CHAPTER III

MARKETING EFFICIENCY AND MARKET INTEGRATION

HYPOTHESES – A THEORETICAL FRAMEWORK

Introduction

The concepts of ‘integrated market’ and ‘efficient market’ are used interchangeably. To have a better understanding of the concepts of marketing efficiency and market integration, it is necessary to know the concepts of ‘market’, ‘integration’ and ‘efficiency’ and the way in which these are interrelated. Generally market is any region in which the buyers and sellers interact each other, in which the price of a good tends to uniformity. Usually, price prevailing in the market depends on the extent of market; which in turn depends on the nature of competition or efficiency prevailing in the market.

The extent of competition or marketing efficiency in its turn depends on the market structure, market conduct and market performance. Marketing efficiency is determined by two factors – economic efficiency and technical efficiency. Economic efficiency deals with matters related to trading or pricing to enhance the degree of competition. Technical efficiency on the other, tries to apply the least cost input combination.

There are two criteria to measure marketing efficiency. One is price spread and the other is market integration. A brief account of the methods to measure price spread will be dealt in this chapter. Besides, a detailed analysis
of various statistical and econometric tools employed by earlier authors to measure the degree of market integration will also be made. Hence, the present chapter is intended to examine these concepts in its theoretical and empirical perspective. Besides, it also attempt to identify the limitations of earlier methodology and the course of future study.

**Concept of Market**

For conceptual clarity of the term 'market', let us briefly discuss some of the important definitions of market. These definitions in general, can be categorized into three on the basis of the emphasis they were given. The first one emphasizes the existence of a public place for transaction. The term market is a derivative of a Latin word 'mercatus' to denote a market place – thereby meaning merchandise, trade or a place where business is conducted (Gravin, 1929). According to Jevons, “the central point of market is a public exchange mart or auction rooms, where the traders agree to meet to transact business… the traders may be spread over a whole town or region of country, and yet make a market, if they are by means of fairs, meetings, published price lists, the post office or other wise in close communication with each other” (Quoted from Marshall, 1961). Cochrane (1957) observes that market is some sphere or space, where the forces of demand and supply were at work, to determine or modify price since the ownership of some quantity of a good, or service was transferred and certain physical and institutional arrangements might be in evidence.
The second category undermines the need for any specific location or space. According to Cournot (1971) "not any particular market place in which things are bought and sold, but the whole of any region in which buyers and sellers are in such free intercourse with one another that the prices of the same goods tend to equality easily and quickly". Bliss and Stern (1982) opined that market refers to exchange of the services of factors take place and the arrangements in force for organizing that exchange. There is no implication that the market is in any sense a formal one with a specified location; still is there any suggestion that the market is perfect or competitive. According to Stonier and Hague (1982) market is "any organization whereby the buyers and sellers of a good are kept in close touch with each other, whenever the market is open, either because they are in the same building or because they are able to talk by telephone at a moment's time".

Other than the existence of location or space; the third set of definitions give emphasis on the prevailing price out of the interactions of agents. Hotelling (1929) in analyzing the relationship between prices in competing markets; focuses on market for identical goods separated by distance. Stigler (1969) defined market as "the area within which the price of a good tends to uniformity, allowance being made for transportation costs". An observation on similar line was made by Cournot (1971), shortrun deviations of prices are allowed in this definition, but arbitrages or substitutability insure that they are related in the long term. "A market is a group of people and firms who are in
contact with one another for the purpose of buying and selling some commodity. It is not that every members of the market may be in contact with every other one; the contact may be indirect” (Dorfman, 1979).

Though there are some differences in defining the term market among economists, one can observe that the basic requirement for a market is that trading or exchange should take place between buyers and sellers. It may be direct or indirect, may be in a small region or the entire globe; may be of visual contact or invisible contact. In our analysis, we use the term market as defined by Stigler. In this definition by making due allowance for transportation cost, the existence of a unified price got prominence. Hence, price is the villain of market; and it depends on the extent of market.

**Extent of the Market**

One of the prominent roles of market is to facilitate exchange between buyers and sellers. Stigler maintains that market area embraces the buyers who are willing to deal with any seller, or the seller who are willing to deal with any buyer or both. It can be maintained that the actual test of market is the uniformity of price movements within the market. This criterion encompasses the crucial role of competition in dominating the price movements within each section of the market.

The idea of exchange and price formation will be clear by observing the view of Stigler and Sherwin (1985). "It is inherent in any exchange, whether of one good for another good or for money, that there be a rate of exchange
between the quid and the quo; a quantity of something is exchanged for a quantity of something else. Therefore to say that a market facilitates the making of exchange is equivalent to saying that markets are where prices are established. One may quote a price for a commodity on the moon if one is visiting that celestial body, but one can only establish a price by making a trade. The market is the area within which price is determined: the market is that set of suppliers and demanders whose trading establishes the price of a good”.

The organizational structure of market strongly determines the process by which prices and output are determined in the real world. Koutsoyiannis (1979) has suggested three basic criteria for market classification. They are product, substitutability and interdependence criterion. Bain has suggested another criterion for market classification, namely the condition of entry, which measures the ease of entry in various markets.

Harris, (1984) opined that the analysis of the structure of commodity markets normally proceeds down a list of characteristics of their organisation: size, distribution, location, entry condition, agent and product differentiation, information and so on. She observes that the numerical size of the sector and its concentration are the two structural aspects most important for the analysis of mercantile power. Salvalore (1998) identifies four different types of market organizations.
(a) Perfect competition at one extreme
(b) Monopoly at the opposite extreme
(c) Monopolistic competition and
(d) Oligopoly in between

However, it can be maintained that the actual market power depends on the competition or monopoly power. The tilt of this power determines the benefits either to the buyer or to the seller. Competitive power is one of the basic criteria to distinguish various forms of market. To understand the extent of competition or efficiency, it is necessary to know the structure of market.

Market Structure

The extent of market depends on several factors. According to Bain, (1968) three distinct approaches can be followed to understand the extent of competition or marketing efficiency in the marketing system. They are:

(i) market structure,
(ii) market conduct, and
(iii) market performance.

Seller concentration, firm’s size, buyer concentration and entry conditions are the basic elements of market structure. These elements in one way or the other influence market integration. Seller concentration or buyer concentration inhibits the free flow of goods and services among markets. This in turn distorts the spirit of a unified or integrated market. Similarly if the
entry condition is restricted, the biggest firm may control the entire market and this lead to weakly integrated markets. Thus, these elements of market structure affects the degree of competition in the market and that in turn influence the magnitude of market integration. Therefore the degree of market integration is determined by the structure of market.

Bain refers by the term market structure to "those characteristics of the organization of a market which seems to influence strategically the nature of competition and pricing within the market". The characteristics of market organization emphasized were the degree of seller concentration, size of the distributing firms, degree of buyer concentration, degree of product differentiation and the condition of entry in the market. The views of George and Singh (1970), Garoian (1971), Purcell (1973), Caves (1977), Dahl and Hammond (1977) and Bhide, et. al (1981) were the same as that of Bain (1968).

However, the above views are not able to highlight the significance of various marketing channels and intermediaries in analyzing the market structure. In the view of Schultz (1946) market structure, includes all the strategic variables, which control or influence the behaviour of different agencies involved in the market.

An all-encompassing version was given by Cundiff and Still (1972). To them, market structure was the whole net work of marketing institutions that serviced society's needs. At one end of the network, producers initiated the
flow of goods and services and various intermediaries such as wholesalers and retailers maintained the flow, finally discharging the goods and services for consumer's use. To Lele (1973) market structure included various market channels, intermediaries, and traders involved in moving the produce from producers to the consumers.

According to George (1984) market structure could be defined as all the agencies involved either vertically or horizontally in the selling and buying of the produce. It includes different marketing channels, their form and market shares and the market environment.

Thus, the market structure through various marketing channels influences the nature of competition and pricing within the market through the intermediaries. However, it is in the market structure that the market agents has to function. And it is the structure that determine the behaviour of the market i.e.; conduct of the market.

**Market Conduct**

By 'market conduct' we mean the behaviour of market agents with regard to price determination, sales promotion tactics and the regulatory activities of government. Market integration has a direct link with all these actions and hence on market conduct. If market agents determine prices on the basis of some collusive tactics, it will lead to an inefficient, non-integrated market. On the other hand if price is determined in the way of a perfectly competitive market, it resembles an integrated market. Similarly, regulatory
actions of government also determines the market conduct and thus market integration. Government restriction and regulation hampers dissemination of market information and it will lead to distorted price determination by the economic agents. This ultimately caters to an inefficient and non-integrated market. On the other hand, the behaviour of economic agents in an economy which is liberated from controls will be conducive for an efficient and well integrated market.

In the opinion of Bain (1968), market conduct refers to the pattern of behaviour followed by the enterprise in adopting or adjusting to the markets in which they sell or buy, in particular methods employed to determine prices, sales promotion and co-ordination policies and the extent of predatory or exclusionary tactics directed against established rivals or potential entrants. According to Moore, et. al. (1973) market conduct comprises several methods practised by traders to attract the customers in their fold. It includes several price competition methods and non – price inducements. According to Purcell (1973) market conduct refers to the actions and behaviour of firms within the given structure. Pricing policies, selling cost, non-price competition are all some of the activities of market conduct.

Hence, market conduct resembles the behavioural pattern of enterprise. It comprises of various decision making techniques of firm in determining price, output, sales promotion policies and other tactics to achieve their economic goals. Thus, given the structure of the market, market conduct
determines the outcome. The result of market behaviour of market agents in fact resembles market performance.

**Market Performance**

The economic result of market structure and market conduct represents market performance. Market performance resembles price level, profit margin, level of investment, reinvestment of profit etc. In an economy, if the price fixed by the firm is just equal to average cost (the condition in perfect competition), the market is said to be performing well or efficient or is called a well integrated one. Similarly, a less profit margin, normally indicates an efficient market performance. In other words, through the level of prices, the level of profit margin etc., one can determine the degree of market integration. Therefore, market performance has a direct bearing on market integration.

In the view of Bain (1968), market performance deals with the economic results that flow-from the system in terms of its pricing efficiency, its flexibility to adopt to new changing situation etc. It represents the economic results of the structure and conduct.

According to Narver and Savitt (1971), marketing performance was the net result of the conduct and was measured in terms of net profits, rate of return on owner’s equity, efficiency with which plant, equipment and other resources were used and so on. Stiefel’s (1976) analysis of market performance is in relation to its structural conditions and conduct with regard to pricing and product policies.
From the above observations it can be maintained that market performance is the combined result of market structure and market conduct. Marketing performance has several connotations. As pointed out by Narasimham (1994), to study the extent of competition, in marketing a commodity, market performance approach seems to be more appropriate. In other words, one can say that marketing performance actually percolates marketing efficiency. To Shrivastava (1996), if the structure, conduct and performance of the marketing system bears a proof about the efficiency, it will percolate in the form of greater income, saving, capital formation and investment. In this context it is pertinent to understand the concept of marketing efficiency.

**Marketing Efficiency**

Marketing efficiency is considered to be a pre-requisite for prompt delivery of goods. Prompt delivery of good at a reasonable price is possible only if the market works in a competitive way. Competitive mechanism is possible only when the market agents are free to exercise their actions. An efficient marketing system implies that price spread or marketing margin is fairly less. In market integration terminology, prices in spatially separated markets will get differed only by transaction costs among markets. Lower price spread also implies that both consumers and producers are gaining from affordable price and reasonable profit. Hence, an efficient marketing system implies the existence of market integration.
Experts have viewed the concept of marketing efficiency in different ways. A brief look at the views can be presented under three heads. They are (i) Maximization of input output ratio as a resemblance of marketing efficiency. (ii) Competition or effective market structure as an indicator of marketing efficiency and (iii) Lower price spread or marketing margin as a condition of marketing efficiency. The examination of these approaches are presented below:

(i) Maximization of input output ratio as a resemblance of marketing efficiency

Kohls' (1967) analysis was on the basis of optimizing behaviour of economic agents. It is the maximisation of input-output ratio, output being consumer’s satisfaction and input as labour, capital and management that marketing firms employed in the productive process.

(ii) Competition or effective market structure as an indicator of marketing efficiency

According to Clark (1954) the three components of effectiveness, cost and their effect on performance on marketing functions and services which in turn affect production and consumption constitute marketing efficiency. Jasdanwalla (1966) opined that marketing efficiency signifies the effectiveness or competence with which market structure performs its designated functions.
(iii) Lower price spread or marketing margin as a condition of marketing efficiency.

The higher the price spread, the greater the inefficiency in the marketing system and a minimum price spread denotes an efficient marketing system. One can consider a marketing system efficient if it performs the following functions – observes Singh, et. al (1987)

- An adequate marketable surplus to be ensured.
- Prevalence of lower price spread.
- Accessibility of agricultural inputs to be ensured to farmers at a reasonable price.

On the whole, there is no unanimity of opinion on the concept of marketing efficiency. Some are giving emphasis to raise output by lowering input. Here no specific analysis of price structure is made. In the second view, importance is given to elimination of wasteful marketing costs or competence of market structure. As per the third view, price spread is considered as an indicator of marketing efficiency and it is more realistic one. A regulated market with low marketing costs and marketing margin is said to be an efficient one. Marketing efficiency or the integrated marketing system also depends on market structure, the nature of commodity and the socio-political system. Price stability can also be considered as an indicator of efficient market system. Hence, it can be cited that there are several factors that determine marketing efficiency.
Determinants of Marketing Efficiency

Economic efficiency and technical efficiency are the two determinants of marketing efficiency. They are explained below:

(a) Pricing, Trading or Economic Efficiency:

Usually economic efficiency is a matter to be considered to enhance the conditions for competition and pricing of commodity in a market. Chahal and Gill (1991) observes that pricing or economic efficiency either relates to functional deficiencies or to the degree of competition or monopoly and to economic structure existing within the marketing system. To them in an efficiently operating market, prices will be related in the following manner.

(i) Prices should only differ (due to transportation costs) between geographic areas of a country,

(ii) The price of storable commodity at one point in time should not exceed price in a previous period of time by more than the cost of storage plus normal profit, and

(iii) The price of the processed products, should only exceed the price of unprocessed product by processing costs plus normal profit.

According to Lipsey and Harbury (1992) economic efficiency has two components. They are: (i) Productive efficiency, and (ii) Allocative efficiency. Productive efficiency is a situation when it is not possible to produce more of any one good without producing less of any other good. Allocative efficiency involves choosing between productively efficient bundles. Resources are said
to be allocatively efficient when it is not possible to produce a combination of goods different from that currently being produced, which will allow any one person to be made better off without making at least one other person worse off.

Thus, as the term denotes it concerns matters related to trading or pricing so as to enrich the degree of competition. When there is enrichment in the degree of competition, the possibility of price spread will be lower. Lower price spread ensures remunerative and affordable prices to various economic agents. Hence, effective measures of pricing efficiency ensures an efficient market system.

(b) Operational, Technical or Organisational Efficiency:

The emphasis of operational efficiency is on the cost of marketing inputs by keeping the cost of physical operations to the least possible. Brunk (1950) held that one of the primary purposes of marketing research is to find ways of increasing efficiency in the physical handling and processing of good. Lau and Yotopoulos (1971) defined technical efficiency as “a firm is considered more technically efficient than another if, given the same quantity of measurable inputs, it consistently produces a larger output”. To quote Henderson and Quandt (1971), the production function differs from the technology in that it presupposes technical efficiency and states the maximum output attainable from every possible input combination. The best utilization of every particular input combination is a technical, not an economic problem.
All these definitions are unanimous in pointing out that a technically efficient system should ensure least cost combination. And an ideal marketing system emanates from optimum marketing efficiency resulting from operational and economic efficiency. Hence, a market through economical and organizational efficiency tries to function effectively. If the organizational and pricing structure smoothens free flow of market information it will lead to an integrated market. Hence, marketing efficiency is concerned with enhancement of utility with the most efficient utilization of scarce resources available in the marketing system; which is the basic principle of economics.

**Measurement of Marketing Efficiency – Criteria**

Usually in the literature there are two criteria that can be used to measure marketing efficiency. One is price spread and the other is market integration.

**Price Spread**: A product has to pass through several distribution channels so as to reach to the consumer. Therefore, it is natural that every distribution channel require a fair share. Longer the channel greater will be the share of these intermediaries in the consumer’s price. Price spread is denoted as the difference between the price received by the producer and the price paid by the consumers for a commodity at a point of time. Lesser the difference; more efficient is the market system. If the intermediaries charge just the normal transaction costs, consumers in the central and peripheral markets can get the
article almost at the same price. If this is realizable, it is a situation of efficient marketing system or it characterizes an integrated market.

According to Dhondyal (1989) price spread simply compares the total value of the product that comes in the backdoor of the business with the total value of that which goes out of the front door. By distinguishing price spread from marketing margin, Dhondyal (1989) states that price spread can be within the same city but the marketing margin is a wider term which is used for various levels of outstation market also. The concept of price spread was conceptualized by George (1972) as the difference between the retail price of product and its value in production. The cost incurred and the profit gained by intermediaries are generally included i.e; charges for assembling, processing, storing, transporting, wholesaling and retailing. These definitions tries to give emphasis on the difference between what producers are able to get and what consumers are bound to pay. Hence, they are unanimous in portraying price spread as the charges spread among intermediaries.

Some of the statistical techniques used to measure the magnitude of price spread can be discussed below: The method followed by Hays and McCoy (1978) can be explained as

\[ PP_{i,j} = P_i - (HC_{i,j} + TC_{i,j} + AS_{i,j}) \]

where

- \( PP_{i,j} \) - parity price of one unit in the i th market in relation to j th market,
the actual retail price of one unit of the article at the i th market.

handling costs involved in moving one unit from the j th to the i th market.

transport cost for moving one unit from j th to the i th market, and

assembler’s charge in moving one unit from the j th to the i th market.

Now the actual price spread between any two markets would be

\[ PS_{ij} = PP_{ij} - P_i \]

where

- \( PS_{ij} \) - price spread for one unit between i th and j th market, and
- \( P_i \) - the actual retail price of one unit in j th market.

In a perfectly competitive market, where the product is moving from the j th to the i th market, \( PP_{ij} \) would always be equal to \( P_i \) and therefore, price spread would be zero. A positive price spread would provide an opportunity for traders to make abnormal profits.

The method followed by Hays and McCoy (1978) is simple in calculation. Almost all the intermediary charges are included in the calculation. Without deviating much from the above method, another way of calculation was used by Naik and Arora (1986). Concurrent method was used by Naik and Arora to compute the price spread. Before proceeding to compute the price spread, the following percentage share has to be obtained.
\[
PSRP_i = \frac{PR_i}{R_p} \times 100
\]

where

\(PSRP_i\) = Percentage share in retail price retained by the \(i\)th intermediary,

\(PR_i\) = Price retained by the \(i\)th intermediary, and

\(R_p\) = Retail price per unit

\[
PSCO_i = \frac{C_i}{R_p} \times 100
\]

\(PSCO_i\) = percentage share in retail price incurred as cost by the \(i\)th intermediary, and

\(C_i\) = the cost incurred by the \(i\)th intermediary per unit.

Now the percentage share in retail price retained as net margin (PSNM_i) or price spread

\[
PSNM_i = PSRP_i - PSCO_i
\]

Lower values of PSNM_i indicates higher marketing efficiency and vice versa.

The method suggested by Hays and McCoy (1978) is an all-encompassing one than by Naik and Arora (1986). In Hays’ method while computing price spread all sorts of transaction cost has taken into consideration. It indicates the actual share retained by the intermediaries after providing necessary allowances. However, both techniques assert that lower price spread indicates greater marketing efficiency. A zero price spread is the
optimum level in attaining highest marketing efficiency. But this is only a theoretical possibility which can be attained in a perfectly competitive market.

**Market Integration**

Before analyzing the concept of market integration; let us know what the notion of integration is? To integrate means unify into a whole. The economic implication of integration is that an element of efficiency is attainable in the unified operation than in the independent actions.

According to Mc Donald (1953) the integrated economy is one in which separated economic process is so functionally related to every other process that the totality of separate operation form a single unit of production with characteristics of its own. Mc Donald (1953) puts some of the manifestations of integration as

(a) Many diverse, specialized and independent economic processes or operations, none of which is complete or self sufficient.

(b) A system of relationship between the various processes which serves to register this interdependence upon the conduct of each process so that all are caused, in some manner to fall under the overall plan.

(c) A concatenation of processes in unified pursuance of the aims and purposes of the larger scheme of things.

(d) A mutual replenishment to spent resources to the end that the continuity of each and all processes shall not be jeopardized.
Re-allocation of productive resources is the integral part of integration. The idea behind integration is that an efficient management of the overall industry or to say the economy for the well-being or betterment of society.

Having dealt the concept of market and integration we can proceed to know the concept of market integration and its relevance in economics. Market integration is considered to be a useful parameter to measure marketing efficiency for temporal and spatial analysis.

Horowitz (1981) maintains that it is common in economics to define market integration on the basis of price determination. Relevance of the concept of market integration will be clear if one looks at the view of Dercon (1995). “Market integration analysis can assess the transmission speed of price changes in the main market to the peripheral markets. A reduction in the time lag of transmitting price signals suggests better arbitrage and therefore an improvement in the functioning of markets”.

Market integration is the process by which price interdependence occurs. To Faminow and Benson (1990) the usual definition in the literature is that integrated markets are those where prices are determined interdependently; which is assumed to mean that price change in one market will be fully passed on the others.

Goodwin and Schroeder (1991) cautions that markets that are not integrated may convey inaccurate price information that might distort producer marketing decision and contribute to inefficient product movements.
Actually what market integration delivers to the economy will be explicit from the following views. Information on market integration provides specific evidence as to the competitiveness of the market, the effectiveness of arbitrage (Carter and Hamilton, 1989) and the efficiency of pricing (Buccola, 1983). Delgado (1986) opined that a well integrated market system is essential to household food security in both food deficit rural areas and those witnessing a rise in the relative importance of non-food cash cropping. To know the working of market, an understanding of market integration measurement will be useful.

Monke and Petzel (1984) defined integrated market as markets in which prices of differentiated products do not behave independently. Spatial market integration refers to a situation in which prices of a commodity in spatially separated markets move together and price signals and information are transmitted smoothly across the markets. Spatial market performance may be evaluated in terms of the relationship between the prices of spatially separated markets and spatial price behaviour in regional markets may be used as a measure of overall market performance (Ghosh, 2000).

Behura and Pradhan (1998) defined market integration as a situation in which arbitrage causes prices in different markets to move together. More specifically two markets may be said to be spatially integrated; when even trade takes place between them, if the price differential for a homogeneous
commodity equals the transfer costs involved in moving that commodity between them.

An equilibrium will have the property that, if trade takes place at all between any two regions, then price in the importing region equals price in the exporting region plus the unit transport cost incurred by moving between the two. If this holds then the markets can be said to be spatially integrated – observes Ravallion (1986).

According to Slade (1986) two trading regions are integrated if price changes in one region cause price changes in the other. The transmission mechanism could be that price increases in one region result the product moving into that region from the other, hence reducing the supply of product in the exporting region and causing price to increase.

Hence, an interrelated or interdependent movement of prices between spatially separated market can be said to be a situation of market integration. Several statistical techniques were employed to test the nature of market integration. Since we are concerned with the testing of market integration hypothesis, it is obvious to review all these available techniques.

Techniques to test Market Integration Hypothesis

Many empirical techniques have been developed and employed to investigate the relationship that exists across space and time. It is from these results drives the conclusion about the magnitude of competition or integration or marketing efficiency that exists in a marketing network. Let us review the
techniques employed over the years in the area of market integration research of agricultural products. Some of the important techniques are:

(i) Price Series Correlation.

(ii) Variance Component Approach.

(iii) Ordinary Least Square Framework.
   (a) Ordinary Least Square method.
   (b) Autoregressive Model.
   (c) Koyck's Distributed Lag Model.
   (d) Ravallion Model.

(iv) Cointegration Technique:
   (a) Stationarity and unit root tests
      - Dickey–Fuller Test
      - Augmented Dickey–Fuller Test
      - Phillips–Perron Test
   (b) Engle-Granger Model of Cointegration
   (c) Error Correction Model.

(v) Parity Bound Model.

(i) Price Series Correlation

The degree of association of price formation in one market with the other can be shown through a zero order correlation matrix of prices in these markets. The system assumes that with random price behaviour expected of a non-integrated market, i.e., bivariate correlation coefficient will tend to zero. On the other, in a perfectly integrated market, correlation coefficient is
expected to be unity. Correlation coefficient can be estimated by the following formula:

\[ r = \frac{\sum (P_{1i} - \overline{P}_1)(P_{2i} - \overline{P}_2)}{\sqrt{\sum (P_{1i} - \overline{P}_1)^2 \sum (P_{2i} - \overline{P}_2)^2}} \]

where

- \( r \) = correlation coefficient,
- \( P_{1i} \) = price of the commodity in the first market at \( i \) th point of time,
- \( P_{2i} \) = price of the commodity in the second market at \( i \) th point of time,
- \( \overline{P}_1 \) = mean price in the first market, and
- \( \overline{P}_2 \) = mean price in the second market.

Correlation coefficient is considered to be a convenient measure of market integration on two counts – price data is the only required data and is easily accessible and calculation is simple. This technique is based on the assumption that if markets are perfectly competitive and spatially well integrated price differences among markets will reflect only processing and transportation costs; and correlation coefficient will be equal to one. Accordingly, higher correlation coefficient implies that the markets are well or strongly integrated; and a lower coefficient specifies a weak form of market integration signifying lack of market information, transport bottlenecks, lack of product homogeneity or an element of monopoly power.
However, an array of criticism has started in using correlation coefficient as a measure of market integration. Blyn (1973) pointed out that because of common trends there may be an upward bias to the results. Blyn further states that the trend may be due to rising demand occasioned by population increase that may affect all parts of the region or due to common climatic condition. Here all price series in a region would be affected by such influences even if each market within the region was independent of others. Blyn therefore cautions that time series correlation need to be restricted to residuals remaining after the trend and seasonal components have removed.

Price series correlation method has also been criticised by Harris (1979) on the ground that a high correlation between the markets does not necessarily mean that these two markets are well integrated in the sense that a competitive network of traders exists which ensures that agricultural goods move between market places in swift response to price difference that exceed transport cost. Lundahl and Petersson (1982) have also cited their criticism almost on the same line with Blyn and Harris.

Problems in using correlation coefficient were also earmarked by Heytens (1986). Heytens observes that though prices in an efficient market system tend to move together, they may do so for other reasons (general inflation, common seasonality) or other common factors may produce sympathetic but unrelated price changes. It is further maintained that a perfect monopoly or price fixing by a central authority can just easily produce a
coefficient of one as a perfectly competitive market. Therefore correlation coefficients are not unequal indicator of market conditions and applications become more indiscriminate. Petzel and Monke (1979-80) also assures the above observation. Harris (1979) and Timmer (1974) too pointed out that markets may be spatially integrated, but demonstrate low price correlation because of changes in the geographical direction of price formation.  

(ii) Variance Component Approach

The technique developed by Delgado (1986) is to test time series of prices for seasonal differences in the price integration of markets. The approach is to decompose the variance of prices into components. The model of price for a crop can be written as

\[ P_{it}^{(s)} = m^{(s)} + V_i^{(s)} + U_t^{(s)} + Z_{it}^{(s)} \]  

Where

Super subscripts \( S = 1 \ldots \) Number of seasons,  
\( i = 1 \ldots \) Number of markets,  
\( t = 1 \ldots \) Number of weeks in season,  
\( P_{it} \) = price of the article concerned in market ‘i’ in week ‘t’,  
\( m \) = the mean price of each season,  
\( V_i \) = a constant location (village) effect,  
\( U_t \) = a constant weekly time effect, and  
\( Z_{it} \) = a stochastic interaction term.
Two important assumptions of a season are:

(i) Variance of prices for a given crop is constant over the season.

(ii) Transport and transaction costs for marketing a given crop between two markets are constant subject to a random disturbance over the season.

Analysis is done for each crop and season. Variations around mean price is divided into two constant deviations and a stochastic term. The yardstick of integration is that the price spread between markets stays approximately constant, subject to random variations either way. Equation (1) shows that after removing a common seasonal trend \((U_i)\) and seasonal mean price for each village \((m+V_i)\) interaction between the residual price term \((Z_{it})\) across villages are independent.

More formally

\[ E(Z_{it}, Z_{it}) = 0 \quad \text{where } i \neq 1 \]

If equation (2) can be shown to hold jointly with a reasonable degree of statistical confidence for all pairs of markets, the system of markets is judged integrated.

Equation (2) can be tested by estimating the \(Z\) elements from the price data. For it one has to remove the long term trends and constant effects peculiar to a particular location by subtracting mean seasonal price for each village and crop from weekly price data.

Thus

\[ P_{it}^* = P_{it} - \bar{P}_i \]
Where the notation is consistent with equation (1) and the mean price for village ‘i’ is calculated separately for each crop and season

\[ P_{it} = U_i - Z_{it} \quad - \quad (4) \]

The next step in retrieving the stochastic \( Z_{it} \) is to eliminate the weekly time effect \( U_t \), which is conceptually constant across villages but different for each week. Netting this effect out removes the common seasonal trend and this eliminates spurious correlation of price movements arising from seasonal influences. The variance component method permits statistical inference from a sample of time series of market prices concerning seasonal and regional differences in the variance of prices.

The major limitations of this model are (i) it assumes constant variance of price over the season (ii) transaction cost between two markets are also assumed to be constant. Once these restrictions are relaxed, the model may not be able to measure the exact degree of market integration.

(iii) Ordinary Least Square Framework

(a) Ordinary Least Square Method

Several researchers have tested integration of agricultural commodity markets with the OLS method and it is presented below:

\[ P_{it} = \beta_a P_{it}^{\beta} T_{it}^{\beta} U_t \quad - \quad (1) \]

where

\[ P_a = \text{price at location i at time t}, \]

\[ P_j = \text{price at different location at time t, and} \]

72
\( T_{ij} \) = indicator of transportation and transaction costs between location i and j at time t.

In order to obtain a linear equation, log of equation (1) is taken for estimation. The estimation is focusing on \( \beta_1 \) as the "elasticity of price transmission". If \( \beta_1 = 1 \) the market is said to be integrated.

The above method has a few limitations. No serious attention has however, been given to the properties of the error term. Unbiasedness requires that the error term has no discernible structure, otherwise the price of central market can not be said to possess all market information and the past history of peripheral market price. Further, as a matter of fact, the notion of non-stationary \( p_{it} \) and \( p_{jt} \) raises doubt about the consistency of the estimation of \( \beta_1 \).

(b) Autoregressive Model

The autoregressive model which was employed by Heytens (1986) to test market integration will be explained below.

\[
\alpha_i (L) P_i = \beta_i (L) \bar{P}_t + \gamma (L) X + U
\]  

(1)

where \( i = 1 \ldots k \) and \( t = 1 \ldots n \).

\( P_i \) = price in market i at time t,

\( \bar{P}_t \) = reference price at t,

\( X \) = vector of seasonal and other relevant variables in market i at time t with the same collection of variables used in all vectors,

\( X_{it} \) = overall markets and all time period,
\[ U_{it} = \text{an error term and} \]

\[ \alpha_i (L), \beta_i (L) \text{ and } \gamma_i (L) \text{ denote the polynomials.} \]

\[ \alpha_i (L) = 1 - \alpha_{i1}(L) - \ldots - \alpha_{in} L^n \]

\[ \beta_i (L) = \beta_{i0} + \beta_{i1} L + \ldots + \beta_{im} L^n \]

\[ \gamma_i (L) = \gamma_{i0} + \gamma_{i1} L + \ldots + \gamma_{im} L^n \]

For the empirical analysis equation (1) will be rewritten with first difference of local price on the dependent variable.

where \( \Delta P_{it} = P_{it} - P_{it-1} \) and \( \Delta^i = P_{it} - \bar{P}_t \)

\[
\Delta P_{it} = \left( \sum_{j=1}^{\alpha_i} \alpha_{ij} L^j \right) L \Delta^i P_{it} + \sum_{j=0}^{m-1} \left( \sum_{k=0}^{i} \alpha_{ik} + \sum_{k=0}^{i} \beta_{ik} - 1 \right) j L \Delta^i \bar{P}_{it} \\
+ \left( \sum_{j=1}^{\alpha_i} \alpha_{ij} + \sum_{j=0}^{m} \beta_{ij} - 1 \right) \tilde{P}_{t-1} + \gamma_i (L) X_t + U_{it} \quad \quad \quad \quad \quad \quad \quad \text{(2)}
\]

Where \( \alpha_{i0} = 1 \). For simplicity equation (2) can be written for one lag each for local and reference market.

\[
\Delta P_{it} = (\alpha_{i1} L - L) \Delta^i P_{it} + \beta_{i0} \Delta \bar{P}_{it} + (\alpha_{i1} + \beta_{i0} + \beta_{i1} - 1) \tilde{P}_{t-1} + \gamma_i (L) X_t + U_{it} \quad \quad \quad \quad \quad \quad \quad \text{(3)}
\]

removing \( \Delta_s \) equation (3) becomes

\[
P_{it} - P_{it-1} = (\alpha_i - 1)(P_{it} - \tilde{P}_{t-1}) + \beta_{i0} (\bar{P}_{t} - \bar{P}_{t-1}) + (\alpha_i + \beta_{i0} + \beta_{i1} - 1) \tilde{P}_{t-1} + \gamma_i X_t + U_{it} \quad \quad \quad \quad \quad \quad \quad \text{(4)}
\]

74
Equation (4) specifies the changes in local price as a function of the change in the reference price for the same period, last period’s spatial price margin, last period’s reference market price and local market characteristics.

\[ \beta_i \] measures the extent to which local market participants know the market conditions of reference market.

\[ \alpha_{i,i-1} \] measures the extent to which last period’s spatial price differential is reflected in this period’s local market price.

Here market ‘i’ could be called segmented if

\[ \beta_{ii} = 0 \]

Which can be determined by testing equation (4) against the following restricted model with an F test

\[ p_i - p_{i-1} = (\alpha_{i,i-1}) p_{i-1} + \gamma x + u_i \] (6)

Acceptance of equation (6) indicates that the price in market i depends only on its own lagged values and local market characteristics.

Now if \[ \beta_i = 1, \beta_{i} (L)i = 1 (\Rightarrow \beta_{ii} = 0) \]

And \[ \alpha_i = 0 \] (8), then market ‘i’ is integrated with the reference market in one time period.

When \[ n=1 \], market integration as indicated by equation (7) and equation (8) implies the absence of local price autocorrelation.

Heytens maintains that some problems are obvious in the model. Determination of appropriate reference prices and variable specification will
be a matter of concern where a broad understanding of the market is limited. There will be the existence of simultaneous equation bias. The model’s parameters are likely to be sensitive to the time length of data. Though the model can handle problem raised by common time trend, it cannot deal the situation when direction of commodity flow between rural and urban areas reverses with the season.

(e) Koyck’s Distributed Lag Model

When the regression model includes not only the current but the lagged values of the explanatory variables, it is called a distributed lag model. Koyck has proposed an ingenious method of estimating distributed lag models (Madnani, 1986).

\[ P_{it} = \alpha + \beta_0 P_{jt} + \beta_1 P_{jt-1} + \ldots + \beta_k P_{jt-k} + \epsilon_t \]  \hspace{1cm} (1)

where

- \( P_{it} \) is the price of the \( i \)th product in period \( t \),
- \( P_{jt} \) is the price of \( j \)th product in period \( t \), and
- \( \alpha \) and \( \beta \) are parameters. Assuming that the \( \beta \)'s are all of the same sign, Koyck assumes that they decline geometrically as follows

\[ \beta_k = \beta_0 \lambda^k \]  \hspace{1cm} (2) \quad k = 0, 1, \ldots

Where \( \lambda \), such that \( 0 < \lambda < 1 \) is known as the rate of decline or decay of the distributed lag and \( (1 - \lambda) \) is the speed of adjustment.
Equation (2) explains that each successive $P_i$ is numerically less than each preceding $P_i$ implying that as one goes back into distant past the effect of lag on $P_i$ becomes progressively smaller. By assuming non-negative values for $\lambda$, Koyck rules out the $\beta$'s from changing sign and by assuming $\lambda < 1$ he gives lesser weight to the distant $\beta$'s than the current one and ensures that the sum of $\beta$'s gives the long run multiplier in a finite amount namely

$$\sum_{k=0}^{\infty} \beta_k = \beta_0 \left( \frac{1}{1 - \lambda} \right)$$

(3)

As a result of equation (2); equation (1) can be written as

$$P_i = \alpha + \beta_0 P_{it} + \beta_1 \lambda P_{i,t-1} + \beta_2 \lambda^2 P_{i,t-2} + \ldots + U_t$$

(4)

As still the model is not amenable to easy estimation due to large number of parameters, Koyck lags equation (4) by one period.

$$P_{i,t-1} = \alpha + \beta_0 P_{i,t-1} + \beta_1 \lambda P_{i,t-2} + \beta_2 \lambda^2 P_{i,t-3} + \ldots + U_{t-1}$$

(5)

Multiplying equation (5) by $\lambda$

$$\lambda P_{i,t-1} = \lambda \alpha + \beta_0 \lambda P_{i,t-1} + \beta_1 \lambda^2 P_{i,t-2} + \beta_2 \lambda^3 P_{i,t-3} + \ldots + \lambda U_{t-1}$$

(6)

Subtracting equation (6) from equation (4)

$$P_i - \lambda P_{i,t-1} = \alpha (1 - \lambda) + \beta_0 P_{it} + (U_t - \lambda U_{t-1})$$

Rearranging

$$P_i = \alpha (1 - \lambda) + \beta_0 P_{it} + \lambda P_{i,t-1} + V_t$$

(7)

where $V_t = (U_t - \lambda U_{t-1})$
Positive signs are expected for $\beta$ and $\lambda$ for market integration in equation (7).

Multicollinearity is resolved by replacing $P_{ji-1}$, $P_{ji-2}$ by a single variable $P_{it-1}$.

Here we have started with a distributed lag model but ended up with an autoregressive model. The presence of lagged explanatory variable violates Durbin-watson ‘d’ test. Therefore, one have to test the serial correlation by Durbin-watson ‘h’ test.

The $\beta$ gives the short-run price adjustment corresponding to a unit change in $j$th price.

Long run adjustment is measured through equation (3).

That is $\beta_k = \beta_0 \left(\frac{1}{1 - \lambda}\right)$. The error term $V_t$ possess OLS properties.

In Koyck’s transformed model the presence of lagged dependent variable raises some problems.

In the new formulation the error term $V_t = (U_t - \lambda U_{t-1})$ is found to be autocorrelated.

$$\begin{align*}
E(V_t \ V_{t-1}) &= E(U_t - \lambda U_{t-1}) (U_{t-1} - \lambda U_{t-2}) \\
&= E(U_t U_{t-1} - U_t \lambda U_{t-2} - \lambda U_{t-1}^2 + \lambda^2 U_{t-1} U_{t-2}) \\
&= -\lambda E(U_{t-1}^2) \\
&= -\lambda \sigma_u^2 \neq 0 \quad (\because 0 < \lambda < 1).
\end{align*}$$

78
The lagged variable $P_{it-1}$ is also not independent of the error term $V_t$ i.e. $E(V_t, V_{t-1}) \neq 0$. This is because $P_{it}$ directly depends on $V_t$. Similarly $P_{it-1}$ on $V_{t-1}$. But since $V_t$ and $V_{t-1}$ are not independent, $P_{it-1}$ will obviously be related to $V_t$.

Due to these two problems, Koyck's distributed lag model give rise to biased and inconsistent estimates. Again it assumes that the impact of past periods decline successively in a specific way. But in reality this may not be the case.

**(d) Ravallion Model**

Ravallion (1986) developed an econometric model of spatial price differentials. It is assumed that there are a number of local markets and a central market. The pattern of price formation among $N$ markets, where market 1 is the central market is summarized by the model

$$P_1 = F_1 (P_2, P_3, \ldots, P_N, X_1) \quad (1)$$

and

$$P_i = F_i (P_i, X_i) \quad (2)$$

where $i = 2, \ldots, N$

$X_i (i = 1, \ldots, N)$ is a vector of other influences on local markets.

By incorporating a dynamic structure to equation (1) and (2), econometric model of $T$ period series of prices for $N$ regions is assumed

$$P_i = \sum_{j=1}^{n} a_{ij} P_{i-j} + \sum_{j=0}^{n} b_{ij} P_{i-j} + X_i C_i + e_i \quad (3)$$

where $i = 2, \ldots, N$. 

79
where \( P_{it} \) = the price of central market and

\[
P_{it} = \text{the price of peripheral market.}
\]

Ravallion used equation (3) to test several hypothesis.

Market is segmented if \( b_{ii} = 0 \) \( \quad (4) \)

Short run market integration is possible If \( b_{i0} = 1 \) \( \quad (5) \)

For lagged effects \( a_{ij} = b_{i0} = 0 \) \( \quad (6) \)

If (5) and (6) are accepted, then one can say that market ‘i’ is integrated with the central market with one time period.

A weak form of market integration will also be tested in which the lagged effects vanish on an average.

\[
\sum_{j=1}^{n} a_{ij} + b_{ij} = 0 \quad (7)
\]

For long run market integration consider the form that equation (3) takes where

\[
P_{it} = P_{i}^*, \quad P_{i}^* = P_{i}^\prime \quad \text{and} \quad e_{it} = 0 \quad \text{for all} \; t; \quad \text{then}
\]

\[
P_{i}^* = \frac{P_{i}^\prime \sum_{j=0}^{n} b_{ij} + X_{i} C_{i}}{1 - \sum_{j=1}^{n} a_{ij}} \quad (8)
\]

Market integration now requires that

\[
\sum_{j=1}^{n} a_{ij} + \sum_{j=0}^{n} b_{ij} = 1 \quad (9)
\]

For long run integration equation (3) was reestimated in the following form
\[ \Delta P_{it} = (a_{it} - 1)(P_{it-1} - P_{lt-1}) + \sum_{j=2}^{u} a_{ij} (P_{it-j} - P_{lt-j}) + b_{it} \Delta P_{lt} + \sum_{j=1}^{n-1} (b_{it} - 1 + \sum_{k=1}^{l} a_{ik} + b_{ik}) \Delta P_{lt-1} + X_{it} C - e_{it} \]

The Ravallion model extracts more information on the nature of spatial price differentials. This model avoids the inferential dangers in using spatial price correlation. It permits price series for each local market to have its own autoregressive structure and a dynamic relationship with market prices in a trading region. Ravallion’s dynamic approach permits a clear distinction between short run market integration and integration as a long run tendency in the short run adjustment process.

However, the Ravallion model is beset with several problems. Palaskas and White (1993) observes that even if the correct estimation procedure is adopted, the coefficient estimates of the stochastic equation can be imprecise if the dynamics are of a relatively high order, the reason being multicollinearity between lagged values of the explanatory variables. Again specification in levels raises the problem of spurious correlation associated with the regression of trending variables in levels. Baulch (1997) maintains that Ravallion model is based on assessing the co-movement of price data alone and fail to recognize the pivotal role played by transfer cost.

(iv) Cointegration Technique:

Cointegration can be regarded as the empirical counterpart of the theoretical notion of long run equilibrium relationship. The development of
Cointegration technique form a formidable achievement of time series econometrics in the 1980s. Cointegration analysis has been necessitated by the earlier approach which generally ignored or misrepresented the time series properties of the price series and hence, serious flaws in the estimation procedure. As a matter of fact, several macro economic time series exhibits trend like behaviour. Granger (1966) expressed this as the series having much of their spectral power at low frequencies and Nelson and Plosser (1982) argued that this persistence was captured by modelling the series as having a unit auto regression root (being integrated of order one). Stock (1999) maintains that “the achievement of cointegration analysis, as developed by Granger (1986), Ganger and Weiss (1983) and Engle and Granger (1987) was to provide a unified framework in which to understand and to reconcile the apparent conflict between spurious regressions and economically meaningful long term relations”.

Cointegration technique is a three-stage procedure. Firstly, variables have to be pre-tested for stationarity. A series is said to be integrated of order ‘d’, I(d), if it has to be differenced ‘d’ times to produce a stationary series. Once stationarity is obtained, variables are to be tested for cointegration or long run relationship. Two series are cointegrated of order (1,1), if the individual series are I(1) and a linear combination of them called the cointegrating regression is I(0). After getting cointegrated relationship, the residuals from the equilibrium regression can be used to estimate the error
correction model. Thus, it can be shown that in the case when two series are I(1) and are cointegrated, the model can be given an error correction representation.

(a) Stationarity and Unit root tests:

To develop models for time series, it is important to know whether or not the underlying stochastic process that generated the series can be assumed to be invariant with respect to time. If the characteristics change over time, that is; if the process is non stationary, it will be difficult to represent the time series over past and future intervals of time by a simple algebraic model. On the other, if the stochastic process is fixed in time, that is; if it is stationary, then one can model the process via an equation with fixed coefficients that can be estimated from the past data.

The presence of unit roots in time series points toward non-stationarity of the series. Regression will be spurious if both independent and dependent variables show the presence of unit root. To have a compatible model, variables should be of same order of integration. Unit root test starts with the level series, takes the difference and tests for the presence of unit roots by regressing in the first difference on lagged variable of the series. If one observes the presence of unit root, the series is said to be non-stationary. Now the exercise is to be repeated by taking the second difference and so on until the series become stationary. Some of the important tests used to check
stationarity are Dickey-Fuller test, Augmented Dickey-Fuller test and Phillips–Perron test.

**Dickey-Fuller Test (DF)**

To test whether the series $Y_t$ is stationary, the test have been provided by Dickey and Fuller (1979, 1981) and it is presented below:

$$\Delta Y_t = \alpha_0 + \rho Y_{t-1} + e_t$$

Test result reveals that $Y_t$ is stationary if $\rho < 1$, non-stationary if $\rho = 1$, and non-stationary and explosive if $\rho > 1$.

If ‘$\rho$’ is negative and statistically significant, the alternative hypothesis that $Y_t$ is integrated of order $I(1)$ is accepted. Dickey and Fuller derived critical values for the test from Monte Carlo experiments and is given as ‘$\tau$’ statistics.

One of the major flaws of DF test is that the problem of serial correlation is endemic. It is also cited that autoregressive or moving average errors have a big effect on the power of DF test.

**Augmented Dickey Fuller Test (ADF)**

It includes additional lags to mop up serial correlation. It also incorporates additional nuisance parameters. Further, data based selection of lag length can be used with little adverse effect. ADF is augmenting the regression equation of DF by adding sufficient terms in $\Delta Y_{t-1}$ and it is presented below:
\[ \Delta Y_t = \omega + \beta Y_{t-1} + \sum_{i=1}^{k} c_i \Delta Y_{t-i} + \epsilon_t \]

Where \( k \) is selected to be large enough to ensure the error \( \epsilon_t \) as a white noise.

Interpretation of ADF results are same as that of DF test.

One of the serious defects of ADF test is that too many lags reduce the power of the test to reject the null of a unit root since the increased number of lags necessitates the estimation of additional parameters and a loss of degrees of freedom. The degrees of freedom decreases since the number of parameters estimated has increased and because the number of observation has decreased due to additional lags.

It is important to note that the Dickey-Fuller test assumes that the errors are independent and have a constant variance. This raises some problems. Firstly, the true data generating process may contain both autoregressive and moving average components. Secondly, one can not properly estimate ‘\( \rho \)’ and its standard error unless all the autoregressive terms are included in the estimating equation. The third problem stems from the fact that Dickey-Fuller test considers only a single unit root.

Now, by relaxing the assumptions of Dickey-Fuller test, a new methodology was developed by Phillips and Perron for testing stationarity of data series.
Phillips-Perron Test

The distribution theory supporting the Dickey-Fuller test assumes that the errors are statistically independent and have a constant variance. While using this methodology utmost care is to be taken to ensure that error terms are uncorrelated and have a constant variance. Phillips and Perron (1988) developed a generalization of the Dickey-Fuller procedure that allows for fairly mild assumption concerning the distribution of errors.

Consider the following regression equation.

\[ Y_t = a_0 + a_1 Y_{t-1} + \mu_t \quad \text{and} \]

\[ Y_t = \bar{a}_0 + \bar{a}_1 Y_{t-1} - 1 + \bar{a}_2 (t - T/2) + \mu_t, \]

where \( T \) = number of observation and the disturbance term \( \mu_t \) is such that \( E \mu_t = 0 \), but there is no requirement that the disturbance term is serially uncorrelated or homogeneous. Instead of Dickey-Fuller assumption of independence and homogeneity, the Phillips-Perron test allows the disturbance term to be weakly dependent and heterogeneously distributed.

Phillips and Perron characterize the distribution and derive test statistics that can be used to test hypothesis about the coefficients \( a_i \) and \( \bar{a}_i \), under the null hypothesis that the data are generated by

\[ Y_t = Y_{t-1} + \mu_t \]

If the coefficients are negative and statistically significant, the series is said to be stationary. The critical values of the Phillips-Perron statistics are precisely those given for the Dickey-Fuller test.
Monte Carlo studies find that the Phillips-Perron test has greater power to reject a false null hypothesis of a unit root. Monte Carlo studies have also shown that in the presence of negative moving average terms, Phillips-Perron test tend to reject the null of a unit root whether or not the actual data generating process contains a negative unit root. But in practice, the choice of the most appropriate test can be difficult since one never know the true data generating process. Enders (1995) observes that a safe choice is to use both types of unit root tests; and if they reinforce each other, one can have confidence in the results.

(b) Engle-Granger Model of Cointegration

Let there exists a constant $\lambda$ such that $X_t$ is $\lambda Y_t$ is I(0). When this occurs, $X_t$ and $Y_t$ are said to be cointegrated but the variable $Z_t = X_t - \lambda Y_t$ is stationary I(0), $\lambda$ is the cointegrated parameter (Granger 1986).

If $X_t$ and $Y_t$ are I(1), it is necessary that $Z_t$ be I(0).

When the series are integrated of order one, to estimate the long run relationship between $X_t$ and $Y_t$ one has to run the OLS regression given below

$$X_t = \alpha + \lambda Y_t + Z_t$$

and test whether the residuals $Z_t$ are stationary. After recovering the residuals, cointegration test can be done in the following way.

First the estimated residuals from

$$X_t = \alpha + \lambda Y_t + Z_t$$

are used to construct a Durbin-watson statistic (CRDW) and is compared with the critical value given in Engle and Yoo
(1987). If the estimated CRDW is above the critical value, the null hypothesis of non-cointegration is rejected. Then CRDW test is reinforced by constructing Dickey-Fuller and Augmented Dickey-Fuller statistics.

**Dickey-Fuller Test (DF)**

DF is computed by running the following regression model.

\[ Z_t = \alpha + b Z_{t-1} + \epsilon_t \]

where \( Z_t \) is the residual from the cointegrating regression. If the 't' statistic of 'b' coefficient is less than one and statistically significant, the existence of cointegration between series is accepted.

**Augmented Dickey-Fuller Test (ADF)**

ADF test is based on the following regression model.

\[ \Delta Z_t = \alpha + b Z_{t-1} + \sum_{i=1}^{p} B_i \Delta Z_{t-i} + \epsilon_t \]

If t-statistic of 'b' coefficient is negative and statistically significant, then the variables are said to be cointegrated.

**(c) Error Correction Model**

Granger (1986) and Engle and Granger (1987) have demonstrated that if \( Y \) and \( X \) are both I(1) variables and cointegrated, an error correction model exists. The principle behind this model is “there often exists a long-run equilibrium relationship between two economic variables. In the short run, however, there may be disequilibrium. With the error correction mechanism, a
proportional disequilibrium in one period is corrected in the next period” (Ramanathan, 1995).

Error Correction Model includes last periods’ equilibrium error as well as lagged values of the first difference of each variable. The degree of disequilibrium can be assessed by examining the relative magnitude and statistical significance of the error correction coefficient. Error correction model combines the long term model with the short-term dynamics when \( Y_t \) and \( X_t \) are cointegrated of order (1,1) the variables have the error correction form.

\[
\Delta Y_t = \alpha + \alpha_1 (Y_{t-1} - \beta_1 X_{t-1}) + \sum_{i=1}^{a_{11}} a_{11}(i) \Delta Y_{t-i} + \sum_{i=1}^{a_{12}} a_{12}(i) \Delta X_{t-i} + \varepsilon_t
\]

\[
\Delta X_t = \alpha_2 + \alpha_3 (Y_{t-1} - \beta_1 X_{t-1}) + \sum_{i=1}^{a_{21}} a_{21}(i) \Delta Y_{t-i} + \sum_{i=1}^{a_{22}} a_{22}(i) \Delta X_{t-i} + \varepsilon_u
\]

The coefficients \( \alpha_y, \alpha_x, \alpha_{11}, \alpha_{12}, \alpha_{21} \) and \( \alpha_{22} \) shows the short run dynamics of the system. If both \( \alpha_y, \alpha_x \) are zero, it assumed that there is no error correction.

**Limitations of Engle-Granger Cointegration**

(i) Engle-Granger procedure is a bivariate model which ignore the linkage that may operate through a third market.

(ii) The existence of more than one long run relationship cannot be captured by co-integration technique.
(iii) The tests conducted for identifying the driving forces in the market ignore the probability of existing multiple common trends; which would imply multiple dominant markets.

(v) **Parity Bound Model (PBM)**

Baulch (1997) developed a PBM to test market integration. Baulch argued that time series techniques involving Granger causality, error correction and cointegration rely on price data alone and fail to recognize the role of transfer costs. These approaches were unable to distinguish integrated from independent markets when both were subject to a common, exogenous inflationary process.

PBM extends earlier work on stochastic frontier and switching regression models. Transfer costs (comprising transportation, loading and unloading costs and trader's normal profit) determine the parity bound within which the prices of a homogeneous commodity in two geographically distinct market can vary independently.

PBM assesses the extent of market integration by distinguishing among three possible trade regimes: Regime 1, at the parity bound (spatial price differentials equals transfer costs) Regime 2, inside parity bound (price differential < transfer costs) Regime 3, outside parity bound (price differential > transfer costs). Deviations of the inter-market price spread from extrapolated transfer costs in any period may be composed into three components. The first error term \( (e_t) \) allows transfer costs to vary between
periods. The second error term \((u_i)\) captures the extent to which price differentials fall short of the parity bound and the third error term \((V_i)\) measures by how much price differentials exceed transfer costs.

The PBM is specified as

\[
L = \prod_{i=1}^{t} \left[ \lambda_{i} F_{i}^{1} + \lambda_{2} F_{i}^{2} + (1-\lambda_{i} - \lambda_{2}) F_{i}^{3} \right]
\]

where Regime 1 is

\[
F_{i}^{1} = \frac{1}{\sigma_{e}} \phi \left[ \frac{Y_{i} - K_{i}}{\sigma_{e}} \right]
\]

Regime 2 is

\[
F_{i}^{2} = \left\{ \frac{2}{(\sigma_{e}^{2} + \sigma_{u}^{2})^{1/2}} \right\} \phi \left[ \frac{Y_{i} - K_{i}}{(\sigma_{e}^{2} + \sigma_{u}^{2})^{1/2}} \right] 1 - \varphi \left[ \frac{(Y_{i} - K_{i}) \sigma_{u}}{(\sigma_{e}^{2} + \sigma_{u}^{2})^{1/2}} \right]
\]

and Regime 3 is

\[
F_{i}^{3} = \left\{ \frac{2}{(\sigma_{e}^{2} + \sigma_{r}^{2})^{1/2}} \right\} \phi \left[ \frac{Y_{i} - K_{i}}{(\sigma_{e}^{2} + \sigma_{r}^{2})^{1/2}} \right] 1 - \varphi \left[ \frac{(Y_{i} - K_{i}) \sigma_{v}}{(\sigma_{e}^{2} + \sigma_{u}^{2})^{1/2}} \right]
\]

\(\lambda_{1}, \lambda_{2} = \) probabilities of regime 1 and 2,

\(Y_{i} = \) the absolute value of natural logarithm of the price spread between markets \(i\) and \(j\) in period \(t\),

\(K_{i} = \) logarithm of nominal transfer cost in period \(t\),
\[ \sigma_{e}, \sigma_{u}, \sigma_{v} = \text{standard deviation of three error terms } e, u, \text{ and } v, \text{ and } \phi \text{ and } \varphi \] denotes standard normal density and distribution functions.

To obtain probability estimates for the three regimes of the PBM, the logarithm of this function may be maximized numerically with respect to \( \lambda_1, \lambda_2, \sigma_{e}, \sigma_{u}, \text{ and } \sigma_{v} \) using the David-Fletcher-Powell algorithm.

Statistical hypothesis tests for the purpose of market integration can be conducted by testing the null hypothesis that \( \lambda_1 + \lambda_2 = 1 \).

The PBM allows for market to be integrated in some periods but not in others. Statistical reliability of the PBM can be assessed with Monte Carlo experiments.

Baulch also gives the limitations of PBM.

(i) Since only contemporaneous spreads are used in its estimation, it is hard for the PBM to take into account the type of lagged price adjustment postulated by causality and Ravallion models.

(ii) Precise estimation of transfer cost is essential. Inaccuracies in estimation of transfer costs will lead to high \( \sigma_{e} \), and problems with the convergence of the maximum likelihood procedure.

(iii) Violations of the spatial arbitrage condition indicate lack of market integration but they do not pinpoint its causes.
Concluding Remarks:

The present chapter tried to examine the theoretical background of the present study and various related concepts of market integration and marketing efficiency. Besides, the present chapter also reviewed the various statistical and econometric tools employed in the earlier literature to verify the validity of market integration hypothesis.

A series of techniques right from correlation coefficient, variance component approach, autoregressive model, distributed lag model, Ravallion model, Engle-Granger cointegration technique to Parity Bound Model was explained in detail. All these techniques in general can be employed to test the validity of the market integration hypothesis in a bivariate framework. In our study, pepper is a product dominated in multiple markets. Hence, Johansen’s multiple cointegration method is an appropriate method to examine the validity of market integration hypothesis pertaining to the pepper market of Kerala.

For detailed discussion on Johansen’s Methodology See Chapter five.