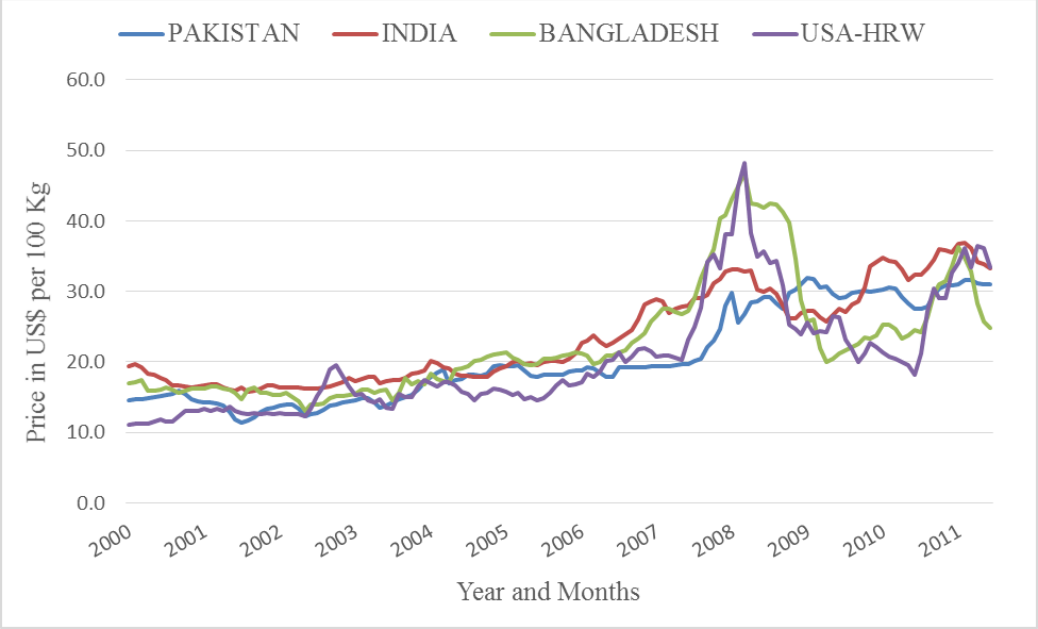
4.1.3 South Asian and the World markets

According to United Nations, South Asia comprises of Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka. But, Bhutan, Maldives, Nepal and Sri Lanka are small countries having less than one percent of total wheat and rice production as well as consumption in the region. Hence, they are not considered for the analysis. Afghanistan can be crucial because of the wheat imports (legal plus illegal) from Pakistan, and Sri Lanka imports wheat from India. However, time series data for monthly wholesale prices for wheat and rice were not available for these countries. Therefore, only Bangladesh, India and Pakistan are considered from the region. A formal request in writing was made to the concerned departments of the countries, but it went unanswered.

For the analysis of market integration in South Asia, monthly wholesale prices of Bangladesh, India and Pakistan are considered only, because of the unavailability of data for other countries in the region. Along with that, wheat export prices of the United States of America (US-HRW) are selected to analyze the wheat market integration of South Asian countries with the world market. Price series of US-HRW were selected because Bangladesh and Pakistan import this type of wheat, and US-HRW is considered as a benchmark for the international export prices in market integration analysis for the countries, which import this type of wheat.

Unfortunately, due to the unavailability of more recent time series for the prices of the countries under study at the time of the analysis, time series for South Asian wheat markets and for US-HRW price series are from January 2000 to June 2011 (138 observations). All the prices are in US $ per 100 kg. Figure 4.5 shows the selected time series.

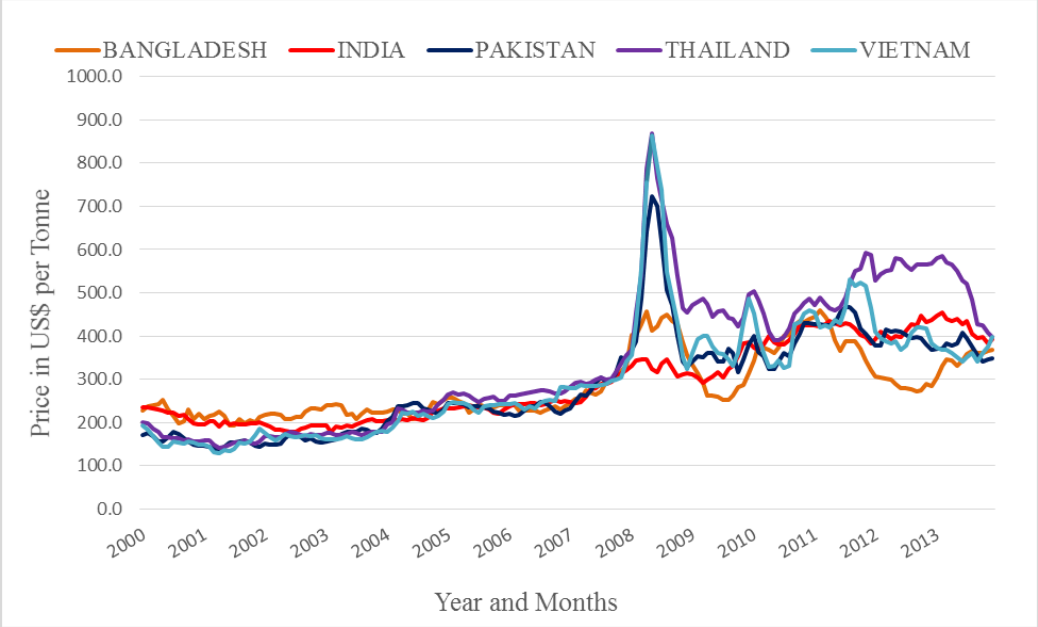
Figure 4.5: Wheat Prices of South Asian Countries and the USA



Source: Own illustration based on the data from FAO, GIEWS (2014).

In the case of rice, Thai and Vietnamese (25 % broken) rice export prices are used to investigate market integration of South Asian countries with the world markets, because these varieties are of the same category (low quality) as Irri-rice of Pakistan and coarse rice of Bangladesh and India. Time series coverage for rice prices of Bangladesh, India, Pakistan, Thailand and Vietnamese rice, are from January 2000 to December 2013 (Figure 4.6). There are 168 observations for the estimation of market integration for South Asian markets and with the world markets. Price series for the rice markets are also in the same currency, namely US$ per tonne.

Figure 4.6: Rice Prices of South Asian Countries, Thailand and Vietnam



Source: Own illustration based on the data from FAO, GIEWS (2014).

4.2 Sources of Data

Time series data for regional wheat and rice markets of Pakistan are collected from different government publications of Agricultural Statistics of Pakistan, which are available online on the homepage of the Pakistan Bureau of Statistics (PBS) and from Economic Surveys of Pakistan (GoP, 2012a).

Time series data for domestic wholesale prices of wheat and rice for Bangladesh, India and Pakistan as well as for export price series of the United States-HRW (Hard Red Winter) wheat, rice export price series of Thailand 25 % broken and Vietnam 25 % broken are downloaded from the Food and Agriculture Organization of the United Nations' Global information and Early Warning System (FAO, GIEWS, 2014).

4.3 Data Problems and Handling

Apart from unavailability constraints for recent observations of the time series under study, missing observations was another issue for wheat and rice markets of Pakistan. Data were thoroughly checked for outliers and for missing observations. There were only few missing values, 31 observations altogether out of 1400 observations in the data set of five wheat markets price series. Out of 280 observations for each market, five observations were missing from Lahore, nine for Multan and 17 for Peshawar. There were more observations missing in the Lahore market price series alone, in the case of rice markets. The price data for five rice markets were completely available over the period under study. The only reason for the missing observations appears to be poor documentation or non-reporting.

It has always been a challenging decision to choose the appropriate method to handle missing data for the analysis. In the past, typically missing values were ignored or replaced with mean or mode of the non-missing values for that variable. In recent times, these approaches are considered as not adequate for valid statistical inferences. Therefore, it is necessary to choose the appropriate method to impute the missing values using the correct degree of randomness.

Depending on the properties of data and the pattern of missing observations, structural time series model of state space methods using fixed-interval smoothing under the umbrella of Kalman filtering, prediction and smoothing was applied for imputing the missing values, using the *'tssmooth'* function supported by the class *'structTS'* in software **'R'**. This model is basically known as local level model (Durbin and Koopman, 2012). The simplest local level model provided by Durbin and Koopman (2012) has the underlying specification:

$$\begin{aligned} y_t &= \alpha_t + \epsilon_t, \epsilon_t \sim N(0, \sigma_\epsilon^2), \\ \alpha_{t+1} &= \alpha_t + \eta_t, \eta_t \sim N(0, \sigma_\eta^2), \end{aligned} \tag{4.1}$$

It is an ARIMA (0,1,1) model, with restrictions on the parameter set and there are two parameters σ_ϵ^2 and σ_η^2. Further we assume that ϵ_t and η_t are identically independently distributed, with zero mean and constant variance, for all t, where $t = 1, 2, 3, ...n$. A time-variant slope and seasonality effects can easily be modeled explicitly in a basic structural model.

Durbin and Koopman (2012) states that this local level model is a simple example of a linear Gaussian state space model in which, the unobserved variable α_t is the state and the objective is to observe the development of this state over time, depending on the observed values of the available univariate time series $y_t = y_1, y_2, ...y_n$.

The local linear trend model used for the imputation of missing values in our univariate time series has the same equation, but additionally, we have a slope term, which is generated by a random walk and gives the following equation:

$$\begin{aligned} y_t &= \alpha_t + \epsilon_t, \epsilon_t \sim N(0, \sigma_\epsilon^2), \\ \alpha_{t+1} &= \alpha_t + v_t + \eta_t, \eta_t \sim N(0, \sigma_\eta^2), \\ v_{t+1} &= v_t + \zeta_t, \zeta_t \sim N(0, \sigma_\zeta^2) \end{aligned} \tag{4.2}$$

Here, if η_t and ζ_t are equal to zero, and $v_{t+1} = v_t = v$, and α_{t+1} will ultimately be equal to $\alpha_t + v$, which means there will be exactly linear trend. But, the variance of η and ζ is greater than zero, implying a time-variant slope and trend.

Chapter 5

Data Analysis and Estimation Method

This chapter presents the methodological framework explaining data analysis techniques, estimation methods and the description of the models used for the econometric analysis, along with some of the deficiencies of other models. The software(s) used for the analysis of the data were **Eviews** and **R**; *urca* package developed by Pfaff (2008) and the *tsDyn* package developed by Antonio et al. (2009) and Stigler (2010) were used in Rstudio for the estimation.

Firstly, the series of prices will be tested for stationarity. Unit root tests are conducted for the individual time series using the augmented Dickey-Fuller (ADF) test (Dickey and Fuller, 1979, 1981) to identify whether the data are stationary or non-stationary. After that, the long-run relationship of the variables (market price series) will be analyzed using pairwise and joint cointegration tests, which are discussed in Section 5.2. A simple Vector Error Correction Model (VECM) will then be presented in Section 5.3, which will be used to estimate the short-run adjustment parameters of different market price series. Some limitations of the VECM models are also discussed in this section. Finally, the Threshold Vector Error Correction Model (VECM) applied to assess the degree of market integration is presented in the last section of this chapter, along with the threshold test applied to the data.

5.1 Unit Root Tests

Dickey and Fuller (1979, 1981) devised a procedure to test for non-stationarity in a univariate time serie. The basic model to conduct this test is a simple AR (1) model (Autoregressive model of order 1) of the form:

$$Y_t = \phi Y_{t-1} + u_t \tag{5.1}$$

This model follows the classical assumptions of a regression model, where u_t is the stochastic error term that has zero mean and constant variance σ^2, and it is not autocorrelated, i.e. the error term must be white noise. ϕ is the coefficient parameter to be estimated. The null hypothesis H_0 of this test is, that $\phi = 1$ (unity) and the alternative hypothesis is $H_1 : \phi < 0$. The key feature of the DF test is whether there is a unit root, that means test for non-stationarity is equivalent to the test for a unit root.

By subtracting Y_{t-1} from both sides of the equation a more convenient version can be obtained:

$$\begin{aligned} Y_t - Y_{t-1} &= \phi Y_{t-1} - Y_{t-1} + u_t \\ \Delta Y_t &= (\phi - 1) Y_{t-1} + u_t \end{aligned}$$

$$\Delta Y_t = \beta Y_{t-1} + u_t \tag{5.2}$$

Here, $\beta = (\phi - 1)$, and $H_0 : \beta = 0$ against the alternate of $H_1 : \beta < 0$, if $\beta = 0$ then Y_t follows a pure random walk. Dickey and Fuller (1979) also proposed two other regression equations to test for stationarity. One includes a constant in the pure random walk process making it a random walk with drift, and takes the form:

$$\Delta Y_t = \alpha_0 + \beta Y_{t-1} + u_t \tag{5.3}$$

This model exhibits a stochastic trend. The second case allows for a deterministic trend in the model:

$$\Delta Y_t = \alpha_0 + \alpha_1 t + \beta Y_{t-1} + u_t \tag{5.4}$$

In all cases, H_0 of the test concerns whether $\beta = 0$, in this particular case we also consider if $\alpha_1 = 1$ in the H_0 against the alternate hypothesis of $\alpha_1 = 0$. The DF test is now normally a *t-test* on the coefficients of the lagged dependent variable, but the test does not have a conventional t-distribution and therefore we must use special critical values provided by Dickey and Fuller as reported in Hamilton (1994). If the DF statistics is smaller than the critical value then we reject the null hypothesis of a unit root and conclude that Y_t is a stationary process.

As the error term u_t is unlikely to be white noise, in order to eliminate autocorrelation, Dickey and Fuller further extended their test procedure and developed an augmented version of the Dickey Fuller test (ADF) and suggested to include extra lagged terms of the dependent variable. The lag length can be determined by Akaike's Information criterion (AIC) or by Shwarz's Bayesian Information criterion (SBIC). In the augmented Dickey-Fuller (ADF) test, above mentioned three cases of equations (5.2), (5.3) and (5.4) take the forms of the general models like:

$$\Delta Y_t = \beta Y_{t-1} + \sum_{i=1}^{k} \gamma \Delta Y_{t-1} + u_t \tag{5.5}$$

$$\Delta Y_t = \alpha_0 + \beta Y_{t-1} + \sum_{i=1}^{k} \gamma \Delta Y_{t-1} + u_t \tag{5.6}$$

$$\Delta Y_t = \alpha_0 + \alpha_1 t + \beta Y_{t-1} + \sum_{i=1}^{k} \gamma \Delta Y_{t-1} + u_t \tag{5.7}$$

If the ADF test results confirms the existence of unit root than we know that Y_t is a non-stationary process and we apply the same testing procedure on the first difference of the series. If the null hypothesis of a unit root is rejected, it can be concluded that series Y_t is first-difference stationary or integrated of order (d). In mathematical form, it can be written as I(d) where $d \geq 1$. If H_0 can not be rejected then we assume that $d \geq 2$ and apply the same testing procedure on second differences of the series.

The Unit Root Test is conducted in the individual time series using the augmented Dickey-Fuller (ADF) test (Dickey and Fuller, 1981) to identify whether the data are stationary or non-stationary. Lag length was selected by Akaike's Information criterion (AIC).

To check whether the error term is a white noise process, an LM test for serial correlation (Breusch-Godfrey Serial Correlation LM test) was applied and Ljung-Box Q statistics was also checked to verify that error terms are white noise. A heteroskedasticity test i.e. the Breusch-Pagan-Godfrey test for heteroskedasticity, was also applied to each series.

The next step is to determine the long run relationship between the variables. If two time series are integrated of the same order then cointegration can be applied, because regression of two I(1) series can be a spurious regression. The concept of spurious regression was first introduced by Yule (1926). The article of Granger and Newbold (1974) led to a greater awareness of the issue of spurious regression in econometrics. Phillips (1986) provided a theoretical explanation of the implications of spurious regressions.

5.2 Cointegration

If two non-stationary variables are integrated of the same order I(d) then a linear combination of those two non-stationary variables is stationary I(0), if the variables are cointegrated (Engle and Granger, 1987). The cointegration process incorporates non-stationarity with both long-term equilibrium and short-term relationships. It is also solution to the spurious regressions. The idea first came from macroeconomics, then energy economists and agricultural economists emphasized cointegration. Cointegration was first introduced by Granger (1981), later on the concept become more popular and improved by Engle and Granger (1987), Johansen (1988), Johansen (1991) and Johansen and Juselius (1990).

Two major cointegration methods which are extensively and consistently been used in the econometric literature are (i) The Engle and Granger two-step method and (ii) Johansen's maximum-likelihood method. To test the pairwise as well as joint cointegration between different prices series, the Johansen (1988) method of maximum-likelihood is used in this study, mainly because of shortcomings of the Engle-Granger approach. Except that it relies on a two-step method, the order of the variables in the regression in the first step is also an important issue (Asteriou and Hall, 2007). Further, one can not test for multiple cointegrating vectors with this approach like with the Johansen method. Another advantage of using the Johansen method is that one can test the hypothesis on the cointegration relationship itself (Brooks, 2008).

After checking the stationarity of our time series, assuming all our price series are integrated of order one I(1), a bivariate cointegration test was conducted using Johansen's Full Information Maximum-Likelihood (FIML) approach (Johansen, 1988; Johansen and Juselius, 1990). Johansen's maximum-likelihood method, which determines the number of cointegration vectors in a non-stationary time series with a restriction imposed on Vector Auto Regression (VAR) model, also known as Vector Error Correction Model (VECM) can be described as:

$$\Delta X_t = \mu + \sum_{i=1}^{k} \Gamma_i \Delta X_{t-i} + \Pi X_{t-i} + \varepsilon_t \tag{5.8}$$

Here, X_t is the (n x 1) vector of all the non-stationary variables, Γ is a (n x n) matrix of coefficients of lags of the variables. μ represents the constant term in the equation. The number of cointegration relationships between the variables in X_t is provided by the rank of the matrix Π. If the rank of matrix Π is $0 < r < n$, there are r linear combinations of variables in X_t that are stationary, where r describe the number of cointegrating relationships in the variables. Π matrix is composed of two (n x r) matrices α and β such that $\Pi = \alpha\beta'$, where α is the matrix of error correction coefficients and measures the speed of adjustment towards equilibrium and β contains r cointegrating

vectors, so that $0 < r < n$. This represents the long-run cointegration relationships between the variables. Akaike's Information criterion (AIC) has been used to determine the lag length for the Johansen's approach of investigating cointegration relation. Akaike's Information criterion (AIC) has been prefered over Schwarz's Bayesian Information criterion (SBIC) because it is more efficient (Brooks, 2008).

Johansen (1991) and Johansen and Juselius (1990) described two likelihood ratio test statistics: the trace test and the maximum eigenvalue test. The trace test based on the stochastic matrix is defined as:

$$\lambda_{trace} = -2lnQ = -T \sum_{i=r+1}^{p} \ln(1 - \lambda_i) \tag{5.9}$$

The Trace statistics test the null hypothesis of no cointegration ($H_0 : r = 0$) against the alternative hypothesis of cointegration ($H_1 : r > 0$). The second likelihood ratio test which is called as Maximum Eigenvalue test and used for detecting the presence of a single cointegration vector, conducts tests on each eigenvalue separately. It tests the null hypothesis that the number of cointegrating vectors is equal to r against the alternative of *r+1* cointegrating vectors (Brooks, 2008). The maximum eigenvalue test is defined as:

$$\lambda_{max} = -2ln(Q : r|r + 1) = -T \ln(1 - \lambda_{r+1}) \tag{5.10}$$

5.3 Vector Error Correction Model

In market integration models, except for a few studies on Parity Bound Models (PBM) presented by Baulch (1997) and Barrett and Li (2002), most of the empirical studies applied Vector Error Correction models, because of their easy and intuitive interpretation. In Parity Bound Models there are three possible trade regimes: at the parity bound, inside the parity bound, outside the parity bound attributed as regimes I, II and III. In these regimes, the price differential between two locations is exactly equal to transaction costs, the difference of prices between two locations is lower than transaction costs

and the price difference is higher than transaction costs, respectively. The PBM has been subject to criticism due to a few limitations. First, as only contemporaneous spreads are used in its estimation, it is difficult for the model to consider the lagged price adjustment. Second, transfer costs are included explicitly in the notion of spatial equilibrium and if transfer cost data are unavailable the PBM requires an assumption about the evolution of transfer costs over time or it is crucial that transfer costs should be estimated as precisely as possible because the estimates of regime probabilities in the model are only as good as the estimate of mean transfer costs used to separate differentials between regimes in the pair of market price. In contrast, VECM is a re-parameterization of Vector Autoregressive (VAR) models. Fundamentally, VECM uses lagged values of the time series in relation to current price change.

A bi-variate VECM Model can be defined as:

$$\begin{bmatrix} \Delta P_{1t} \\ \Delta P_{2t} \end{bmatrix} = \begin{bmatrix} \alpha_1 \\ \alpha_2 \end{bmatrix} + \sum_{i=1}^{k} \begin{bmatrix} \beta_i^{P_1,P_1} & \beta_i^{P_1,P_2} \\ \beta_i^{P_2,P_1} & \beta_i^{P_2,P_2} \end{bmatrix} \mathsf{x} \begin{bmatrix} \Delta P_{1t-1} \\ \Delta P_{2t-1} \end{bmatrix} + \begin{bmatrix} \phi_1 \\ \phi_2 \end{bmatrix} \left[\; ECT_{t-1} \right] + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix} \tag{5.11}$$

Where: $\Delta P_t = P_t - P_{t-1}$, P_1 is the price series in one market and P_2 is the price series in the other. VECM is different from VAR in the sense that it separates the long-run relationship (cointegration coefficients) from short-run adjustments that describe the correction of price to disequilibrium. In this model, the ϕ_i coefficients describe the long-run reaction of prices to disequilibrium, while β_i are adjustment parameters for lagged short-run dynamics. If the two price series are cointegrated then $\phi_1 < 0$ and $\phi_2 > 0$.

Hassouneh et al. (2012) describe two limitations of VECM. First, parameters of VECM are linear, as they are assumed constant over the whole period under study. Second, a linearity restriction is described by the linear reaction

of dependent variables subject to the change in independent variables. Many studies emphasized the deviations from one or both forms of linearity in different applications of market integration (Meyer and von Cramon-Taubadel, 2004; Greb et al., 2012; Hassouneh et al., 2012).

Parameters of price transmission between two spatially separated markets having variable transportation costs cannot be constant. In this case, the first type of linearity is a very hard restriction. Barrett and Li (2002) describe the difficulties in observing all possible transaction costs like: trade flows, risk assessment, discount rates and other possible costs. They also implied the possibility of trade and adjustment of short-run prices due to arbitrage, if the difference between two market prices is higher than transaction costs, because of the unobservable costs, policy interventions and different strategies. Hence, if the price difference is less than a certain threshold, there is no arbitrage benefit for traders.

There are also serious arguments against the assumption of symmetry and in strong favour of non-linear adjustment. In the linear cointegration case, both decreasing and increasing deviations are assumed to be corrected in the same way. Again, this assumption has been theoretically challenged because of market power and in the case of a small developing country and the world market (for details see: Abdulai, 2000; Meyer and von Cramon-Taubadel, 2004; Hassouneh et al., 2012; Acosta et al., 2014).

To compare the results between linear and non-linear models, the VECM was applied to see if the results are dramatically different or more or less the same, knowing the fact that this model lacks the information and is more restrictive. Therefore, a VECM was applied to all the pairs of wheat and rice market price series of Pakistan and also to the South Asian and the world markets price series pairs.

5.4 Threshold Vector Error Correction Model

Balke and Fomby (1997) introduced the concept of threshold cointegration, based on discontinuous long-run equilibrium adjustments. This concept allows addressing the above mentioned criticism on linear cointegration and justifies the use of threshold models for price adjustment. In particular, this model allows for a no-arbitrage band. Adjustments only occur, when the deviations from the long-run equilibrium are greater than transaction costs or a particular threshold, where the error-correction term determines the threshold parameter. Bekkerman et al. (2013) argue that transaction costs are difficult to explicitly observe, but a neutral threshold band is a reasonable representation of the costs. They further emphasize that price differences exceeding transaction costs required to transfer the commodity from one market to the other, will be arbitraged quickly.

In a VECM such as (5.11) price adjustments induced by deviations from the long-term equilibrium are assumed to be a continuous and linear function. Thus, prices are adjusted in each market even as a result of very small deviations from the long-term equilibrium. This assumption might lead to a biased result because it ignores the impact of transaction costs, as pointed out by Meyer (2004). But as established earlier, in the case of significant transaction costs, adjustment to the long-term equilibrium should not be continuous or constant over time.

Serious implications of transaction costs and asymmetric behavior of the price adjustments provides a justification for the use of threshold models. A TVECM is a special form of an asymmetric VECM and price adjustment can be different depending on the regimes. This model is extendable, by incorporating constants or intercepts and lags in each regime. Regime-switching models have attracted several researchers of price transmission analysis, and have been extended and applied by many researchers such as, Goodwin and Piggott (2001); Lo and Zivot (2001); Hansen and Seo (2002); Meyer (2004); Seo (2006); Bekkerman et al. (2013) and others.

On the basis of the number of thresholds γ each model contains $\gamma + 1$ different regimes of price adjustment. Some of the market integration studies have either used one threshold like Balke and Fomby (1997); Sephton (2003); Meyer (2004) or two thresholds such as Obstfeld and Taylor (1997); Goodwin and Piggott (2001); Greb et al. (2013). No explicit justification is provided in most of the analysis, but generally a two-threshold model is considered as more flexible than a one-threshold model. It also makes more economic sense, because in the two-threshold model the band between the two thresholds can be interpreted as a band of noarbitrage. The upper and lower limits of the neutral band described by the thresholds that trigger arbitrage behavior if price differences exceeds the unobserved transaction cost or the thresholds. Such a band can not be modeled in a single-threshold model. Further, a two-threshold model (TVECM) takes into account both positive and negative deviations from the equilibrium outside the band. Another advantage of using a two-threshold TVECM model is that it is easy to interpret. The approach used and proposed by Hansen and Seo (2002) and Meyer (2004) is extended here with a two-threshold model. The specification of the TVECM used here takes the following form:

$$
\begin{aligned}
\begin{bmatrix} \Delta P_{1t} \\ \Delta P_{2t} \end{bmatrix} &= \begin{bmatrix} \alpha_1 \\ \alpha_2 \end{bmatrix} + \sum_{i=1}^{k} \begin{bmatrix} \beta_i^{P_1,P_1} & \beta_i^{P_1,P_2} \\ \beta_i^{P_2,P_1} & \beta_i^{P_2,P_2} \end{bmatrix} \times \begin{bmatrix} \Delta P_{1t-1} \\ \Delta P_{2t-1} \end{bmatrix} \\
&\quad + \begin{bmatrix} \phi_1 \\ \phi_2 \end{bmatrix} \Big[\, ECT_{t-1} \Big] + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix}, if ECT_{t-1} \leq \gamma_1 \\
\begin{bmatrix} \Delta P_{1t} \\ \Delta P_{2t} \end{bmatrix} &= \begin{bmatrix} \alpha_1 \\ \alpha_2 \end{bmatrix} + \sum_{i=1}^{k} \begin{bmatrix} \beta_i^{P_1,P_1} & \beta_i^{P_1,P_2} \\ \beta_i^{P_2,P_1} & \beta_i^{P_2,P_2} \end{bmatrix} \times \begin{bmatrix} \Delta P_{1t-1} \\ \Delta P_{2t-1} \end{bmatrix} \\
&\quad + \begin{bmatrix} \phi_1 \\ \phi_2 \end{bmatrix} \Big[\, ECT_{t-1} \Big] + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix}, if \gamma_1 \leq ECT_{t_1} \leq \gamma_2 \\
\begin{bmatrix} \Delta P_{1t} \\ \Delta P_{2t} \end{bmatrix} &= \begin{bmatrix} \alpha_1 \\ \alpha_2 \end{bmatrix} + \sum_{i=1}^{k} \begin{bmatrix} \beta_i^{P_1,P_1} & \beta_i^{P_1,P_2} \\ \beta_i^{P_2,P_1} & \beta_i^{P_2,P_2} \end{bmatrix} \times \begin{bmatrix} \Delta P_{1t-1} \\ \Delta P_{2t-1} \end{bmatrix} \\
&\quad + \begin{bmatrix} \phi_1 \\ \phi_2 \end{bmatrix} \Big[\, ECT_{t-1} \Big] + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix}, if ECT_{t-1} \geq \gamma_2
\end{aligned}
\tag{5.12}
$$

Here, γ_1 and γ_2 are the threshold parameters. P_1 and P_2 represent the prices in two markets respectively. This model has three regimes, namely, lower, middle and upper. Thresholds are determined here by ECT terms itself from the model and regimes are defined on the basis of the thresholds. Autoregressive parameters differ based on regimes, whether the variables are below the first threshold $if ECT_{t-1} \leq \gamma_1$ (lower regime or regime 1), between the two thresholds $if \gamma_1 \leq ECT_{t_1} \leq \gamma_2$ (middle regime or regime 2) or above the higher threshold $if ECT_{t-1} \geq \gamma_2$ (upper regime or regime 3).

The middle regime (regime 2) is the band of noarbitrage or band of no adjustment, which basically means that the deviations from the equilibrium are very small so that as a result either there is no adjustment or there is no arbitrage benefit to trade. Each regime in the model should contain at least 5 to 15 percent of all observations for empirical application, following Goodwin and Piggott (2001); Hansen and Seo (2002); Meyer (2004). Estimation of this model takes place with two-dimensional grid search over the thresholds and cointegrating values based on a maximum-likelihood estimator using the tsDyn package in R developed by Antonio et al. (2009) and Stigler (2010).

Like the VECM (5.11) this two-threshold (TVECM) model also explains the price changes by short-run as well as long-run adjustments, but conditional on the deviation from the long-term equilibrium, if they are below, above or between two thresholds. Similar to the VECM, in this model also P_1 is the price series in one market and P_2 is the price series in the other and $\Delta P_t = P_t - P_{t-1}$. In this model, the ϕ_i coefficients describe the long-run reaction of prices to disequilibrium, while β_i are adjustment parameters for lagged short-run dynamics.

Testing for Thresholds

To test for threshold effects, the SupLM (Supremum Lagrange Multiplier) test developed by Hansen and Seo (2002) has been used, having the null hypothesis of linear cointegration against the alternate hypothesis of threshold cointegration. This test uses the cointegration coefficient parameter from a linear VECM representation and applies a grid search over the threshold parameter. Critical values and the p-values are generated by a fixed-regressor bootstrap method. The advantage of this method is that LM-like statistics allow for heteroskedasticity of unknown form in the same way as White's consistent heteroskedastic standard errors, hence it achieves the correct first-order asymptotic distribution. The SupLM test statistic can be denoted as:

$$SupLM = sup_{\gamma^L \leq \gamma \geq \gamma^U} LM(\tilde{\beta}, \gamma) \tag{5.13}$$

Where the $\tilde{\beta}$ cointegration value is β estimated and γ is the threshold parameter. γ^L is the trimming parameter π_0 of the constraint set for the number of observations below the threshold parameter and γ^U is $(1 - \pi_0)$, i.e. the number of observations above the threshold. The restriction for the number of observations in the regimes (trimming parameter) must satisfy the following expression:

$$\pi_0 \leq P(ECT_{t-1} \leq \gamma) \leq 1 - \pi_0$$

In this analysis, π_0 is equal to 10 percent, following Hansen and Seo (2002) and based on Andrews (1993) emphasizes that the value of π_0 should range from 5 to 15 percent in the unknown change points for parameter stability. Further, 5000 bootstrap replications are used in the analysis to calculate asymptotic critical values and the p-values for the test.

Chapter 6

Results

The results of integration analysis of the selected markets are presented in this chapter. Section 6.1 provides the complete results of wheat and rice markets integration analysis of Pakistan. Market integration analysis of South Asian markets with each other and with the world markets are presented in Section 6.2. The results of the unit root tests, cointegration tests, VECM and TVECM along with threshold tests are separated by sub-sections.

6.1 Market Integration Analysis of Pakistan

This section presents the results of market integration analysis of regional markets of wheat and rice in Pakistan, using price series of wheat and rice in logarithmic form. The analysis started with testing for stationarity. For that purpose, the augmented Dickey-Fuller test was used as mentioned in the previous chapter, then long-run as well as short-run relationships of the regional markets were evaluated empirically.

6.1.1 Domestic Wheat Market Integration Analysis

Unit root test results of logged monthly wholesale prices series of five regional markets of wheat in Pakistan at levels and at first differences are presented in Table 6.1. All the series were found non-stationary at levels and stationary at the first difference. Results in Table 6.1 indicate that the null hypothesis of a unit root in all the five markets cannot be rejected at levels, because the ADF statistics observed at levels were not smaller than the critical value at the 5 percent significant level provided in Dickey and Fuller (1981).

Table 6.1: ADF Test Results for Wheat Markets of Pakistan

Markets	Levels	1st Differences
Hyderabad (LHYD)	-0.177	-14.413***
Lahore (LLHR)	0.110	-12.821***
Multan (LMLTN)	-0.218	-12.415***
Peshawar (LPSHWR)	-0.470	-13.936***
Rawalpindi (LPINDI)	-0.096	-13.706***

Critical values at 1, 5 and 10 percent respectively are -3.454, -2.872, -2.572.
Source: Own calculations.

To check the stationarity in the price series at first difference, again the ADF test was applied to the differenced price series. Results revealed that all the price series are stationary at first difference because the ADF statistics indicate the rejection of the null hypothesis of unit root significantly. Therefore, it can be concluded that price series of every wheat market under study are non-stationary at levels and stationary at first difference. In other words, all five series can be considered as integrated of order one I (1).

To test the stationarity in the time series, the augmented Dickey-Fuller (ADF) test was carried out in all the seven rice market prices. Table 6.2 presents the results of augmented Dickey-Fuller test for logged price series of seven regional markets of rice at levels and at first difference.

Table 6.2: ADF Test Results for Rice Markets of Pakistan

Markets	Levels	1st Differences
Hyderabad (LHYD)	-0.552	-13.320***
Lahore (LLHR)	-0.993	-16.728***
Multan (LMLTN)	-0.694	-11.907***
Peshawar (LPSHWR)	-0.107	-15.177***
Quetta (LQUETTA)	0.059	-14.141***
Rawalpindi(LPINDI)	-0.507	-11.684***
Sukkur (LSKR)	-0.437	-10.556***

Critical values at 1, 5 and 10 percent respectively are -3.454, -2.871, -2.572.
Source: Own calculations.

The ADF test results reveal that the null hypothesis of unit root in all the seven markets cannot be rejected at levels. The ADF test was also applied to the first difference of the series. Results show that all the price series are stationary at first difference because the ADF statistics rejects the null hypothesis of unit root significantly. Conclusively all the seven rice markets Hyderabad, Lahore, Multan, Peshawar, Quetta, Rawalpindi and Sukkur were found non-stationary at levels and stationary at the 1st difference. All series are integrated of order one I (1), since the results indicate that the price series of rice markets under study are first difference stationary. Thus, cointegration tests can be applied to see whether there are long-run relationships between the markets.

The LM test for serial correlation (Breusch-Godfrey Serial Correlation LM test) and heteroskedasticity test (Breusch-Pagan-Godfrey test for heteroskedasticity) were also applied to the residuals of ADF test of each series. No evidence of serial correlation and heteroskedasticity has been found in any of the wheat market series. The Ljung-Box Q statistics was also checked to verify that the error terms are white noise.

6.1.2 Cointegration Test Results for Wheat Markets

To avoid possible spurious regression results, stationarity of the variables was checked and found that all the price series were integrated of order one I(1). Therefore, Johansen's cointegration test was applied to the pairwise market prices. In this method, one can test the hypothesis on the cointegration relationship itself. Before testing for cointegration, lag orders of the VAR for each price relationship have been tested and selected. The Akaike information criterion suggested one lag in most of the pairs for pairwise cointegration as well as for joint cointegration.

Table 6.3: Pairwise Cointegration Test Results for Wheat Markets of Pakistan

Market Pairs	H_0	H_1	Trace Statistics	Maximum Eigenvalue Statistics
LLHR-	r = 0	r ≥ 1	41.284 (15.494)***	41.251 (14.264)***
LHYD	r ≤ 1	r ≥ 2	0.033 (3.841)	0.033 (3.841)
LLHR-	r = 0	r ≥ 1	32.892 (15.494)***	32.891 (14.264)***
LMLTN	r ≤ 1	r ≥ 2	0.000 (3.841)	0.000 (3.841)
LLHR-	r = 0	r ≥ 1	54.744 (15.494)***	54.744 (14.264)***
LPINDI	r ≤ 1	r ≥ 2	0.000 (3.841)	0.000 (3.841)
LLHR-	r = 0	r ≥ 1	16.853 (15.494)***	16.839 (14.264)***
LPSHWR	r ≤ 1	r ≥ 2	0.014 (3.841)	0.014 (3.841)
LHYD-	r = 0	r ≥ 1	40.627 (15.494)***	40.598 (14.264)***
LMLTN	r ≤ 1	r ≥ 2	0.029 (3.841)	0.029 (3.841)
LHYD-	r = 0	r ≥ 1	38.019 (15.494)***	37.992 (14.264)***
LPINDI	r ≤ 1	r ≥ 2	0.026 (3.841)	0.026 (3.841)
LHYD-	r = 0	r ≥ 1	22.452 (15.494)***	22.383 (14.264)***
LPSHWR	r ≤ 1	r ≥ 2	0.068 (3.841)	0.068 (3.841)
LMLTN-	r = 0	r ≥ 1	15.731 (15.494)**	15.710 (14.264)**
LPSHWR	r ≤ 1	r ≥ 2	0.020 (3.841)	0.020 (3.841)
LMLTN-	r = 0	r ≥ 1	43.079 (15.494)***	43.076 (14.264)***
LPINDI	r ≤ 1	r ≥ 2	0.003 (3.841)	0.003 (3.841)
LPINDI-	r = 0	r ≥ 1	15.984 (15.494)**	15.967 (14.264)**
LPSHWR	r ≤ 1	r ≥ 2	0.016 (3.841)	0.016 (3.841)

Critical values at 95 percent confidence level are in parentheses.
Source: Own calculations.

Pairwise cointegration test results for selected wheat markets are presented in Table 6.3. Results clearly indicate the existence of long-run equilibrium relationship between all the pairs of regional wheat markets. Both trace statistics and maximum eigenvalue statistics suggest a cointegration relation in all the ten pairs of five markets. Cointegration between market pairs of Multan-Peshawar and Rawalpindi-Peshawar was found at 95 percent confidence level, while for all other pairs it was significant at 99 percent confidence level, which describes that wheat markets of Pakistan are strongly integrated in the long run.

Table 6.4: Joint Cointegration Test Results for Wheat Markets of Pakistan

Equation Tested	H_0	H_1	Trace Statistics	Maximum Eigenvalue Statistics
LHYD	r = 0	r ≥ 1	171.086 (69.818)***	59.278 (33.876)***
LLHR	r ≤ 1	r ≥ 2	111.807 (47.856)***	50.844 (27.584)***
LMLTN	r ≤ 2	r ≥ 3	60.962 (29.797)***	44.989 (21.131)***
LPINDI	r ≤ 3	r ≥ 4	15.973 (15.494)**	15.900 (14.264)**
LPSHWR	r ≤ 4	r ≥ 5	0.073 (3.841)	0.073 (3.841)

Critical values at 95 percent confidence level are in parentheses.
Source: Own calculations.

Table 6.4 presents the results of the joint cointegration test of five wheat markets of Pakistan. The trace statistics as well as maximum eigenvalue statistics suggest that all the five markets are strongly cointegrated and converge to the long-run equilibrium. Test results revealed that there are four cointegrating equations in the five wheat markets. As Greene (2011) proves that there can be at most K-1 cointegration vectors in the joint cointegration test, where "K" indicates the number of variables in the system (price series here). This implies that there are four linear independent combinations of the variables; each combination is stationary. It also shows that there is one common stochastic trend, which may be because of certain common factors such as weather conditions, demand and supply variations and some other factors.

6.1.3 Vector Error Correction Model Results of Wheat Markets of Pakistan

The Vector Error Correction Model (VECM) was applied to estimate the long-term coefficients along with short-term dynamics to the data. Linear VECM model results are presented in Table 6.5. Results show a highly significant adjustment of prices in almost all the pairs of markets except for the Hyderabad market. Adjustment to disequilibrium from the Hyderabad market is slower as well as insignificant in some cases, such as with Lahore and Peshawar market, although it is a leading market of Sindh province and is well connected through good infrastructure with the distant markets of Punjab. The Hyderabad market shows significant adjustment of about 8 and 9 percent with Rawalpindi and Multan market, respectively. Whereas the degree of adjustment from these two markets is about 15 percent, which can not be explained by the relationship of these markets, because trade takes place mostly from Punjab province to the Sindh province. The Peshawar market is in the KPK province, but it is near to Rawalpindi market of the Punjab province and wheat demands of KPK province are fulfilled by other provinces specially by Punjab province. Therefore, significant adjustment from Peshawar market to all other markets can be seen from the analysis.

Table 6.5: VECM Results for Wheat Markets of Pakistan

Market Pairs	Speed of Adjustment	Market Pairs	Speed of Adjustment
LLHR- LHYD	-0.183*** 0.050	LHYD- LPINDI	-0.085** 0.156***
LLHR- LMLTN	-0.2497*** 0.063	LHYD- LPSHWR	-0.033 0.095***
LLHR- LPINDI	-0.171*** 0.177**	LMLTN- LPSHWR	-0.037** 0.068***
LLHR- LPSHWR	-0.041* 0.060**	LMLTN- LPINDI	-0.047 0.246***
LHYD- LMLTN	-0.090** 0.151***	LPINDI- LPSHWR	-0.042* 0.057**

Here: *,** and *** show the significance at 10, 5 and 1 percent.
Source: Own calculations.

Lahore is one of the major markets in which multi-directional trade takes place and Multan is one of the major wheat-producing regions. Due to favorable infrastructure, higher demand and dense urban population, wheat trade to Lahore and Rawalpindi markets from other parts of the country (specially from other cities of Punjab province) pushes them to adjust quickly to the price changes. Lahore, Multan and Rawalpindi are also well connected as well as close to each other as compared to the other markets under study. It is still surprising to see that Lahore and Rawalpindi markets show the adjustment of about 24 percent to disequilibrium in Multan market, while Multan market does not show any significant adjustment to the shock in these two markets.

Overall, the degree of adjustment is low, except for the pair of Lahore and Rawalpindi markets, both markets show about 17 percent of adjustment to disequilibrium, which are not only close to each other but are also well connected to each other through different means of transport and via trade. It should be noted that these results are from a linear VECM model without considering transaction costs. However, these results may differ when a two-threshold (TVECM) model will be applied.

Threshold test

Estimates of SupLM test with 1 lag on price series of wheat markets of Pakistan are provided in Table 6.6. To calculate asymptotic critical values and the p-value for the test 5000 bootstrap replications are used.

The SupLM test applied for testing for threshold cointegration and to justify the use of a threshold vector error-correction model, clearly rejects the null hypothesis of linear cointegration against the alternate hypothesis of threshold cointegration at the 5 percent significance level. This holds true for seven out of ten pairs of different wheat market price series of Pakistan. While, for three pairs of price series namely Multan-Peshawar, Hyderabad-

Peshawar and Lahore-Peshawar, the null hypothesis is rejected at the 10 percent significance level. Test results provide enough conclusive evidence of threshold cointegration to justify an application of the TVECM to the data.

Table 6.6: Estimates of SupLM Test Applied on Price Series of Wheat Markets of Pakistan

Market Pairs	Cointegration Vector	Threshold Parameter	SupLM Test Value	Critical Value	P-Value
LLHR-LHYD	-1.006	-0.066	20.161	18.828	0.026
LLHR-LMLTN	-0.982	0.139	20.414	19.334	0.031
LLHR-LPINDI	-0.960	0.230	34.650	16.117	0.000
LLHR-LPSHWR	-0.997	0.018	16.865	17.464	0.063
LHYD-LMLTN	-0.976	0.153	19.461	15.714	0.008
LHYD-LPINDI	-0.954	0.179	26.348	15.554	0.000
LHYD-LPSHWR	-0.982	0.074	17.575	18.388	0.080
LMLTN-LPINDI	-0.978	0.077	27.437	18.868	0.000
LMLTN-LPSHWR	-1.011	-0.112	17.415	18.558	0.084
LPINDI-LPSHWR	-1.036	-0.272	18.503	15.252	0.012

Source: Own calculations.

6.1.4 TVECM Analysis of Domestic Wheat Markets

Appendix A.7 presents the results of the TVECM model with two thresholds (three regimes). The band between the two thresholds (regime 2 or middle regime) is the band of non-adjustment because deviations from the long-term equilibrium as compared to transaction costs are so small that they will not cause an adjustment of the related prices within the band. As expected, the TVECM model produced better results than the simple VECM model estimations. The adjustment parameters are higher and significant in most cases as compared to the results of the linear VECM, which depicts that the threshold model describes the short-run adjustment in the prices as quicker and higher in magnitude. The cointegration clearly describes the long-run relationship among different wheat markets of Pakistan but the short-run adjustments to disequilibrium from the threshold model are somehow mixed.

Results reveal that some market pairs show higher adjustment in both regimes, while others only indicate the adjustment either in the upper or the lower regime significantly, which can be explained by significant transaction costs and unidirectional trade flows. Lahore and Hyderabad markets adjust quickly, when the shock is higher than the second threshold, which implies that prices adjust quickly when they are higher and adjustment is slow when the price difference is below the lower threshold. More than 60 percent adjustment to equilibrium is done by Lahore market, whereas 30 percent by Hyderabad market in the upper regime only. Hyderabad market has shown the speed of adjustment of about 12 percent in the lower regime also. Hyderabad and Lahore both are leading markets of the respective provinces and both are well connected by different means of transport. Hyderabad market has also shown significant adjustment of about 49 percent in the lower regime with the Rawalpindi market and 36 percent with the Multan market in the upper regime. The Peshawar market has shown significant adjustment of about 25 percent with the Hyderabad and Multan markets only.

Lahore being the major production and consumption region in Punjab province of Pakistan forces other markets of Punjab, namely Rawalpindi and Multan, to adjust quickly. These two markets are close to Lahore in terms of distance and are well connected through favorable infrastructure supporting transportation. The linear VECM estimated a higher extent of adjustment from the Lahore market, which was somewhat surprising as the Lahore market is considered the leader rather than the follower. The Multan market adjusts for about 65 percent in the lower regime and about 36 percent in the upper regime and the Rawalpindi market has shown 40 percent adjustment only in the lower regime to the changes in the Lahore market. This is in accordance with the argument that Lahore is the leading market and major supplier to other markets, hence other markets follow. In most cases, higher and significant adjustments revealed by the estimation occur in the upper regime. When these deviations are above the second threshold and provide the opportunity for traders to take advantage of the arbitrage, then as expected, prices adjust quickly to form a new equilibrium.

6.1.5 Domestic Rice Market Integration Analysis

The results of augmented Dickey-Fuller tests indicate that the price series of rice markets of Pakistan under study are first-difference stationary, i.e. I(1). Thus, cointegration tests can be applied to see whether there exists long run relationships between the different pairs of regional rice markets. Pairwise cointegration test results for seven rice markets under study are presented in Table 6.7 and Table 6.8.

Table 6.7: Pairwise Cointegration Test Results for Rice Markets of Pakistan

Market Pairs	H_0	H_1	Trace Statistics	Maximum Eigenvalue Statistics
LLHR-LHYD	r = 0 r ≤ 1	r ≥ 1 r ≥ 2	18.274 (15.494)*** 0.332 (3.841)	17.941 (14.264)*** 0.332 (3.841)
LLHR-LMLTN	r = 0 r ≤ 1	r ≥ 1 r ≥ 2	15.324 (15.494) 0.292 (3.841)	15.032 (14.264)** 0.292 (3.841)
LLHR-LPINDI	r = 0 r ≤ 1	r ≥ 1 r ≥ 2	16.801 (15.494)** 0.208 (3.841)	16.592 (14.264)** 0.208 (3.841)
LLHR-LPSHWR	r = 0 r ≤ 1	r ≥ 1 r ≥ 2	15.304 (15.494) 0.035 (3.841)	15.268 (14.264)** 0.035 (3.841)
LLHR-LQUETA	r = 0 r ≤ 1	r ≥ 1 r ≥ 2	15.390 (15.494) 0.000 (3.841)	15.389 (14.264)** 0.000 (3.841)
LLHR-LSUKUR	r = 0 r ≤ 1	r ≥ 1 r ≥ 2	22.927 (15.494)*** 0.228 (3.841)	22.698 (14.264)*** 0.228 (3.841)
LHYD-LMLTN	r = 0 r ≤ 1	r ≥ 1 r ≥ 2	16.365 (15.494)** 0.081 (3.841)	16.284 (14.264)** 0.081 (3.841)
LHYD-LPINDI	r = 0 r ≤ 1	r ≥ 1 r ≥ 2	17.516 (15.494)** 0.086 (3.841)	17.430 (14.264)*** 0.086 (3.841)
LHYD-LPSHWR	r = 0 r≤ 1	r ≥ 1 r ≥ 2	16.750 (15.494)** 0.001 (3.841)	16.748 (14.264)*** 0.001 (3.841)
LHYD-LQUETA	r = 0 r ≤ 1	r ≥ 1 r ≥ 2	13.399 (15.494) 0.206 (3.841)	13.192 (14.264) 0.206 (3.841)
LHYD-LSUKUR	r = 0 r ≤ 1	r ≥ 1 r ≥ 2	26.004 (15.494)*** 0.058 (3.841)	25.945 (14.264)*** 0.058 (3.841)

Critical values at 95 percent confidence level are in parentheses.
Source: Own calculations.

The Johansen's cointegration test results indicate the existence of long-run equilibrium relationship between twenty out of twenty one different pairs of seven regional rice markets. The maximum eigenvalue statistics suggest cointegration relationship in almost all the pairs of markets at the 5 percent confidence level except the pair of Hyderabad and Quetta. Results from the trace statistics are slightly different. Unlike maximum eigenvalue statistics, trace statistics suggest weak or no cointegration in the pairs of Lahore rice market series with Multan, Peshawar and Quetta rice market prices.

Table 6.8: Pairwise Cointegration Test Results for Rice Markets of Pakistan-II

Market Pairs	H_0	H_1	Trace Statistics	Maximum Eigenvalue Statistics
LMLTN-LPSHWR	r = 0 r ≤ 1	r ≥ 1 r ≥ 2	28.690 (15.494)*** 0.042 (3.841)	28.648 (14.264)*** 0.042 (3.841)
LMLTN-LPINDI	r = 0 r ≤ 1	r ≥ 1 r ≥ 2	44.615 (15.494)*** 0.151 (3.841)	44.460 (14.264)*** 0.151 (3.841)
LMLTN-LQUETA	r = 0 r ≤ 1	r ≥ 1 r ≥ 2	58.169 (15.494)*** 0.029 (3.841)	58.140 (14.264)*** 0.029 (3.841)
LMLTN-LSUKUR	r = 0 r ≤ 1	r ≥ 1 r ≥ 2	30.472 (15.494)*** 0.154 (3.841)	30.318 (14.264)*** 0.154 (3.841)
LPSHWR-LPINDI	r = 0 r ≤ 1	r ≥ 1 r ≥ 2	31.135 (15.494)*** 0.081 (3.841)	31.054 (14.264)*** 0.081 (3.841)
LPSHWR-LQUETA	r = 0 r ≤ 1	r ≥ 1 r ≥ 2	27.456 (15.494)*** 0.002 (3.841)	27.453 (14.264)*** 0.002 (3.841)
LPSHWR-LSUKUR	r = 0 r ≤ 1	r ≥ 1 r ≥ 2	22.072 (15.494)*** 0.032 (3.841)	22.039 (14.264)*** 0.032 (3.841)
LPINDI-LQUETA	r = 0 r ≤ 1	r ≥ 1 r ≥ 2	37.584 (15.494)*** 0.018 (3.841)	37.565 (14.264)*** 0.018 (3.841)
LPINDI-LSUKUR	r = 0 r ≤ 1	r ≥ 1 r ≥ 2	41.678 (15.494)*** 0.123 (3.841)	41.555 (14.264)*** 0.123 (3.841)
LQUETA-LSUKUR	r = 0 r ≤ 1	r ≥ 1 r ≥ 2	43.037 (15.494)*** 0.018 (3.841)	43.018 (14.264)*** 0.018 (3.841)

Critical values at 95 percent confidence level are in parentheses.
Source: Own calculations.

It can also be seen from other long-run relationships that the Lahore market is cointegrated with Hyderabad, Rawalpindi and Sukkur, and the Quetta market is cointegrated with all other markets, it can therefore be considered that there exist long-run relationships between Hyderabad-Quetta and Lahore-Multan market pairs, as well as Lahore with Peshawar and Quetta. As compared to wheat, integration between rice markets seems to be weak based on the trace statistics of the Johansen's cointegration test.

After establishing the pairwise long-run relationship of different rice markets of Pakistan, it is necessary to check the joint cointegration to find out the number of independent combinations within seven markets of rice. Table 6.9 presents the results of a joint cointegration test for seven regional rice markets of Pakistan. The trace as well as the maximum eigenvalue statistics suggest that there are five cointegrating equations and the markets are cointegrated and converge to the long-run equilibrium in a sense that they are stationary in five directions and non-stationary in two directions, which implies that there are at least five linear independent combinations in the system, which are stationary.

Table 6.9: Joint Cointegration Test Results for Rice Markets of Pakistan

Equation Tested	H_0	H_1	Trace Statistics	Maximum Eigenvalue Statistics
LHYD	r = 0	r ≥ 1	270.956 (125.615)***	109.171 (46.231)***
LLHR	r ≤ 1	r ≥ 2	161.784 (95.753)***	51.574 (40.077)***
LMLTN	r ≤ 2	r ≥ 3	110.210 (69.818)***	43.784 (33.876)***
LPINDI	r ≤ 3	r ≥ 4	66.425 (47.856)***	29.106 (27.584)***
LPSHWR	r ≤ 4	r ≥ 5	37.319 (29.797)***	23.653 (21.131)***
LQUETA	r ≤ 5	r ≥ 6	13.665 (15.494)	13.652 (14.264)
LSUKUR	r ≤ 6	r ≥ 7	0.013 (3.841)	0.013 (3.841)

Critical values at 95 percent confidence level are in parentheses.
Source: Own calculations.

In Table 6.9, it can be seen that the first five trace statistics are 270.956, 161.784, 110.210, 66.425 and 37.665, and maximum eigenvalue statistics are 109.171, 51.574, 43.784, 29.106 and 23.653, which are significantly higher than the respective critical values at 95 percent. There are two common stochastic trends. These results are in accordance with the pairwise cointegration test results. As, a long run relationship has not been identified in few pairs of rice markets. The Quetta market was found to be less integrated or not cointegrated with the Lahore and Hyderabad markets and the Lahore market was also not found to be integrated in the long run with some markets. This might be the reason for two stochastic trends, apart from one stochastic trend due to some common factors of the regional markets.

6.1.6 Vector Error Correction Model Results of Rice Markets of Pakistan

The Vector Error Correction Model (VECM) was also applied to rice markets of Pakistan to estimate the long-term coefficients along with short-term dynamics. Linear VECM model results are presented in Table 6.10. Results show highly significant adjustment of prices in almost all the pairs of markets except the pairs including the Quetta market. Adjustment to equilibrium from and to the Quetta market are slower as well as insignificant in some cases because this market is far away from the other markets. The Quetta market shows significant adjustment of about 20 percent to changes in prices of the Multan market and about 18 percent of that to the Rawalpindi market, which is uni-directional only. This implies that the Multan and Rawalpindi markets do not adjust to the changes in prices in Quetta market because Quetta is a smaller market and trade of rice is also uni-directional. This market is from the largest province of Pakistan in terms of area, but smallest in terms of population. Hence, the requirement of this province seems to be less, as its demand for rice can be fulfilled by one or two markets. Hence, there is no surprise in the limited integration of Quetta with other markets.

Table 6.10: VECM Results of Rice Markets of Pakistan

Market Pairs	Speed of Adjustment	Market Pairs	Speed of Adjustment
LLHR-	-0.083**	LMLTN-	-0.129***
LHYD	0.047**	LPSHWR	0.098**
LLHR-	-0.080***	LMLTN-	-0.172***
LMLTN	0.047**	LPINDI	0.141***
LLHR-	-0.088***	LMLTN-	-0.061*
LPINDI	0.036*	LQUETA	0.200***
LLHR-	-0.079**	LMLTN-	-0.093**
LPSHWR	0.036*	LSUKUR	0.148***
LLHR-	-0.085***	LPINDI-	-0.135***
LQUETA	0.024	LPSHWR	0.117***
LLHR-	-0.088**	LPINDI-	-0.042
LSUKUR	0.081**	LQUETA	0.183***
LHYD-	-0.051***	LPINDI-	-0.106***
LMLTN	0.049*	LSUKUR	0.156***
LHYD-	-0.049**	LPSHWR-	-0.028
LPINDI	0.051*	LQUETA	0.116***
LHYD-	-0.049***	LPSHWR-	-0.083**
LPSHWR	0.044*	LSUKUR	0.118***
LHYD-	-0.025	LQUETA-	-0.134***
LQUETA	0.058**	LSUKUR	0.068*
LHYD-	-0.064***		
LSUKUR	0.092**		

Here: *,** and *** show the significance at 10, 5 and 1 percent.
Source: Own calculations.

Estimations reveal that the speed of adjustment within Multan and Sukkur markets and with most of the markets under study are higher. The highest error correction term is between the market pair of Multan and Rawalpindi. More than 15 percent of the adjustment is done in each direction. As the ECT co-efficients have the proper signs, it can be said that almost 30 percent of prices are adjusted in one month.

Like wheat market integration estimates of VECM, in the case of rice markets, Lahore also shows significant adjustment to all other markets but the coefficients of adjustment are smaller in absolute terms. This might be

due to the fact that irri rice is produced in Sindh province mostly, whereas Lahore market is situated in Punjab province. On the basis of VECM estimations, it can be concluded that all the rice markets under study are not only integrated in the long run but also show significant adjustment in the short run. It should be noted that these are VECM estimates, application of threshold (TVECM) will provide further insight.

Threshold Test for Rice Markets

Table 6.11 presents the estimates of the SupLM test for the regional rice markets of Pakistan.

Table 6.11: Estimates of SupLM Test Applied on Price Series of Rice Markets of Pakistan

Market Pairs	Cointegration Vector	Threshold Parameter	SupLM Test Value	Critical Value	P-Value
LLHR-LHYD	-0.918	0.431	19.334	15.716	0.005
LLHR-LMLTN	-0.897	0.600	19.696	16.548	0.008
LLHR-LPINDI	-0.874	0.588	14.486	15.941	0.099
LLHR-LPSHWR	-0.841	0.778	11.979	9.369	0.012
LLHR-LQUETA	-0.896	0.577	17.574	15.941	0.021
LLHR-LSUKUR	-0.866	0.828	15.438	16.053	0.068
LHYD-LMLTN	-0.982	-0.026	15.937	15.377	0.036
LHYD-LPINDI	-0.957	0.248	23.943	24.361	0.062
LHYD-LPSHWR	-0.917	0.486	17.760	18.304	0.066
LHYD-LQUETA	-0.967	0.157	18.331	18.595	0.055
LHYD-LSUKUR	-0.947	0.512	14.337	15.264	0.084
LMLTN-LPSHWR	-0.938	0.405	20.814	19.774	0.032
LMLTN-LPINDI	-0.986	-0.015	14.115	15.266	0.088
LMLTN-LQUETA	-1.006	-0.029	17.024	18.438	0.091
LMLTN-LSUKUR	-0.966	0.292	24.955	16.222	0.000
LPINDI-LPSHWR	-0.954	0.269	25.916	15.888	0.000
LPINDI-LQUETA	-1.017	-0.006	19.230	18.330	0.034
LPINDI-LSUKUR	-0.981	0.272	24.173	16.347	0.001
LPSHWR-LQUETA	-1.060	-0.295	17.479	18.623	0.084
LPSHWR-LSUKUR	-1.032	-0.122	13.056	18.606	0.526
LQUETA-LSUKUR	-0.966	0.321	14.935	15.520	0.065

Source: Own calculations.

The SupLM test clearly rejects the null hypothesis of linear cointegration against the alternate hypothesis of threshold cointegration. The results reveal that the SupLM test values of eleven pairs of regional rice markets out of twenty different pairs are greater than the critical value at the 95 percent significance, while for nine pairs it is significant at the 90 percent level. Except the Peshawar and Sukkur rice markets pair, evidence of threshold effects has been found in all twenty different pairs at the 90 percent significance. The Peshawar market is the smallest market in terms of quantity produced as well as consumed and it has more trade with neighboring markets like Rawalpindi, while, Sukkur is quite far from Peshawar. Thus, it makes sense to have no or only limited trade with each other specially for rice. Therefore, the null hypothesis could not be rejected for this pair. On the basis of these results, it can be concluded that there exists threshold cointegration instead of linear cointegration.

6.1.7 TVECM Analysis of Domestic Rice Markets

After finding the long-run cointegration in almost all the pairs of regional rice markets of Pakistan, the Threshold Vector Error Correction Model was applied using maximum-likelihood method for estimation to see the short-run dynamics and to identify the speed of adjustment to the shock. Estimation results for the Threshold Vector Error Correction Model (TVECM) for seven regional rice markets of Pakistan are presented in Appendix A.8. Except Rawalpindi and Sukkur markets, all the pairs show significant adjustment in either the lower or the upper regime, which implies that none of these two markets react to a shock in the system with respect to each other.

Although, these markets have a long-run relationship, but short-run adjustment can not be seen in threshold estimation. Hence, it can be concluded that Rawalpindi and Sukkur are not integrated in the short run. This can be explained by the distance between two markets and their strong relationship

with other neighboring markets, like, Sukkur is closer to Hyderabad market and it has more trade with Hyderabad market and Rawalpindi is closely integrated with Lahore and Multan markets. Results also confirm that the relationships between these markets are significant in one or both regimes.

The Lahore and Hyderabad market pair shows the highest and significant speed of adjustment in the lower regime with 61 percent and 27 percent, respectively. Both the markets are apparently larger markets in the respective provinces, hence, they are well connected through transport and communication which explains the higher adjustment from both markets. The Lahore market also shows significant adjustment in response to changes in Rawalpindi market prices in both regimes, whereas Rawalpindi market adjusted only in the lower regime. Similarly, Multan and Peshawar rice markets also adjust in the lower regime to the changes in Lahore market. This implies that when prices go down in the Lahore market, the Multan, Peshawar and Rawalpindi markets adjust to that, because Lahore is the central market in the Punjab province, hence the Multan and Rawalpindi markets are well connected to Lahore market, although the Peshawar market is in KPK province but this market is also close to Lahore and Rawalpindi and it depends mostly on the supply from these two markets.

All the markets show significant adjustment to the changes in prices of the Hyderabad market in the lower regime mostly. Hyderabad is the central market of the largest irri rice producing province of Pakistan. Hence, it might be considered as the leading market in irri rice prices. It is interesting to see that Hyderabad market adjusts to some markets in the upper regime only, which implies that due to higher demand in the other markets (deficient markets), which leads to increase in the prices, the Hyderabad market responses to that increase and take the advantage of arbitrage and as a result prices also increase in the Hyderabad market. It is also important to note here that adjustments from the Hyderabad market are three times less than the adjustment from other markets to the changes in prices of Hyderabad market.

6.2 Market Integration Analysis of South Asian Markets

As mentioned in the data section, only Bangladesh, India and Pakistan have been selected for the analysis, due to data unavailability for other countries. Further, the US-HRW wheat export prices and Thailand and Vietnamese rice export prices are also included to check the integration between South Asian markets with the world markets.

Stationarity of the time series data of wheat prices for Bangladesh, India, Pakistan and the United States (HRW-wheat) has been checked using the augmented Dickey-Fuller test. Table 6.12 presents the results of the augmented Dickey-Fuller unit root test. The results show that all the price series are non-stationary at levels and stationary at first differences, which is usually termed as integrated of order one I(1).

Table 6.12: ADF Test Results Wheat Markets of South Asia and the USA

Markets	Levels	1st Differences
Bangladesh	-1.480	-7.884 ***
India	-0.438	-8.020 ***
Pakistan	-0.548	-8.413 ***
US HRW	-1.476	-8.896 ***

Critical values at 1, 5 and 10 percent respectively are -3.479, -2.883, -2.578.
Source: Own calculations.

Similarly, the unit root test was applied to rice markets of South Asian countries namely, Bangladesh, India and Pakistan, as well as to Thailand and Vietnamese export prices of rice. Results for the augmented Dickey-Fuller unit root test are presented in Table 6.13. The results for rice markets also revealed that all five price series are non-stationary at levels and stationary at first difference. It is therefore concluded that all the variables are integrated of order one, i.e. I(1).

Table 6.13: ADF Test Results Rice Markets of South Asia, Thailand and Vietnam

Markets	Levels	1st Differences
Bangladesh	-1.398	-10.135***
India	-0.205	-11.441***
Pakistan	-1.677	-7.310***
Thailand	-1.414	-7.275***
Vietnam	-1.894	-7.290***

Critical values at 1, 5 and 10 percent respectively are -3.479, -2.883, -2.578.
Source: Own calculations.

To check whether the residuals of ADF are white noise process, LM test for serial correlation (Breusch-Godfrey Serial Correlation LM test) was applied and Ljung-Box Q-statistics was also checked to verify that error terms are white noise. Heteroskedasticity test (Breusch-Pagan-Godfrey test for heteroskedasticity) was also applied to each series, the null hypothesis of no serial correlation could not be rejected for any of the of wheat and rice markets. As we know from the previous chapter, if two series are integrated of the same order then cointegration can be applied. Hence, Johansen's cointegration was applied to all the pairs of the markets.

6.2.1 Cointegration Test Results of Wheat and Rice Markets of South Asia

The Johansen (1988) test for cointegration revealed the existence of the long-run relationships in the price series of South Asian countries with each other as well as with the world price series (Table 6.14). Cointegration between Bangladesh and US wheat series was found at 10 percent significance on the basis of trace statistics, but, according to maximum eigenvalue statistics it was also significant at 5 percent. All other pairs show that there is cointegration between the price series of the said market prices at 5 percent.

Table 6.14: Pairwise Cointegration Test Results for Wheat Markets of South Asia and the USA

Market Pairs	H_0	H_1	Trace Statistics	Maximum Eigenvalue Statistics
Bangladesh-	r = 0	r ≥ 1	26.378 (25.872)***	19.624 (19.387)***
India	r ≤ 1	r ≥ 2	6.754 (12.518)	6.754 (12.518)
Bangladesh-	r = 0	r ≥ 1	16.124 (15.495)**	15.589 (14.265)**
Pakistan	r ≤ 1	r ≥ 2	0.534 (3.841)	0.534 (3.841)
Bangladesh-	r = 0	r ≥ 1	25.594 (25.872)*	19.594 (19.387)**
US HRW	r ≤ 1	r ≥ 2	6.001 (12.518)	6.001 (12.518)
India-	r = 0	r ≥ 1	31.371 (25.872)***	25.558 (19.387)***
Pakistan	r ≤ 1	r ≥ 2	5.813 (12.518)	5.813 (12.518)
India-	r = 0	r ≥ 1	20.468 (15.495)***	20.181 (14.265)***
US HRW	r ≤ 1	r ≥ 2	0.287 (3.841)	0.287 (3.841)
Pakistan-	r = 0	r ≥ 1	26.212 (15.495)***	26.201 (14.265)***
US HRW	r ≤ 1	r ≥ 2	0.011 (3.841)	0.011 (3.841)

Critical values at 95 percent confidence level are in parentheses.
Source: Own calculations.

In order to check the common stochastic trends in the combination of all four variables, joint cointegration tests were applied. Results obtained from the joint cointegration test also suggest that the variables are cointegrated. Trace statistics suggested two linear combinations while maximum eigenvalue statistics suggested that there are three common long-run independent stationary combinations and there is one stochastic trend (Table 6.15).

Table 6.15: Joint Cointegration Test Results Wheat Markets of South Asia and the USA

Equation Tested	H_0	H_1	Trace Statistics	Maximum Eigenvalue Statistics
Bangladesh	r = 0	r ≥ 1	110.692 (63.876)***	57.624 (32.118)***
India	r ≤ 1	r ≥ 2	53.068 (42.915)***	30.117 (25.823)***
Pakistan	r ≤ 2	r ≥ 3	22.952 (25.872)	19.513 (19.387)**
US HRW	r ≤ 3	r ≥ 4	3.439 (12.518)	3.439 (12.518)

Critical values at 95 percent confidence level are in parentheses.
Source: Own calculations.

As established, there exists a long-run relationship in almost all pairs of price series of different wheat markets of South Asia and the US-HRW export price. To see the short-run dynamics, VECM was applied to all the different combinations of the price series of wheat. VEVM estimation results for wheat markets of South Asia and US export price are provided in Table 6.16.

Table 6.16: VECM Results of Wheat Markets of South Asia and the USA

Market Pairs	Speed of Adjustment
Bangladesh-India	-0.067** -0.010
Bangladesh-Pakistan	-0.039 0.036**
Bangladesh-US HRW	-0.054* 0.089**
India-Pakistan	-0.018 0.060**
India-US HRW	-0.006 0.122***
Pakistan-US HRW	-0.040*** 0.056*

Here: *,** and *** show the significance at 10, 5 and 1 percent.
Source: Own calculations.

Results reveal that India shows no speed of adjustment with all other markets. Pakistani and Bangladeshi wheat markets seems to be a little adjustable to the shocks: The speed of adjustment is very low but significant. Linear VECM results does not provide a satisfactory performance in the price adjustment of South Asian wheat markets with each other as well as with the world price. On the basis of these results it can be concluded that wheat markets of South Asia are not integrated in the short run. It is yet to be seen, if incorporation of transaction costs by a two-threshold (TVECM) model produces higher and significantly different estimates for the co-efficients of adjustment for these markets than the linear VECM or not.

Table 6.17: Pairwise Cointegration Test Results for Rice Markets of South Asia, Thailand and Vietnam

Market Pairs	H_0	H_1	Trace Statistics	Maximum Eigenvalue Statistics
Bangladesh-India	r = 0	r ≥ 1	17.452 (15.495)**	17.154 (14.265)***
	r ≤ 1	r ≥ 2	0.297 (3.841)	0.2973 (3.841)
Bangladesh-Pakistan	r = 0	r ≥ 1	18.738 (15.495)***	17.344 (14.265)***
	r ≤ 1	r ≥ 2	1.394 (3.841)	1.394 (3.841)
Bangladesh-Thailand	r = 0	r ≥ 1	19.649 (15.495)***	17.925 (14.265)***
	r ≤ 1	r ≥ 2	1.724 (3.841)	1.724 (3.841)
Bangladesh-Vietnam	r = 0	r ≥ 1	19.374 (15.495)***	17.135 (14.265)***
	r ≤ 1	r ≥ 2	2.239 (3.841)	2.239 (3.841)
Pakistan-India	r = 0	r ≥ 1	16.429 (15.495)**	16.212 (14.265)**
	r ≤ 1	r ≥ 2	0.217 (3.841)	0.217 (3.841)
Pakistan-Thailand	r = 0	r ≥ 1	25.120 (15.495)***	22.879 (14.265)***
	r ≤ 1	r ≥ 2	2.241 (3.841)	2.241 (3.841)
Pakistan-Vietnam	r = 0	r ≥ 1	34.514 (15.495)***	32.377 (14.265)***
	r ≤ 1	r ≥ 2	2.137 (3.841)	2.137 (3.841)
India-Thailand	r = 0	r ≥ 1	13.322 (15.495)	13.074 (14.265)*
	r ≤ 1	r ≥ 2	0.248 (3.841)	0.248 (3.841)
India-Vietnam	r = 0	r ≥ 1	17.216 (15.495)**	17.078 (14.265)***
	r ≤ 1	r ≥ 2	0.138 (3.841)	0.138 (3.841)
Thailand-Vietnam	r = 0	r ≥ 1	25.826 (15.495)***	23.762 (14.265)***
	r ≤ 1	r ≥ 2	2.064 (3.841)	2.064 (3.841)

Critical values at 95 percent confidence level are in parentheses.
Source: Own calculations.

Bangladesh, India, Pakistan, Thailand and Vietnam rice markets price series are also integrated of order one, hence Johansen's cointegration was applied to all the pairs of these markets price series. Pairwise cointegration test results of all pairs rejected the null hypothesis of no cointegration and accepted the alternate hypothesis of cointegration between the pairs on the basis of maximum eigenvalue statistics at 95 percent significance level. Only for the pair of India and Thailand, the null hypothesis was rejected at 90 percent. Trace statistics also provided similar results, the cointegration between India and Thailand price series was not found at 95 percent significance level (Table 6.17).

Table 6.18: Joint Cointegration Test Results for Rice Markets of South Asia, Thailand and Vietnam

Equation Tested	H_0	H_1	Trace Statistics	Maximum Eigenvalue Statistics
Bangladesh	r = 0	r ≥ 1	111.617 (69.819)***	49.034 (33.877)***
India	r ≤ 1	r ≥ 2	62.583 (47.856)***	28.976 (27.584)**
Pakistan	r ≤ 2	r ≥ 3	33.606 (29.797)***	24.986 (21.132)***
Thailand	r ≤ 3	r ≥ 4	8.620 (15.495)	6.558 (14.265)
Vietnam	r ≤ 4	r ≥ 5	2.062 (3.841)	2.062 (3.841)

Critical values at 95 percent confidence level are in parentheses.
Source: Own calculations.

Joint cointegration tests were then applied to all five price series of rice markets under study to check the common stochastic trend. Trace statistics as well as maximum eigenvalue statistics suggested that there are three common long-run independent stationary combinations and there are two stochastic trends (Table 6.18). One stochastic trend is obvious due to certain factors of the markets, but the second trend might be due to the fact that the Indian rice market is less integrated with Thailand, as pointed out already by pairwise cointegration estimations.

First three trace statistics and maximum eigenvalue statistics are significantly higher than the critical values at 95 percent. First three trace statistics obtained from the joint cointegration test are 111.617, 62.583, and 33.606 which are significantly higher than the respective critical values 69.819, 47.856 and 29.797. Maximum Eigenvalue statistics 49.034, 28.976 and 24.986 are also higher from their critical values 33.877, 27.584 and 21.132, respectively. While, the last two values for trace statistics as well as for Maximum Eigenvalue Statistics are lower than the respective critical values (Table 6.18).

Table 6.19: VECM Results of Rice Markets of South Asia, Thailand and Vietnam

Market Pairs	Speed of Adjustment
Bangladesh-India	-0.078*** -0.011
Bangladesh-Pakistan	-0.078*** 0.088***
Bangladesh-Thailand	-0.065** 0.048*
Bangladesh-Vietnam	-0.068*** 0.108***
India-Pakistan	-0.028* 0.086***
India-Thailand	-0.026 0.080***
India-Vietnam	-0.016 0.102***
Pakistan-Thailand	-0.065 0.125***
Pakistan-Vietnam	-0.049 0.268***
Thailand-Vietnam	-0.032 0.133***

Here: *,** and *** show the significance at 10, 5 and 1 percent.
Source: Own calculations.

Table 6.19 presents the results of VECM of rice markets of Bangladesh, India, Pakistan, Thailand and Vietnam. Like wheat markets, most of the coefficients of adjustment in the rice markets are also very low but significant, and significantly higher than wheat market parameters. Indian rice markets also adjust very little to disequilibrium in percentage terms. The only significant adjustment of the Indian rice market is 2.8 percent with the Pakistani rice market, which is only significant at 90 percent. With all other markets, like Bangladesh, Thailand and Vietnam, the speed of adjustment for India is not significant and only 1.1, 2.5 and 1.6 percent, respectively.

This low degree of integration of Indian markets can be explained by their government interventions. For example after the price spikes in 2007, the Government of India banned its imports and exports of wheat and rice and kept the prices low to protect the consumers of higher international prices.

The adjustment parameter of Bangladesh market prices is higher and significant with all other markets. About 7 to 8 percent of prices are adjusted by Bangladesh rice market with all other markets. Short-run adjustment between Bangladesh and Pakistan rice market prices is about 15 percent. The Vietnamese market shows the highest adjustment of 26 percent and highly significant with Pakistan rice market prices. It also depicts higher and significant adjustment to Bangladesh, India and Thailand with 10.8, 10.1 and 13.2 percent, respectively. These results might be due to the general rise in prices after the 2007 food price spikes.

The Pakistani rice market also adjusts with a percentage of 8.8 and 8.6 with Bangladesh and India, respectively. The Bangladesh market shows significant adjustment of about 7.8 percent with Indian market, as India exports some quantity of rice to Bangladesh in some years. Estimations of the TVECM will provide further insights of the dynamics of the rice markets of South Asia and their integration with world's leading export markets as well.

The next section provides the estimations results for the Threshold Vector Error Correction Model of wheat markets of Bangladesh, India, Pakistan and US-HRW and also for rice markets of Bangladesh, India, Pakistan, Thailand and Vietnam. Before that, the threshold test developed by Hansen and Seo (2002) is applied to the data and the results of that test are also provided.

6.2.2 TVECM Results of Wheat Markets of South Asia

The SupLM test was applied to the pairs of wheat price series of Bangladesh, India, Pakistan and US-HRW, to test for threshold cointegration. SupLM test estimations provided the evidence of the existence of threshold effects in five out of six market pairs. The null hypothesis of linear cointegration could not be rejected in only one pair of Pakistan and US-HRW wheat market prices in the bivariate SupLM test (Table 6.20). Linear cointegration was already established through Johansen's pairwise cointegration test. But tests for the existence of significant transaction costs was not accepted for this market pair. The null hypothesis was rejected or alternate hypothesis of threshold cointegration was accepted at 95-percent significance for the pairs Bangladesh-India, Bangladesh-Pakistan and India-Pakistan market prices of wheat. For the pairs Bangladesh-US(HRW) and India-US(HRW), the null hypothesis was rejected at the 90-percent significance level, which is established on the basis of the higher value of the SupLM test than the critical value obtained with 5000 bootstrap replications.

Table 6.20: Estimates of SupLM Test Applied on Price Series of Wheat Markets of South Asia and the USA

Market Pairs	Cointegration Vector	Threshold Parameter	SupLM Test Value	Critical Value	P-Value
Bangladesh-India	-0.935	0.227	16.790	14.616	0.024
Bangladesh-Pakistan	-0.835	0.725	16.490	15.528	0.034
Bangladesh-US HRW	-0.916	0.318	36.465	37.670	0.079
India-Pakistan	-0.894	0.501	15.299	15.144	0.048
India-US HRW	-0.869	0.602	31.538	33.390	0.098
Pakistan-US HRW	-0.864	0.532	31.777	35.572	0.135

Source: Own calculations.

Threshold Vector Error Correction Model estimates for wheat markets of Bangladesh, India, Pakistan and US-HRW are presented in Appendix A.9. Not surprisingly, results are quite different in the TVECM estimations, in terms of higher and significant adjustments. Immediate short-run adjustments for all the market pairs could not be established, which can be explained by the domestic protectionists policies of the South Asian countries. Even then, results of the TVECM show better short-run relationship between South Asian markets with each other and with world price as compared to a linear VECM. Results reveal that 21.6 percent of adjustment to the price shocks is done by the Indian domestic market prices of wheat in the lower regime and about 14.5 percent adjustment by Bangladesh in the upper regime only. Lagged short-run dynamics show even higher adjustments from Bangladesh, around 54 percent in lower regime and about 68 percent in the upper regime and Indian markets adjust about 22 percent to the shock in the system in lower regime. This implies that along with a long-run integration between Bangladesh and Indian wheat markets, short-run dynamics show higher adjustment from Bangladesh when prices difference is above the second threshold. As Bangladesh is a net wheat importer, it not only imports wheat from India, but due to their porous border they are also affected by the policies of each other directly or indirectly.

If we look at the TVECM estimations for Bangladesh and Pakistani wheat market pair, immediate adjustment from Bangladesh can not be seen. The Pakistan market shows a significant adjustment of about 65 percent in the upper regime only. This implies that, when prices are higher than a certain threshold in wheat markets of Bangladesh, domestic prices of Pakistan are affected and they try to adjust to form a new equilibrium quickly. Significant adjustment from Bangladesh market can be seen in the lagged short-run adjustment of more than 40 percent in each regime, so a response from the Bangladesh market is observed after one period. Although Pakistan is not a permanent exporter of wheat, and especially, does not export wheat to Bangladesh, there exists quite a close integration of wheat markets of Bangladesh and Pakistan.

Application of TVECM on wheat market price series of India and Pakistan revealed a significant speed of adjustment to the shock in the system. On average, about 30 percent adjustment to the disequilibrium is observed in the upper regime. It means when prices increase significantly, both the markets respond to it quickly to form a new equilibrium. Indian wheat prices adjust by 26 percent and Pakistani markets try to adjust by 32 percent of the price change. Almost similar adjustment parameters can be found in the lagged prices of India and Pakistan.

The linear model revealed significant adjustment from Bangladesh and US wheat market pairs in both directions, whereas, TVECM results provides no evidence of significant adjustment from any of the market, neither in lower nor in upper regime. Lagged short-run adjustment is witnessed in the relationship between Bangladesh and US wheat markets. Apparently, prices are transmitted to the Bangladesh market from the world market after one month.

The Indian wheat market has no significant adjustment with US export price series of wheat, mainly due to the protectionist policies and no significant imports of wheat from international markets, because India is not only self-sufficient in wheat, but also an exporter of wheat. As witnessed from the linear VECM, the US export price of wheat has shown significant adjustment in the short run in the pairwise analysis of wheat markets of India and United States of America. Similarly, in the TVECM estimations, US markets has shown significant adjustment of about 37 percent to the decrease in Indian wheat prices below the first threshold. Adjustment in lags are also significant in the lower regime by both markets.

From South Asian countries, only the Pakistani wheat market has shown about 16 percent degree of adjustment to the US-HRW market in the lower regime. Pakistan, in being importer of wheat in some years of acute shortage, imports wheat from US, hence it adjust to the international market. But this adjustment in the lower regime may only be due to the government-led

imports at higher costs but distribution at subsidized rates. Further, the role of the private sector in the wheat trade is very limited.

Results from the threshold model for the pairs of India-US-HRW and Pakistan-US-HRW show similar trends as it was shown by linear VECM. But the threshold model provides better insight of the speed of adjustment, based on the thresholds and different regimes. Further, it can be seen that the speed of adjustment or degree of market integration for all pairs is higher as compared to the simple model. This means that linear models do not provide sufficient information because of the fact that transaction costs which play an important role for trade of the commodities between different markets, is completely ignored in the linear models.

6.2.3 TVECM Results of Rice Markets of South Asia

Before the TVECM estimates, it is ideal to see SupLM test results for rice markets. This test will provide the base and justification for the use of Thresholds Vector Error Correction Model. Table 6.21 provides the SupLM test results for the price series pairs of South Asian rice markets, Thailand and Vietnam. Test results revealed that all market pairs have significant transactions costs because the null hypothesis of linear cointegration was rejected for all the pairs of rice markets under study. Hence, the threshold cointegration was significantly observed.

Eight out of ten different pairs of Bangladesh, India, Pakistan, Thailand and Vietnam rice markets have provided the evidence of threshold effects at the 95-percent significance level. Only Bangladesh-India and India-Pakistan rice market price pairs reject the null hypothesis at 90 percent significance. As this test only provides the idea whether there exists a threshold cointegration or a linear cointegration, but does not provide the number of thresholds, P-values of 90 percent are also taken into account. After establishing the existence of threshold effects, TVECM was applied to all market pairs.

Table 6.21: Estimates of SupLM Test Applied on Price Series of Rice Markets of South Asia, Thailand and Vietnam

Market Pairs	Cointegration Vector	Threshold Parameter	SupLM Test Value	Critical Value	P-Value
Bangladesh-India	-0.706	1.665	15.349	16.097	0.071
Bangladesh-Pakistan	-0.623	2.167	16.851	15.495	0.024
Bangladesh-Thailand	-0.492	2.793	17.244	15.649	0.019
Bangladesh-Vietnam	-0.600	2.211	19.491	15.304	0.004
India-Pakistan	-0.856	0.942	18.956	19.315	0.059
India-Thailand	-0.690	1.785	19.500	15.771	0.007
India-Vietnam	-0.814	1.028	17.370	15.569	0.021
Pakistan-Thailand	-0.786	1.043	18.609	15.906	0.011
Pakistan-Vietnam	-0.951	0.297	26.079	15.745	0.000
Thailand-Vietnam	-1.197	-0.969	16.741	15.460	0.026

Source: Own calculations.

SupLM tests provided the evidence of existence of significant transaction costs or thresholds, hence the Threshold Vector Error Correction Model was then applied to rice markets price series of Bangladesh, India, Pakistan, Thailand and Vietnam. Results for the Threshold Vector Error Correction Model estimates for rice markets of these countries are presented in Appendix A.10. Results of a pairwise two-threshold (three-regimes) model reveal statistically significant adjustment to rice price changes in different regimes in almost all the market pairs used for the analysis, except for the pair Bangladesh-India price series. This suggests that no short-run adjustment of prices to disequilibrium within Bangladesh and Indian rice markets occurs. This might be due to an outright ban on the export of rice from India after 2007-08 price

spikes in the international market. Further, the price series under study are domestic wholesale prices for both countries, so it may be the case that domestic prices of India are isolated from its export prices, to protect its consumers. As mentioned by John (2013) there is a growing concern of the importing countries that exporting countries isolate their domestic markets from the international or export prices through protectionist policies. India is a major exporter of rice with some interventionist policies. In particular during the food crisis India announced a ban on its exports and imports to avoid the price hike in the country to protect its consumers form the higher prices.

Long-run as well as short-run integration between Bangladesh and Pakistan is higher in rice markets as compared to wheat markets. The speed of adjustment in the upper regime is about 17 percent on average and more than 30 percent net adjustment is observed. Pakistan is a major exporter of rice and also exports some quantity of rice to Bangladesh in selected years. Further, rice market of Pakistan are not restricted by the heavy government intervention in the recent past, except for the few years of international food crisis and the private sector plays an important role in the rice trade. Therefore, adjustment to disequilibrium from both the markets is significant.

Bangladesh also shows statistically significant adjustment to Thai prices of rice in both the lower as well as in the upper regime. Although immediate response is slower, the lagged dynamics show significant adjustment of more than 30 percent in all the regimes. The adjustment parameter of Bangladesh market is higher for the changes in Vietnam market prices, especially when the shock is higher than the second threshold, in other words, when the prices of Vietnam market is higher.

TVECM estimations for the pairwise market prices series of India and Pakistan show that response from both markets is asymmetric. If prices are lower than the first threshold, the Pakistani rice market tends to adjust by about 15 percent and when the prices are higher than the second threshold

than Indian rice markets by about 11 percent. This might be because both countries are major exporters of rice, but India is more restrictive in terms of government interventions in the rice markets.

Short-run adjustments for the pair of rice prices of India and Thailand show significant speed of about 6 percent from India for the shock in Thailand market, if the shock is above the second threshold. 18 percent of the adjustment is observed from the Thai market price in the lower regime only. Lagged dynamics show stronger and significant adjustment from the both the markets. This implies that it takes some time to form a new equilibrium or to absorb the shock. There is no significant speed of adjustment in the TVECM analysis of the India-Vietnam price series pair, from the Indian rice market. A significant although slow adjustment can be seen from Vietnam market price in the lower regime only.

Similar results have been found for TVECM estimations for Pakistan-Thailand and Pakistan-Vietnam market pairs. Speed of adjustment from Pakistani rice market is statistically significant in the lower regime only, with 22 percent for Thailand market prices. While, the shock in the Vietnam market is adjusted in the upper regime only with about 36 percent. Response from the Vietnam market is about 97 percent in lower regime, which means that shock in rice prices of Pakistan is transferred immediately to the Vietnam market, specially when prices go down.

Overall, rice markets of South Asia are integrated with the international markets in the long run, but in the short run, it takes at least one or two months to form the new equilibrium. Specially the Indian market is less integrated in the short run with international markets. However, Bangladesh seems to be more integrated, due to its imports of rice from major exporters of rice. The Bangladesh rice market is more integrated with Pakistani market rather than India, unlike the case of wheat markets. It also adjust quickly to changes in Vietnam rice markets as compared to Thailand.

Chapter 7

Conclusion and Recommendations

The aim of this study was to empirically assess the degree of market integration in the wheat and rice markets of Pakistan and the extent of market integration in the domestic markets of South Asian countries with each other and with leading international markets. This was attempted using a dynamic model, which incorporates unobserved transaction costs. The contribution of this research was to understand the integration of spatial food markets through the application of TVECM with three regimes, in order to take into account the effects of transaction costs. As discussed earlier, TVECM enables us to incorporate the unobserved/unobservable transaction costs as a neutral band of no adjustment in the middle regime.

In the past, wheat and rice markets of Pakistan have been analyzed using cointegration techniques, causality and linear error-correction mechanism only. Thereby, transaction costs have not been considered for the analysis in the previous studies, which play an important role to understand the dynamics of spatial markets. Long-run cointegration estimates for the wheat markets of Pakistan largely agree with the existing literature that spatial wheat markets of Pakistan are very well integrated. But, evidence for the presence of significant transaction costs have been found for almost all the

pairs of wheat markets of Pakistan by applying the SupLM test. Therefore, TVECM was applied and it was found that short-run adjustment estimates obtained form the threshold model are substantially higher as compared to the estimated parameters via linear error correction mechanism, where the role of transaction costs is ignored. The higher adjustment coefficients obtained from the application of the threshold model strongly support the argument raised by Mushtaque et al. (2007a), Dorosh and Salam (2008) and others about the unnecessary government interventions in the wheat sector.

Wheat being the major staple food has been the center of extensive and costly government interventions, because its availability and access to the whole population is linked with food security. Estimation results, based on the different wheat markets of Pakistan, reveal that wheat markets are well integrated, which ultimately leaves the impression of efficient market functioning. Hence, the expensive interventions of the government should be reduced and private sector should be allowed to trade wheat within the country, and invest in wheat storage and transportation, which will not only reduce the burden on the economy but will also increase the effectiveness of arbitrage and the efficiency of market functioning.

Rice markets of Pakistan, which are subject to less government interventions as compared to wheat, has also shown the long-run as well as short-run integration. Results from the linear error-correction model showed a speed of adjustment between 4 to 10 percent per month for most of the markets as a result of a shock to the equilibrium, only for some markets adjustment occurred above 10 percent. Like wheat, the TVECM applied to rice markets using the maximum-likelihood method of estimation to observe the degree of market integration or speed of adjustment revealed higher degree of adjustment in the rice markets in the TVECM analysis as compared to linear VECMs.

It can be concluded that wheat and rice markets of Pakistan are well integrated in the long run as well as in the short run. This also implies that

price signals and related arbitrage are well practiced in the regional food markets of Pakistan. Despite the occasional interventions in the rice sector by the Pakistan government, a higher degree of integration in the rice markets as compared to wheat markets support the argument of reducing the costly interventions in the wheat sector.

Market integration analysis of wheat markets of South Asian countries with each other and with the US wheat export price series revealed a long-run relationship in all the market pairs. The VECM analysis showed that India has the lowest and an insignificant speed of adjustment with all other markets. The speed of adjustment of wheat market of Pakistan is also low but significant. A higher degree of integration occurred between Bangladesh and the US-HRW wheat market than those of Pakistani and Indian markets with the US wheat market. The extent of market integration between South Asian markets with each other on the basis of VECM was very low. However, the application of TVECM revealed a higher speed of adjustment estimates, depending on different regimes.

The speed of adjustment to the disequilibrium between India and Pakistan was higher, significant and bi-directional. Almost 30 percent of adjustment takes place in both markets, but only in the upper regime. This implies that when prices of wheat increase significantly, both markets respond to it quickly to form a new equilibrium. It can be concluded that South Asian markets are integrated in the long run, but only partially integrated in the short run with each other.

International to domestic market estimations using the threshold model disclosed no immediate adjustment to the shock from Bangladesh market with the US market. Indian wheat market also showed no significant adjustment with the US export price series of wheat, mainly due to the protectionist policies. Only significant short-run adjustments from Pakistan have been found in the lower regime, may be due to the fact that Pakistan imports wheat from US, during deficit years. Hence, it is also evident from the anal-

ysis that domestic wheat markets of Bangladesh and India are isolated from the world market, whereas the domestic wheat market of Pakistan is partially integrated with the US export market. Therefore, it can be concluded that due to protectionist policies of the concerned governments, domestic markets of South Asia are less integrated with the world market. Consequently, they became vulnerable to price instability in the case of internal shocks.

Long-run integration was also found in the rice markets of South Asian countries and also with the leading world markets of rice. Results of pairwise two-threshold (three-regimes) models reveal statistically significant adjustment to rice price changes in different regimes in almost all the market pairs used for the analysis, except for the Bangladesh-India price series pair. This implies no short-run adjustment of prices to disequilibrium within Bangladesh and Indian rice markets. India is a major exporter of rice and also exports to Bangladesh, and this finding might be due to the outright ban on the export of rice by India, after 2007-08 price spikes in the international market.

The short-run integration between Bangladesh and Pakistan is higher in rice markets as compared to wheat markets, possibly because Pakistan exports some quantity of Rice to Bangladesh. TVECM estimations for the pairwise market prices series of India and Pakistan also revealed significant adjustment from both markets. Indian markets adjust significantly in the upper regime and Pakistani markets in the lower regime.

Rice market integration analysis between domestic markets of South Asian countries with Thailand and Vietnam markets have shown integration in the long run. As far as short-run adjustments are concerned, Bangladesh have shown significant adjustment to Thailand as well as to Vietnam prices of rice. The speed of adjustment of Bangladesh market is higher in response to the changes in Vietnam market prices compared to Thai market prices, especially when the shock is higher than the second threshold. Indian rice markets have shown a very low speed of adjustment of about six percent in

response to shocks in Thailand rice prices. There is no significant speed of adjustment from the Indian rice market as a result of a shock in the Vietnam market which implies that the domestic market of India is not well integrated with its international counterparts.

TVECM estimations for Pakistan-Thailand and Pakistan-Vietnam market pairs display that the speed of adjustment from Pakistani rice market is statistically significant in the lower regime only, with 22 percent for Thailand market prices. While, the shock in the Vietnam market is adjusted in the upper regime only with about 36 percent. It can be said that rice markets of Bangladesh and Pakistan are integrated with the world markets not only in the long run but also in the short run.

Broadly speaking, six main conclusions can be drawn from this study. First, regional wheat and rice markets of Pakistan are very well integrated in the long run as well as in the short run. Second, South Asian wheat markets are well integrated in the long run with each other, but only partially integrated in the short run. Third, domestic wheat markets of South Asia are also only integrated in the long run with international wheat prices, but in the short run Bangladesh and India can be termed as isolated from the world market, whereas the wheat market of Pakistan is partially integrated with the international market used in this study. The low degree of integration of South Asian markets with the international market might be due to high government interventions in the wheat sector in South Asia. Fourth, rice markets of South Asia are well integrated in the long run only. Bangladesh and Indian rice markets seem to be isolated in the short run. Only the Pakistani market is integrated in the short run with Bangladesh as well as with India. Fifth, rice markets of South Asia are integrated with the international markets in the long run, but the speed of adjustment in the short run is either slow or it adjusts only with the time lags, which means that it takes some time to form a new equilibrium or to absorb the shock. Especially the Indian market is less integrated in the short run with international markets. Bangladesh seems to be more integrated, due to its higher imports of rice

from major exporters of rice, like India, Pakistan, Thailand and Vietnam. An important sixth conclusion is that TVECM provides better insights and the inferences drawn from this model are plausible as compared to linear VECM.

Interventions of the respective governments in the food markets of South Asia appear to be one of the causes of low degree of integration in the short run of wheat and rice markets of South Asia with each other and with their respective international prices. Although these policies are implemented with intentions to stabilize prices and ensure food security, by protecting their producers through support price policy and consumers through subsidizing wheat flour. But actually, these protectionists policies are impediments to the efficient market functioning. It is therefore suggested that interventions of the respective governments should be reduced, the private sector should be encouraged to actively participate in the efficient functioning of markets. Trade within South Asia should be encouraged and facilitated. This will reduce the fiscal burden of the respective economies and trade with neighboring countries at lower cost rather than with more distant countries at higher costs. This will not only stabilize the prices in the region, but will also be helpful in ensuring food security in the region.

Appendix A

Appendices

Note: Negative values in these tables show the deficit and positive show the surplus amount in surplus/deficit column. Here consumption includes not only food but seed, processing, waste as well as other uses like other products etc. Production includes only wheat or rice produced in the country. Column six provides the amount of available stock at the beginning of the year.

Table A.1: Production, Utilization and Surplus or Deficit of Wheat in Bangladesh in Thousand Tonnes from 2001 to 2013

BANGLADESH						
Year	Production	Consumption	Surplus /deficit	Import Quantity	Stock Variation	Export Quantity
2001	1673	3245	-1572	2513	-941	0
2002	1606	3732	-2126	1661	465	1
2003	1507	3677	-2170	2401	-230	1
2004	1253	3758	-2505	2087	418	1
2005	976	3582	-2606	2122	486	3
2006	735	3280	-2545	2152	395	3
2007	737	2971	-2234	2721	-484	3
2008	844	2958	-2114	1337	781	5
2009	849	3094	-2245	2415	-164	6
2010	901	3227	-2326	3213	-880	8
2011	972	3394	-2422	3118	-685	11
2012	995	3357	-2362	2094	280	13
2013	1255	3497	-2242	2882	-627	13

Source: FAOSTAT. Available at: `http://faostat3.fao.org/download/FB/FBS/E`, last accessed on 20th May 2015.

Table A.2: Production, Utilization and Surplus or Deficit of Wheat in India in Thousand Tonnes from 2001 to 2013

INDIA						
Year	Production	Consumption	Surplus /deficit	Import Quantity	Stock Variation	Export Quantity
2001	69681	71676	-1995	10	5000	3016
2002	72766	72527	239	48	4000	4288
2003	65761	69952	-4191	47	9000	4856
2004	72156	71008	1148	114	940	2202
2005	68637	68833	-196	47	1016	867
2006	69354	74147	-4793	6093	-1138	162
2007	75807	77373	-1566	2690	-996	128
2008	78570	80421	-1851	14	2000	163
2009	80679	79214	1465	180	-1500	146
2010	80804	82394	-1590	199	1550	158
2011	86874	81976	4898	17	-4130	784
2012	94880	81141	13739	15	-8713	5040
2013	93510	86372	7138	27	3	7168

Source: FAOSTAT. Available at: `http://faostat3.fao.org/download/FB/FBS/E`, last accessed on 20th May 2015.

Table A.3: Production, Utilization and Surplus or Deficit of Wheat in Pakistan in Thousand Tonnes from 2001 to 2013

PAKISTAN						
Year	Production	Consumption	Surplus /deficit	Import Quantity	Stock Variation	Export Quantity
2001	19024	19783	-759	149	1445	835
2002	18227	19528	-1301	267	2314	1280
2003	19183	19914	-731	150	2193	1612
2004	19500	20438	-938	109	1223	394
2005	21612	20933	679	1447	-1302	824
2006	21277	22137	-860	873	554	567
2007	23295	21361	1934	139	-993	1079
2008	20959	21978	-1019	1835	-469	346
2009	24033	23227	806	3104	-3750	160
2010	23311	23189	122	203	-296	28
2011	25214	23849	1365	63	2149	3577
2012	23473	24003	-530	97	1686	1253
2013	24231	24373	-142	421	668	946

Source: FAOSTAT. Available at: `http://faostat3.fao.org/download/FB/FBS/E`, last accessed on 20th May 2015.

Table A.4: Production, Utilization and Surplus or Deficit of Rice in Bangladesh in Thousand Tonnes from 2001 to 2013

BANGLADESH						
Year	Production	Consumption	Surplus /deficit	Import Quantity	Stock Variation	Export Quantity
2001	24191	25949	-1758	151	1608	1
2002	25075	26416	-1341	939	403	1
2003	25587	27222	-1635	1246	389	0
2004	24169	27240	-3071	987	2084	0
2005	26544	27085	-541	705	-159	4
2006	27196	27673	-477	577	-83	16
2007	28802	28848	-46	616	-551	19
2008	31177	29045	2132	838	-2962	8
2009	32112	29226	2886	43	-2924	5
2010	33391	29558	3833	680	-4509	4
2011	33768	29857	3911	1310	-5221	1
2012	33681	30164	3517	39	-3556	1
2013	34350	30432	3918	260	-4177	1

Source: FAOSTAT. Available at: `http://faostat3.fao.org/download/FB/FBS/E`, last accessed on 20th May 2015.

Table A.5: Production, Utilization and Surplus or Deficit of Rice in India in Thousand Tonnes from 2001 to 2013

INDIA						
Year	Production	Consumption	Surplus /deficit	Import Quantity	Stock Variation	Export Quantity
2001	93313	81697	11616	28	-9425	2220
2002	71856	80298	-8442	45	13475	5078
2003	88570	81123	7447	30	-4055	3422
2004	83173	84446	-1273	39	6055	4821
2005	91839	87772	4067	32	0	4100
2006	92804	88062	4742	31	0	4773
2007	96428	89960	6468	22	0	6490
2008	98740	92237	6503	12	-4000	2514
2009	90494	92354	-1860	41	4000	2181
2010	96023	94270	1753	11	500	2264
2011	105319	95287	10032	12	-5000	5045
2012	105253	94756	10497	4	0	10501
2013	106186	94854	11332	5	0	11337

Source: FAOSTAT. Available at: `http://faostat3.fao.org/download/FB/FBS/E`, last accessed on 20th May 2015.

Table A.6: Production, Utilization and Surplus or Deficit of Rice in Pakistan in Thousand Tonnes from 2001 to 2013

PAKISTAN						
Year	Production	Consumption	Surplus /deficit	Import Quantity	Stock Variation	Export Quantity
2001	3884	2654	1230	14	1171	2415
2002	4481	2498	1983	14	-318	1680
2003	4850	3046	1804	5	6	1815
2004	5027	2975	2052	1	-236	1817
2005	5550	2440	3110	1	-228	2883
2006	5441	2121	3320	3	353	3676
2007	5566	2664	2902	5	212	3120
2008	6955	2905	4050	5	-1256	2800
2009	6893	3360	3533	6	-798	2740
2010	4826	2874	1952	3	2204	4159
2011	6132	2815	3317	25	53	3396
2012	5511	2869	2642	13	752	3408
2013	6767	2940	3827	63	-92	3799

Source: FAOSTAT. Available at: `http://faostat3.fao.org/download/FB/FBS/E`, last accessed on 20th May 2015.

Table A.7: TVECM Results of Wheat Markets of Pakistan

Market pairs	Regimes	Speed of adjustment	Constant	P_{1t-1}	P_{2t-1}
	Lower	-0.098	0.010*	0.081	-0.039
	Regime	0.124*	0.011**	-0.043	0.270***
LLHR	Middle	-0.142	0.004	0.627**	-0.177
LHYD	Regime	-0.459	0.017	0.095	-0.105
	Upper	-0.686***	0.036**	0.029	0.011
	Regime	-0.343*	0.036**	-0.101	0.349
	Lower	-0.324	0.004	-0.319	0.221
	Regime	0.651***	0.024**	-0.355**	0.346**
LLHR	Middle	-0.219	0.012**	0.253**	0.085
LMLTN	Regime	0.196	0.005	0.128	0.294***
	Upper	0.188	-0.022	0.044	0.237
	Regime	0.369**	-0.029**	0.262**	0.195
	Lower	0.022	0.014***	0.032	0.130
	Regime	0.402***	0.023***	-0.120	0.402***
LLHR	Middle	0.065	-0.005	0.231	-0.283*
LPINDI	Regime	0.387	-0.009	0.463*	-0.311*
	Upper	-0.089	0.004	0.222	0.159
	Regime	0.156	0.004	-0.152	0.283*
	Lower	-0.029	0.008	0.270**	0.047
	Regime	0.094	0.007	0.110	0.237***
LLHR	Middle	0.082	0.001	-0.170	-0.299**
LPSHWR	Regime	0.152	0.004	-0.298	0.018
	Upper	-0.292***	0.039***	0.343***	0.009
	Regime	-0.070	0.018*	0.200*	0.252*
	Lower	-0.190	-0.004	-0.202	0.333**
	Regime	1.115***	0.097***	0.069	0.248*
LHYD	Middle	-0.019	0.006**	0.052	0.197**
LMLTN	Regime	0.1834***	0.003	-0.218**	0.604***
	Upper	-0.361**	0.032*	0.283***	-0.113
	Regime	0.004	0.016	0.170*	0.039

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Market pairs	Regimes	Speed of adjustment	Constant	P_{1t-1}	P_{2t-1}
	Lower	-0.492***	-0.015*	0.284*	0.023
	Regime	-0.263	-0.022**	0.151	0.094
LHYD	Middle	0.019	0.007*	0.124	0.077
LPINDI	Regime	0.041	0.009*	-0.141	0.512***
	Upper	-0.118	0.017	-0.021	-0.029
	Regime	0.237*	-0.013	-0.010	0.044
	Lower	-0.016	0.007	0.181	0.036
	Regime	0.250***	0.011**	-0.366***	0.569***
LHYD	Middle	-0.063	0.010	0.392**	-0.216*
LPSHWR	Regime	-0.257	0.023	-0.130	-0.118
	Upper	-0.310***	0.045***	0.120	-0.043
	Regime	-0.125	0.029**	0.189*	0.135
	Lower	-0.283	-0.004	0.338**	0.121
	Regime	0.801***	0.057**	0.292	0.240
LMLTN	Middle	0.296**	0.003	0.443***	-0.034
LPINDI	Regime	0.641***	0.002	0.198*	0.246***
	Upper	0.043	0.006	0.041	0.080
	Regime	0.369***	-0.003	-0.178	0.123
	Lower	-0.099***	-0.002	0.366***	-0.078
	Regime	0.031	0.002	-0.013	0.192**
LMLTN	Middle	-0.103	0.017	0.037	0.422***
LPSHWR	Regime	-0.198	0.011	0.345	0.461**
	Upper	-0.235**	0.030***	0.366***	-0.105
	Regime	-0.213*	0.045***	0.222	-0.049
	Lower	-0.126*	-0.011	0.249***	0.020
	Regime	0.034	-0.000	-0.079	0.351***
LPINDI	Middle	-0.928**	-0.017	-0.059	0.313**
LPSHWR	Regime	-1.165**	-0.017	0.063	-0.048
	Upper	-0.207***	0.018***	0.142	0.147
	Regime	-0.041	0.015**	0.054	0.104

Here: *,** and *** show the significance at 10, 5 and 1 percent.
Source: Own calculations.

Table A.8: TVECM Results of Rice Markets of Pakistan

Market pairs	Regimes	Speed of adjustment	Constant	P_{1t-1}	P_{2t-1}
LLHR LHYD	Lower	-0.615***	-0.095***	0.011	0.108
	Regime	0.271***	0.039**	0.241***	0.431**
	Middle	0.059	0.012*	0.176	-0.034
	Regime	0.005	0.005	0.032	0.323***
	Upper	-0.070	0.017	0.333***	0.953***
	Regime	0.009	0.011	0.014	0.116
LLHR LMLTN	Lower	0.002	0.025	-0.241***	0.010
	Regime	0.237***	0.079***	-0.073	0.352***
	Middle	-0.121	0.011*	0.136	0.135
	Regime	0.017	0.005	0.024	0.372***
	Upper	0.036	-0.023	0.594***	-0.266*
	Regime	0.047	0.000	0.043	0.342***
LLHR LPINDI	Lower	0.079**	0.043***	-0.484***	0.060
	Regime	0.160***	0.041***	-0.039	0.524***
	Middle	-0.101*	0.009**	0.346***	0.097
	Regime	-0.026	0.008*	0.099	0.130
	Upper	-0.187**	0.037*	-0.162	1.629***
	Regime	-0.037	0.014	0.035	0.140
LLHR LPSHWR	Lower	0.032	0.019	-0.501***	0.036
	Regime	0.173***	0.050***	-0.027	0.270**
	Middle	0.005	0.021***	0.500***	0.001
	Regime	0.369**	-0.008	0.128	0.350***
	Upper	-0.162***	0.026***	0.268***	0.061
	Regime	-0.038	0.018**	0.156*	-0.094
LLHR LQUETTA	Lower	-0.019	0.020	-0.171**	0.025
	Regime	0.056*	0.017*	-0.030	0.222***
	Middle	0.052	0.013	0.227**	0.263
	Regime	-0.063	-0.003	0.081	1.214***
	Upper	-0.010	-0.014	0.555***	-0.229
	Regime	0.034	0.003	0.149	-0.252***
LLHR LSUKKUR	Lower	-0.035	0.016	-0.216***	0.001
	Regime	0.265***	0.068***	-0.156*	0.161*
	Middle	0.009	0.011*	0.188*	0.064
	Regime	-0.146	-0.001	0.170*	-0.064
	Upper	-0.017	-0.005	0.551***	-0.284**
	Regime	0.039	0.011	-0.003	0.169

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Market pairs	Regimes	Speed of adjustment	Constant	P_{1t-1}	P_{2t-1}
	Lower	-0.059	0.009	0.306***	0.109**
	Regime	0.204***	0.029***	-0.213*	0.426***
LHYD	Middle	0.538*	-0.003	-0.570*	0.050
LMLTN	Regime	0.743*	-0.003	0.424	0.363**
	Upper	-0.054*	0.012*	0.067	0.120*
	Regime	0.042	0.003	-0.197	0.388***
	Lower	0.015	0.023*	0.279***	0.222***
	Regime	0.289***	0.061***	0.027	0.519***
LHYD	Middle	-0.032	0.006*	0.167*	-0.012
LPINDI	Regime	0.058	0.007	-0.147	0.275***
	Upper	-0.152**	0.035**	0.086	0.278**
	Regime	0.128	-0.016	-0.025	0.299**
	Lower	-0.072*	0.002	0.498***	-0.012
	Regime	0.211***	0.058**	-0.046	0.275***
LHYD	Middle	-0.001	-0.008	0.145	0.379***
LPSHWR	Regime	-0.222	-0.022	-0.077	0.160
	Upper	-0.069**	0.012**	0.068	-0.064
	Regime	-0.007	0.010*	0.139	0.055
	Lower	-0.021	0.009	0.397***	-0.006
	Regime	0.142***	0.013*	-0.169	0.352***
LHYD	Middle	0.109	0.001	0.118	-0.094
LQUETTA	Regime	0.016	0.012	0.315**	-0.024
	Upper	-0.033	0.010	0.141	0.058
	Regime	0.135***	-0.013	0.120	0.023
	Lower	-0.016	0.021**	0.426***	-0.040
	Regime	0.232***	0.044***	-0.235	0.083
LHYD	Middle	0.342**	0.016***	-0.049	0.043
LSUKKUR	Regime	-0.288	-0.005	0.561**	0.428***
	Upper	-0.078*	0.009*	0.168**	0.111
	Regime	0.025	0.011	-0.046	0.136
	Lower	-0.139*	0.005	0.549***	0.056
	Regime	0.097	-0.000	0.073	0.119
LMLTN	Middle	-0.482	0.025**	0.623***	0.456***
LPSHWR	Regime	-0.483	0.026**	0.260*	0.777***
	Upper	-0.070	0.003	0.047	0.165
	Regime	-0.095	0.036***	0.002	-0.215**

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Market pairs	Regimes	Speed of adjustment	Constant	P_{1t-1}	P_{2t-1}
	Lower	-0.204**	0.003	0.436***	0.015
	Regime	0.045	0.002	0.262***	0.186**
LMLTN	Middle	1.349	-0.024	0.385*	0.289
LPINDI	Regime	1.219	-0.021	0.328*	0.552**
	Upper	0.084	-0.029**	0.433***	-0.279**
	Regime	0.339***	-0.016	0.300***	0.145
	Lower	-0.122*	0.001	0.467***	0.036
	Regime	0.222***	0.020***	0.015	0.305***
LMLTN	Middle	-0.696	0.022	-0.237	0.118
LQUETTA	Regime	0.029	0.008	-0.054	0.355**
	Upper	-0.025	-0.000	0.440***	-0.192*
	Regime	0.360***	0.009	-0.487***	-0.281***
	Lower	0.003	0.011***	0.442***	0.071
	Regime	0.169***	0.000	0.188**	0.283***
LMLTN	Middle	1.278**	-0.162**	0.226	-0.170
LSUKKUR	Regime	1.783***	-0.194***	-0.285	-0.256**
	Upper	-0.468**	0.098**	v0.349***	0.224
	Regime	-0.063	0.033	0.590***	-0.193
	Lower	-0.365***	-0.052***	0.312**	0.563***
	Regime	-0.118	-0.039**	-0.245	0.482***
LPINDI	Middle	-0.095	0.003	0.346***	-0.009
LPSHWR	Regime	0.250***	0.009**	-0.059	0.142
	Upper	-0.206*	0.029	0.100	0.283**
	Regime	-0.125	0.043*	0.128	-0.210
	Lower	0.273*	0.121***	0.596***	-0.210
	Regime	0.071	-0.018	-0.222*	0.454***
LPINDI	Middle	-0.121*	0.002	0.466***	-0.032
LQUETTA	Regime	0.136***	0.002	-0.008	0.331***
	Upper	-0.101	0.056**	0.342**	-0.146
	Regime	0.600***	-0.099***	-0.343***	-0.286***

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Market pairs	Regimes	Speed of adjustment	Constant	P_{1t-1}	P_{2t-1}
	Lower	-0.058	0.024	0.356***	0.040
	Regime	0.032	-0.013	-0.298**	0.166
LPINDI	Middle	-0.169	0.006	0.208*	0.006
LSUKKUR	Regime	0.317*	-0.002	0.027	0.541***
	Upper	-0.101	0.012	0.398***	0.151*
	Regime	0.131	0.002	0.098	-0.051
	Lower	-0.064	0.001	0.019	0.067
	Regime	0.075**	0.011**	0.135*	0.416***
LPSHWR	Middle	-0.173	0.014	0.154	-0.116
LQUETTA	Regime	0.459	0.000	-0.098	0.085
	Upper	0.028	-0.008	0.245**	-0.067
	Regime	0.394***	-0.012	-0.494***	-0.028
	Lower	-0.219**	-0.020	0.074	-0.163
	Regime	-0.200	-0.035	0.074	-0.224*
LPSHWR	Middle	-0.460	-0.026	1.281***	0.290**
LSUKKUR	Regime	0.833	0.079	0.015	0.387**
	Upper	-0.121**	0.007*	0.103	0.077
	Regime	0.186***	0.008	0.162**	0.178**
	Lower	-0.358***	-0.020*	-0.010	-0.427***
	Regime	-0.128*	-0.006	-0.122	-0.208*
LQUETA	Middle	-0.047	0.003	0.253***	0.123**
LSUKKUR	Regime	0.144*	0.003	0.250*	0.249***
	Upper	-0.094	0.020	0.174	0.165*
	Regime	0.584***	-0.068**	-0.251	0.266*

Here: *,** and *** show the significance at 10, 5 and 1 percent.
Source: Own calculations.

Table A.9: TVECM Results of Wheat Markets of South Asia and the USA

Market pairs	Regimes	Speed of adjustment	Constant	P_{1t-1}	P_{2t-1}
Bangladesh-India	Lower Regime	-0.074 0.216*	0.147*** 0.046	0.543*** 0.224*	-0.163 0.190
	Middle Regime	-0.305** 0.055	-0.012 -0.001	0.185 0.134*	0.097 0.327**
	Upper Regime	-0.145* -0.078	-0.031 0.008	0.675*** 0.104	0.354 0.231
Bangladesh-Pakistan	Lower Regime	0.048 0.033	0.003** 0.006	0.408*** 0.058	-0.237 0.210
	Middle Regime	0.023 0.035	-0.009 0.001	-0.411*** 0.071	-0.230 0.498**
	Upper Regime	-0.387 0.648***	0.124 -0.177***	0.625** -0.030	-0.086 0.267*
Bangladesh-US HRW	Lower Regime	-0.144 0.207	-0.048 0.018	0.557*** -0.404	0.144 0.466***
	Middle Regime	-0.097 1.191***	0.018 0.100***	-0.151 -0.100	0.228** 0.497***
	Upper Regime	-0.057 0.119	-0.001 -0.010	0.406*** 0.103	0.312*** 0.185
India-Pakistan	Lower Regime	-0.071** 0.000	-0.001 0.001	0.387*** 0.009	0.124 0.150
	Middle Regime	-0.157 -0.103	0.011 -0.003	0.021 -0.050	0.282* 0.890***
	Upper Regime	-0.267*** -0.325***	0.046** 0.079***	0.186 -0.013	0.102 0.249*
India-US HRW	Lower Regime	0.062 0.375***	0.015 0.096***	0.171 -0.098	0.166*** 0.359***
	Middle Regime	-0.051 0.090	0.006 -0.001	0.261** 0.033	0.082 0.280**
	Upper Regime	-0.067 -0.131	0.012 0.064)**	0.393** 0.149	-0.015 0.433
Pakistan-US HRW	Lower Regime	-0.162*** 0.307**	-0.041** 0.095***	0.163 -0.095**	0.067 0.423***
	Middle Regime	-0.192 1.129**	-0.014 0.147**	0.112 0.114	-0.093 0.423
	Upper Regime	-0.021 0.032	0.004 0.007	0.475*** 0.022	0.040 0.186

Here: *,** and *** show the significance at 10, 5 and 1 percent.

Source: Own calculations.

Table A.10: TVECM Results of Rice Markets of South Asia, Thailand and Vietnam

Market pairs	Regimes	Speed of adjustment	Constant	P_{1t-1}	P_{2t-1}
Bangladesh-India	Lower Regime	0.005 -0.036	0.013* -0.004	0.439*** -0.066	0.181 0.062
	Middle Regime	1.113 -0.011	-0.049 0.005	0.354 0.149	1.157** 0.278
	Upper Regime	0.059 -0.034	0.001 0.008	0.004 0.071	0.151 0.045
Bangladesh-Pakistan	Lower Regime	-0.060 0.386***	-0.008 0.079*	0.059 -0.295	-0.190 0.594***
	Middle Regime	-0.050 0.120**	0.002 0.003	0.396 -0.063	0.219** 0.588***
	Upper Regime	-0.183*** 0.168**	0.066** -0.059**	-0.112 -0.163	-0.569*** 0.449**
Bangladesh-Thailand	Lower Regime	-0.195* 0.016	-0.069* -0.004	0.408** 0.392**	-0.282*** 0.151
	Middle Regime	-0.040 0.078	-0.008 0.011	0.563*** -0.110	0.314** 1.280***
	Upper Regime	-0.043* -0.008	0.015* 0.009	0.086 0.192**	0.139 0.395***
Bangladesh-Vietnam	Lower Regime	-0.075 0.486***	-0.025 0.176***	0.545*** -0.081	-0.088 0.770***
	Middle Regime	-0.045 0.129**	0.001 0.015**	0.301*** 0.168	0.164*** 0.453***
	Upper Regime	-0.302*** 0.069	0.083*** -0.016	-0.110 -0.023	-0.575*** 0.436**
India-Pakistan	Lower Regime	0.019 0.146***	0.010 0.023	0.118 0.081	-0.035 0.715***
	Middle Regime	-0.030 0.705***	0.005 0.041**	0.548** 0.947**	0.066 0.241
	Upper Regime	-0.106*** 0.010	0.014*** 0.006	-0.073 0.307*	-0.064 0.380***

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Market pairs	Regimes	Speed of adjustment	Constant	P_{1t-1}	P_{2t-1}
India-Thailand	Lower	0.013	0.006	0.073	-0.159***
	Regime	0.186***	0.055	0.671***	0.578***
	Middle	0.032	0.008	0.277*	-0.131
	Regime	0.099	-0.006	0.755***	0.624***
	Upper	-0.057**	0.013**	-0.086	0.085
	Regime	-0.030	0.014*	0.120	0.400**
India-Vietnam	Lower	0.013	0.006	0.143	-0.046
	Regime	0.126***	0.022	0.486*	0.692***
	Middle	-0.041	0.007**	0.181	-0.008
	Regime	0.143	0.015**	0.369	0.203*
	Upper	-0.051	0.002	-0.325*	-0.012
	Regime	0.044	-0.005	0.023	0.407*
Pakistan-Thailand	Lower	-0.221**	0.015	0.253*	0.162
	Regime	-0.037	-0.004	0.061	0.259**
	Middle	-0.446	0.009	0.545***	0.743***
	Regime	0.387	-0.007	0.406**	0.842***
	Upper	-0.183	0.019	0.367**	0.152
	Regime	0.154	-0.022	0.146	0.214
Pakistan-Vietnam	Lower	0.062	-0.007	0.230*	0.486***
	Regime	0.973***	0.106**	-0.187	0.924***
	Middle	-0.211	-0.001	0.392**	0.196**
	Regime	0.051	-0.007	0.089	0.496***
	Upper	-0.362**	0.032**	0.372**	0.119
	Regime	0.148	0.011	0.111	0.151
Thailand-Vietnam	Lower	-0.095	0.003	-0.058	0.686***
	Regime	0.503*	0.081	-0.360	1.151***
	Middle	-0.223**	-0.013	0.331***	0.172*
	Regime	0.095	0.008	0.362**	0.452***
	Upper	-0.108	0.061	0.573*	-0.285
	Regime	0.340	0.234**	-0.038	0.475*

Here: *,** and *** show the significance at 10, 5 and 1 percent.
Source: Own calculations.

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