Market Integration and Price Transmission in Selected Area of the South African Market

by

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Declaration

I, Lekang Victor Mmutle, declare that the mini-dissertation for the degree of Masters in Commerce at the North West University, Mafikeng Campus, hereby submitted, has not previously been submitted by me for a degree at this or any other university. All information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

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L.V. Mmutle

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Abstract

The present study addresses the issue of the market integration of an aspect of the South African market. The researcher investigates the mechanism of asymmetric price transmission using twelve macroeconomic variables. The analysis of price transmission of the select area of the South African market is useful for making inferences about the competitive environment and efficiency of the market in South Africa. Furthermore, this analysis is important for policymakers considering the challenges faced by the South African market in relation to world market.

Using cointegration, causality, vector error correction mechanism, impulse response function and variance decomposition methods, the researcher finds asymmetries in the selected price chains. The empirical findings give evidence of existence of long-run equilibrium relationship between producer and consumer prices of goods, and that producer prices of goods Granger-causes consumer prices of goods, but not the reverse. The findings also indicate that transmission between consumer prices of goods and producer prices of goods is asymmetrical. It is further established that shocks from money supply M1 and GDP are the most important determinants in the variation in the consumer prices for housing while shocks from exchange rates and GDP were the most important determinants in the variation in producer prices for manufacturing food. An expansion of the study is needed to help improve the understanding of asymmetries in the South African market.

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List of Operational Definitions of Important Concepts

Trade Liberalization	A term which describes the complete or partial elimination of trade distorting government policies
Market Integration	Removal of barriers between two markets for the same product, so that prices on the two markets become more closely linked
Simultaneity	Happening or existing or done at the same time
Asymmetry	The difference in the reaction to cost increases compared to cost decreases
Price Transmission	Means by which resources are allocated and re-allocated within a market-based economic system.
Vertical Transmission	The interaction between prices at different stages
Horizontal Transmission	The interaction between prices of a given commodity on different markets at the same stage of the supply chain
Price Elasticity	The percentage change in the quantity divided by the percentage change in the price
Time Series	A set of observations on the values that a variable takes at different time points, preferably at a constant time interval.
Stationary Time Series	A time series that has a constant mean and variance
Non-Stationary Time Series	A time series that has a non-constant mean and variance
Cointegration	When the linear combination of two or more non-stationary time series with the same order of integration is stationary
Business Cycle	Periodic fluctuations in the general rate of economic activity, as measured by the levels of employment, prices, and production
Volatility	A statistical measure of the tendency of a security's price to change over time

Persistence	The percentage price change of a stock over a set period of time and ranking it on a scale of 1 to 100 against all other stocks on the market, with 1 being worst and 100 being best.
Cyclicality	The act that a stock follows the general macroeconomic conditions
Comovement	Patterns of positive correlation of between two or more macroeconomic variables

CHAPTER ONE

Introduction

1.1 Study Background

Price is the primary mechanism by which all levels of the market are linked. The extent of adjustment and speed with which shocks are transmitted among prices is an important factor reflecting the actions of market participants at different levels. Price transmission is central in understanding the extent of the integration of economic agents into the market process.

Research works on price transmission signals are based on concepts related to competitive pricing behaviour (Fackler and Goodwin, 2001). In spatial terms, the classical paradigm of the Law of One Price, as well as the predictions on market integration provided by the standard spatial price determination models (Takayama and Judge, 1972) postulate that price transmission is complete with equilibrium prices of a commodity sold on competitive foreign and domestic markets differing only by transfer costs, when converted to a common currency. The absence of market integration or of complete pass-through of price changes from one market to another has important implications for economic welfare (Barrett, 2001). Incomplete price transmission arising either due to, say, situations like poor transport and communication infrastructure, results in a reduction in the price information available to economic agents and consequently may lead to decisions that contribute to inefficient outcomes.

Research works on price transmission studies are ostensibly an empirical exercise testing the predictions of economic theory and providing important insights as to how changes in one market are transmitted to another, thus reflecting the extent of market integration, as well as the extent to which markets function efficiently. Price transmission features prominently in the applications that test economic theories, for example, in the World Food Model of the UN Food and Agriculture Organization and other models including the model developed by Tyers and Anderson (1992). The increasingly use of these models to address sensitive policy issues, such as trade liberalization and the distribution of benefits and costs across countries and population groups, attests versatility of the price transmission mechanism.

The primary objective of this study is to provide evidence on price transmission in a number of macroeconomic variables in the South African economy by applying a number of macroeconometric techniques.

1.2 Problem Statement and Study Rationale

Economists are constantly interested in the functionality of markets to appropriately design, recommend and assess market policies through price transmission and market integration analysis - that is, the degree that markets inter-relationships determines the strength and effectiveness of price mechanism (Baulch, 1997). In addition, it is known that the formulation of market-enhancing policies to increase the performance of local market requires a better understanding of how the market functions. Aggregate market performance is better understood by studying the level of market integration that exists.

Quite recently, Schimmelpfennig et al (2003) undertook a study on price transmission and presented an Error-Correction-Model (ECM) of the short-run equilibrium and long-run equilibrium between the world price of maize, the local producer and consumer price of maize, and the exchange rate. Even though this study dwelt more on long-run and short-term shocks in the maize market, it did not go too far by considering price transmission from oil price through to consumer prices, the elasticity of price transmission, the transmission effects of exchange rates on housing and food prices, among other scenarios.

In the context of this study, market performance will be investigated by studying the transmission mechanism of some selected market prices, price spreads and market volatility in the South African market. A review of the literature showed that little or no study has been specifically conducted to measure the extent of market integration and price transmission in the South African market. Clearly, by investigating the mechanism of the selected prices, the models developed can also be used to investigate the extent of market integration in this area of the South African market as well as developing the same.

1.3 Research Objectives

The primary objective of this study is to investigate transmission behaviour of some selected prices in the South African market. Specific objectives include:

- Quantifying the elasticity of price transmission between consumer and producer prices as well as the nature of the transmission.
- Investigating the price transmission effects of exchange rates on housing and food prices as well as the degree of transmission on the shocks on housing and food prices.
- Estimating the transmission shocks from oil prices through exchange rates to consumer prices as well as the nature of the shock effect from oil prices on consumer prices.
- Investigating the short-run fluctuations (i.e., business cycles) of export and import prices; the existence or otherwise of persistence and volatility in the export and import cycles; examining the extent to which import and export prices co-move and the nature of the co-movement of their cyclicality, and generating forecast models for import and export prices.
- Conducting a comparative assessment of future forecasts for import and export prices using three forecasting models - double exponential smoothing, Winter's multiplicative method, and the Box-Jenkins forecasting method.

1.4 Significance of the Study

As indicated earlier, the significance of price transmission is overwhelming, especially in developing economies like South Africa. Without integration of markets, for instance, price signals will not be transmitted from supply deficit areas of the economy to surplus markets. Without market integration, prices will be more volatile and unstable and agricultural and food producers, for instance, will not specialize according to long-run comparative advantage, and gains from trade will not be realized (Baulch 1997). Thus, the importance of understanding price transmission and market integration mechanisms in market economies, especially the emerging and developing economies in general, and South Africa in particular, cannot be overemphasized.

In the context of this study, the lack of extensive research studies done in this area of the South African market is a clear indication of a serious gap that exists. This requires a prompt attention which is the very reason the researcher has decided to conduct this study. Furthermore, the researcher sees this study as a contribution to the body of research and applications on price transmission focusing on some selected prices and to highlight a number of important issues related to the definition of price transmission, the various econometric methods used to examine its extent and the interpretation of the results within the area of study.

1.5 Scope and Limitations of the Study

As with most studies, some limitations and delimitations will have to be highlighted before analyzing the data and interpreting the results.

1.5.1 Study Limitations

As indicated earlier, price transmission is important in the understanding of certain commodities or products that are influenced by prices of other products. One apparent limitation of this study is that it concentrates on macroeconomic variables and uses aggregated data. This means that there may be other important variables, other than macroeconomic variables used in this study that might explain the prices of such macroeconomic variables. This revelation itself is a topic for further research and is not addressed in this study. A study that utilizes disaggregated data might arrive at slightly different conclusions, if not totally.

Another general limitation regarding the use of time series data concerns which time horizon to select, especially the staring date. Yet another limitation related to the data used in the study that we had to be concerned with was the base in which one or two variables were measured; specifically whether at current prices or at a specific year-base price.

1.5.2 Study Delimitations

Price transmission mechanism is a broad area of research. However, this study intends to look only into some selected market prices. Also, the study focuses only on these selected macroeconomic variables, controlling for non-macroeconomic variables.

1.6 Outline of the Study

The study is organized into five chapters. Following this introductory chapter, Chapter 2 presents a literature survey on price asymmetry modelling. Chapter 3 focuses on the research methodology and theoretical foundations followed in the study. This chapter also includes a descriptive overview of all the thirteen prices studied in this thesis. Chapter 4 conducts an extensive analysis of the data as well as discussions on the results. Chapter 5 presents a summary of the findings and recommendations.

CHAPTER TWO

Review of the Relevant Literature

2.1 Introduction

Economists have always had an interest in relationships between prices, even though theory in general argues that other variables are equally important in describing and explaining market equilibrium. There are two common forms of analysis of relationships between prices - market integration studies and analyses of marketing margins (Fackler and Goodwin, 2001). In market integration studies, the objective is to investigate the extent of a market by analyzing the development of prices over time for potentially competing products while the analysis of marketing margins focuses on how supply and demand shocks at one level of the supply chain are transmitted to other levels in the chain. The investigation of relationships between prices in market integration analysis is confronted by the problem of simultaneity problem, as economic theory does not gives any indication about the direction of the relationship (Goodwin et al, 1990a). Moreover, this problem only disappears if one price is exogenous, that is, determined outside the system. In the market integration case this is only possible if one market can be assumed to be the leading price. This is the case if price signals are transmitted only in one direction in the supply chain.

In market integration analysis, the econometric models are mostly conducted on the logarithms of the prices in question, even though there are also situations where prices are analyzed in their levels (Ravallion, 1986). In the transportation of goods, say, the basic relationship to be investigated is given as:

$$\ln P_{1t} = a + b.\ln P_{2t}, \qquad (2.1)$$

where a is a constant term, called the proportionality coefficient, captures cost of transportation and b gives the relationship between the prices (Goodwin et al, 1990b). If $b=0$, there are no relationship between the prices, while if $b=1$, the relative price is constant. This is the so-called Law of One Price and in such a situation, the goods in question are said to be perfect substitutes. There exists a relationship between prices if $0<b<1$. For this scenario, the relative price will not be constant, and as so the goods are said to be imperfect substitutes. The analysis of prices in levels imposes a proportional relationship (i.e. stable relative price) when there is a relationship, and the alternative hypothesis includes both no and imperfect market integration. Equation 2.1 describes the situation when prices adjust immediately, although in most instances, there will be a dynamic adjustment pattern. The adjustment pattern can be accounted for by introducing lags of the two prices (Ravallion, 1986).

The choice of functional form, either at levels or in logarithm form, can be regarded as a discussion of whether there is a unit or a percentage mark-up. If the objective is to investigate market integration and price transmission simultaneously, it is recommended that one chooses between the two functional forms. In this study, the logarithmic specification will be used as this allows us to distinguish between more economic structures, more so due to the fact that the theory of derived demand indicates that one should expect a relationship between prices at different stages in the supply chain, although one will in general not expect the prices to be proportional giving full price transmission (Gardner and Heien, 1975).

2.2 Price Transmission and Macroeconomic Theory

This section briefly presents a discussion on some fundamentals of price transmission with particular emphasis on horizontal and vertical transmission, symmetry in transmission, and ambiguities in the interpretation transmission results.

2.2.1 Horizontal and Vertical Transmission

As stated earlier, the issue of price transmission has been extensively touched in the economic literature, surveyed by Meyer and Cramon-Taubadel (2004). A distinction can be drawn between horizontal price transmission, which relates to the interaction between prices of a given commodity on different markets at the same stage of the supply chain and vertical price transmission, which also relates to the interactions between prices at different stages.

Vertical price interactions are characterized by degree of speed, and type of price adjustments through the supply chain. Such changes are usually represented as responses to shocks at some point in the chain. The degree of price transmission may depend on the following:

- The importance of the delivery from an upstream stage of the chain for the total costs of producing a processed commodity;
- the competitiveness of the markets; and
- The transaction costs associated with adjusting prices.

2.2.2 Symmetry in Transmission

In the recent literature, efforts of researchers have been geared toward asymmetries in price transmission. This entails differences in degree or speed of price adjustment, depending on whether the price-change is upward or downward. Among factors that can explain such asymmetries, the literature most often finds two major types of explanation. These are:

- Transaction costs; and
- Imperfect competition.

<u>Transaction Costs</u>

A number of sources have been attributed to transaction costs. Menu costs, which are related to changing price labels, advertisements, etc, may lead to a situation where suppliers are more reluctant to reduce prices than to raise them (Ball and Mankiw, 1994). Uncertainty about whether a price-change is temporary or long-lasting is also likely to affect decisions on price changes, although whether this leads to upward or downward asymmetry in price transmission is ambiguous.

Time lags in price transmission may be as a result of firms' holding inventory (Wohlgenant, 1985; Blinder, 1982). Hence, suppliers may be reluctant to lower their prices due to an input price decline, because of the fear that their inventory may run down too quickly, thus running the risk of disappointing customers (Reagan and Weitzman, 1982). The other side of the coin is that suppliers may feel reluctant to increase the prices of products with a short shelf-life, thus running the risk of not getting the products sold in time (Ward, 1982). In addition to these scenarios, some accounting methods and taxation intricacies may provide incentives for asymmetries in the pricing responses by firms. Suppliers may also fear negative reputation effects, if they raise their prices too often, implying an upward asymmetry in price transmission.

In a handful of research papers, authors like Gardner (1975) and Kinnucan and Forker (1987) found that policy interventions or expectations of such interventions often lead to downward asymmetric price responses by market agents. To support this conclusion, Goodwin and Piggott (2001) argued that if the price change is to be transmitted to other stages of the food supply chain, some threshold price change must be exceeded. This means that gains from changing the prices should more than outweigh the transaction costs associated with changing these prices.

Imperfect Competition

In an imperfect competitive market, market agents may have incentives and possibilities for exhibiting strategic behaviour in terms of pricing their products in ways that prevent raw material price changes from being fully transmitted to the prices of processed commodities. Such strategic explanations of asymmetric price response include:

- Market agents' fears of invoking a price war by adjusting their prices downwards (Zachariasse and Bunte, 2003). This leads to upward asymmetry in price transmission

- Suppliers' possibility of exploiting consumers' geographical constraints and the fact that finding the best offer involves search costs (Benson and Faminow, 1985). This also leads to upward asymmetry.

Even though increased market concentration often lead to a higher degree of strategic behaviour, resulting in upward asymmetry in price transmission, the presence of larger firms may also imply presence and/or utilization of economies of scale, which may lead to more effective price transmission (McCorriston et al., 2001; Weldegebriel, 2004) - the latter depending on the form of cost functions.

2.2.3 Ambiguities in Interpretation of Transmission Results

It is important to stress that neither transaction costs nor imperfect competition can lead to unambiguous conclusions about the extent and direction of asymmetries in vertical price transmission. Most of the sources of transaction costs discussed above may be expected to lead to upward asymmetry, although exceptions include firm' fear of not selling with short shelf-life in time and the fear of interventions from competition authorities. High concentration in an industry also has the potential to creating an upward asymmetry, although economies of scale may in some cases lead to more symmetric price transmission (McCorriston et al., 2001; Weldegebriel, 2004). In several instances, some of the above arguments may be more relevant than others, when taking specific account of, for example, the nature of the commodities, the structure of the industry, the variability of prices or the legislation surrounding the industry in question (McCorriston et al., 2001; Weldegebriel, 2004).

2.3 Price Transmission Elasticity

Assessing the spread in vertical price relationships and analyzing the nature of price transmission along the supply chain from the producer to consumer have evolved as widely used methods to gain insight into the functioning of, and degree of competition in food markets. In the literature, several authors have studied asymmetric price transmission using different econometric methods, from the classical Wolffram (1971) and Houck (1977) specification to cointegration (von Cramon-Taubadel, 1998) and threshold autoregressive models (e.g. Goodwin and Harper, 2000). As a result of the inherited pre-1989 distorted markets, low developed price-discovery mechanisms and often ad-hoc policy interventions, most transitional economies often have generally larger marketing margins and more pronounced price transmission asymmetries than advanced economies.

2.3.1 Theoretical Considerations

Since most data used in macroeconometric analysis are expressed in logarithms to reduce data variability, the estimated parameters can directly be interpreted as transmission elasticities of one price with respect to another. The dangers involved in this interpretation are clearly highlighted in the literature, particularly by the critics of the econometric approach. In fact, such parameters can be:

- Affected by factors that do not prevent market integration or the transmission of price signals (Barrett and Li, 2002; Brooks and Melyukhina, 2003), so that a low parameter may arise between two markets which are in fact integrated;

- Smaller than one even if price transmission and market integration are complete. A transmission elasticity is equal to one only if there are no fixed elements involved in the transaction (Sharma, 2003).

Given these two caveats, still the value of the parameters and their significance level provides information about the extent to which markets share the same price shocks or, conversely, the extent to which they are "messy" (Barrett and Li, 2002). In other words, a transmission parameter summarizes the overall effect of a set of factors affecting price signals, including transaction costs that may be stationary, the existence of market power among the agents involved in transactions, the existence of non-constant returns to scale, the degree of product homogeneity, the changes of the exchange rates, and the effects of border and domestic policies (Barrett and Li, 2002). Since most price transmission estimation include a constant term, they should include only the effects of those elements that change proportionally with prices, without accounting for the interaction between the effects of each of those elements.

In the price transmission equations, the coefficient of the constant term may be included together with the transmission elasticity, so as to account for the fixed effects separately from the proportional ones. For instance, in multi-markets models, the inclusion of a set of variables representing a specific policy tool should be preferred to the inclusion of a simple transmission elasticity, which summarizes the effect of many factors, since in the first case it is possible to assess the effect of a change in the policy itself on the transmission of prices, while in the second it will not be possible to separate the effect of the policy change from one taking place in the other factors affecting transmission. The calibration of policy analysis models could benefit from information on transmission parameters. It is possible to check the extent to which the results generated by the structural model are consistent with the overall price transmission observed in the real econometric situation. The application of this concept is found large size equilibrium models, specifically in agricultural market projection and policy simulation where policy variables, rather than transmission elasticities, are not defined. A review of the spatial price transmission mechanism in such models is documented in Cluff (2003) in which, for example, in the FAO WFM model price transmission for countries with no WTO commitments is modelled without qualifying the cause affecting it, simply with a price transmission elasticity derived in some cases from estimation, but often from expert judgments or calibration. In Cluff's (2003) document, policies are assumed to be the major determinant of price transmission for countries that have undertaken WTO commitments, together with a residual term accounting for transaction costs.

In the literature on price transmission, market structure as a factor affecting price transmission appears very rarely in transmission equations of large size equilibrium models. For instance, Francois et al (2003) talked about the GTAP application where the assumption of increasing returns to scale allows for spatial transmission to be governed by a non-competitive pricing rule. A similar example on the use of market structure as a factor affecting price transmission can be found in the partial model proposed by Moro et al. (2002), in which price transmission include policies as price wedges, while wedges between producer and consumer prices, representing vertical transmission, are driven by Herfindhal indexes, related to the degree of concentration of that particular market. Within the limitations implied by such simple modelling, the representation allows for a separate simulation of the effects of a change in the market structure of an industry and those in the policy setting (Moro et al, 2002).

In summary, rather than directly providing parameters to be inserted in policy analysis models, evidence on price transmission may be employed to check the consistency of the results of such models. Ideally, by including an explicit modelling of those factors that affect price transmission - such as policies, the exchange rate, transaction costs, quality differentials, the degree of concentration, etc, - equilibrium models should be able to reproduce a degree of transmission consistent with the one found in real life econometric situation.

2.3.2 Price Transmission Elasticity Estimation

Given two prices, P_1 and P_2, the marketing margin (M) is the difference between the two prices:

$$M = P_2 - P_1 . \qquad (2.2)$$

Since M is composed of an absolute amount and the mark-up of P_2, the relationship:

$$M_t = \alpha + \beta . P_{2,t} , \qquad (2.3)$$

where $\alpha \geq 0$ and $0 \leq \beta < 1$ suffices. By using the logarithmic data, the long-run elasticity between the two prices is readily available from the marketing margin model.

<u>**Scenario 1**</u>: If prices are determined at the producer level, the applicable mark-up model is given by:

$$P_{2,t} = \alpha_1 + \beta_1 . P_{1,t} \qquad (2.4)$$

where the term $\varepsilon_1 . P_{1,t}$ represents the price transmission elasticity from the P_1 towards the P_2.

- If $\varepsilon_1 = 1$, there is perfect transmission, and thus the mark-up will be $(e^{\alpha_1} - 1)$.
- If $0 < \varepsilon_1 < 1$, there is imperfect transmission.

Scenario 2: If prices are determined at the consumer level, the applicable mark-down model is given by:

$$P_{1,t} = \alpha_2 + \varepsilon_2 . P_{2,t} \qquad (2.5)$$

where ε_2 represents the elasticity of transmission from the P_2 to P_1.

- If $\varepsilon_2 = 1$, there is perfect transmission, and thus the mark-down will be $(1 - e^{\alpha_2})$.
- If $\varepsilon_2 > 1$, there is imperfect transmission.

2.4 Causes of Asymmetric Price Transmission

A common perception is that responses to price increases differ from responses to price decreases. In particular, retailers tend to pass more rapidly price increases to consumers, whilst it takes longer for consumer prices to adjust to producer prices if the latter decrease. There are several major explanations for the existence of price asymmetries. First, asymmetric price transmission occurs when firms can take advantage of quickly changing prices. This is explained by the theory of the search costs (Miller and Hayenga, 2001). They occur in locally imperfect markets, where retailers can exercise their local market power. Although customers would have a finite number of choices, they might face difficulties in quickly gathering information about the pricing of the competing stores because of the search costs. Thus firms can quickly raise the retail price as the producer price rises, and reduce much slower retail prices when upstream prices decline.

Second, asymmetric price transmission occurs as a result of the problem of perishable goods that withholds retailers from raising prices as producer prices rise (Ward, 1982). Wholesalers and retailers in possession of perishable goods may resist the temptation to increase the prices because they risk a lower demand and ultimately being left with the spoiled product. Third, the adjustment costs or menu costs (Goodwin and Holt, 1999) may underlie asymmetric price adjustments. Menu costs involve all the cost occurring with the re-pricing and the adoption of a new pricing strategy. As with perishable goods, menu costs also act against retailers changing prices. Finally, the exercise of market power can favour asymmetric price transmission. It appears in markets with highly inelastic demand and concentrated supply; many food chains have such market organization characteristics. It also needs to be mentioned that such collusive behaviour is rather difficult to maintain in long run, because of the incentive for one firm to cheat the others (Miller and Hayenga, 2001).

A number of other causes of asymmetric price transmission have been proposed in the literature that cannot be subsumed directly under market power or adjustment costs. In agriculture economics, price support, often in the form of floor prices, is quite common. In their paper, Kinnucan and Forker (1987) argued that a political intervention can lead to asymmetric price transmission if it leads wholesalers or retailers to believe that a reduction in farm prices will only be temporary because it will trigger government intervention, while an increase in farm prices is more likely to be permanent. From another angel, Blinder et al. (1998) argued in their research paper that psychological pricing points could have an analogous influence on price transmission.

In their influential papers, researchers like Kinnucan and Forker (1987) and v. Cramon-Taubadel (1998) consider asymmetric price transmission in the framework of the marketing margin model developed by Gardner (1975) and argued that the farm-retail price spread depends on shifts in both retail-level demand and farm-level supply. Under conditions of perfect competition and constant returns to scale, Gardner (1975) deduces a stronger impact of retail-level demand shifts than of farm-level supply shifts on the farm-retail price spread, a scenario Kinnucan and Forker (1987) argued that this differential impact could lead to asymmetric price transmission.

On the other hand, von Cramon-Taubadel (1998), argue that asymmetric price transmission will only appear to arise if one type of shift is predominantly positive or negative, i.e. if the distribution of demand and/or supply shifts is skewed (Gardner, 1975). Otherwise there will be equally many episodes of larger demand-driven (and smaller supply driven) transmission in each direction (von Cramon-Taubadel, 1998). An instance could be cited about the European beef market, where large negative shifts in retail demand due to food crises have been common in recent years. In the framework of

Gardner's model, the result would be a preponderance of episodes of strong transmission of downward price movements.

In their research paper, Bailey and Brorsen (1989) also argued that APT can arise due to such asymmetric information. The authors were of the view that if larger firms benefit from economies of size in information gathering, this could lead to asymmetric information between competing firms. The authors (Bailey and Brorsen, 1989) cited the US broiler market as an example and cited a spokesman for a large buyer of broilers who claims that price decreases are not reported as quickly as price increases. According to von Cramon-Taubadel et al (1995), a similar asymmetric price transmission might arise under institutional arrangements whereby reference or indicative, for example wholesale prices are determined and quoted on a regular basis by committees of observers, often industry representatives who have vested interests.

2.5 Spatial Asymmetric Price Transmission

In the context of price transmission, asymmetry can be categorized into three - due to speed, due to magnitude, and due to a combination of speed and magnitude. The first category relates to whether it is the speed or magnitude of price transmission that is asymmetric. Assuming a price, P_{1t}, depends on another price, P_{2t}, that either increases or decreases at a specific time, t.

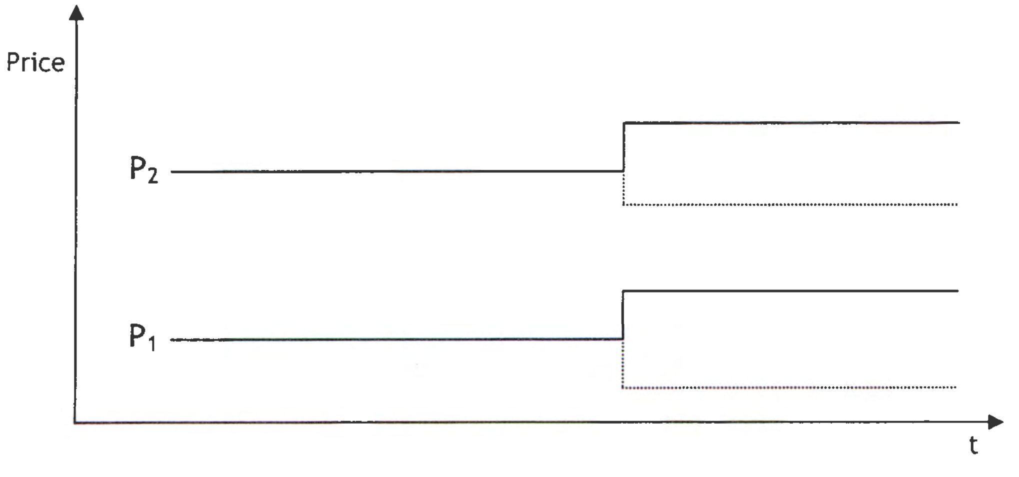


Figure 3.1: Asymmetric Price Transmission - Magnitude Only

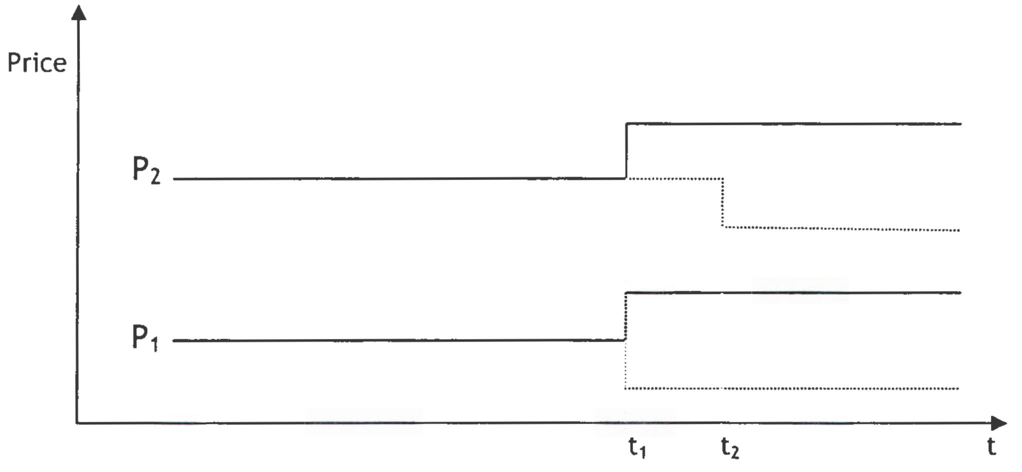


Figure 3.2: Asymmetric Price Transmission - Speed Only

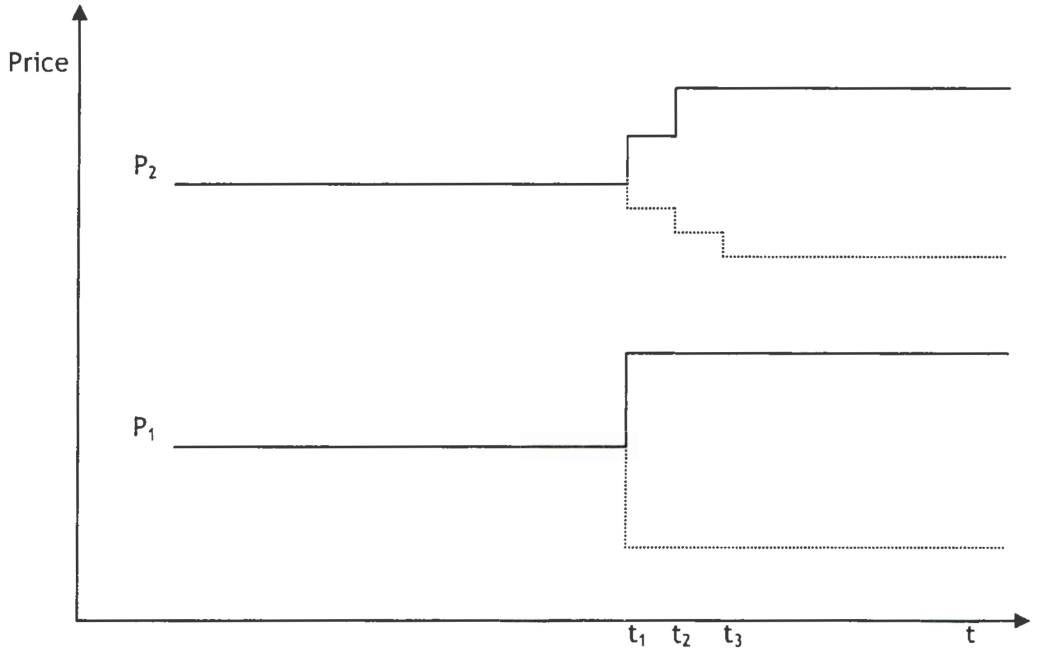


Figure 3.3: Asymmetric Price Transmission - Speed and Magnitude Combined

Then the magnitude of the response to a change in P_{2t} depends on the direction of this change (Figure 3.1) or the speed of the response that depends on the direction of this change (Figure 3.2). Combining the two fundamentals of asymmetry is conceivable. In Figure 3.3, price transmission is asymmetric with respect to the two fundamentals f asymmetry because an increase in P_{2t} takes two time points, t_1 and t_2, to be completely transmitted to P_{1t}, while a decrease in P_{2t} requires three time points, t_1, t_2 and t_3.

Given the two prices, P_{1t} and P_{2t}, spatial asymmetric price transmission occurs when the two prices are not at different levels of the marketing chain but rather to prices for the same product at different locations. The literature argues that spatial price transmission may be asymmetric due to four reasons - asymmetric adjustment costs, asymmetric information, market power, and asymmetric price reporting (Bailey and Brorsen (1989).

The welfare effects of the three types of asymmetric price transmission are shown schematically in the shaded regions in Figure 3.1, Figure 3.2, and Figure 3.3, respectively. Asymmetry in relation to the magnitude of price transmission leads to a permanent transfer of welfare, the size depends predominantly on the price changes and transaction volumes involved. Figure 3.3 is a schematic representation of asymmetry with respect to speed and magnitude leading to a combination of provisional and unending welfare transfers. If an asymmetric price transmission results from the exercise of market power, then asymmetry with respect to magnitude, perhaps accumulated over a number of asymmetric price transmission events, could be used as a way of secretly imposing or 'easing in' oligopoly or monopoly pricing. In this case, as noted above, asymmetric price transmission will imply not only welfare transfers but also net welfare losses.

Following Peltzman (2000), the second category relates to whether a price transmission is positive of negative. If the effect of an increase in P_{2t} on P_{1t} is more swift or rapid than to a decrease, such an effect results in what is termed 'positive asymmetry'. In a similar fashion, if the effect of an decrease in P_{2t} on P_{1t} is more swift or rapid than to a increase, such an effect becomes what is referred to as the 'negative asymmetry'. Figure 3.4 and Figure 3.5, respectively, present the schematic representations of these two types of asymmetry.

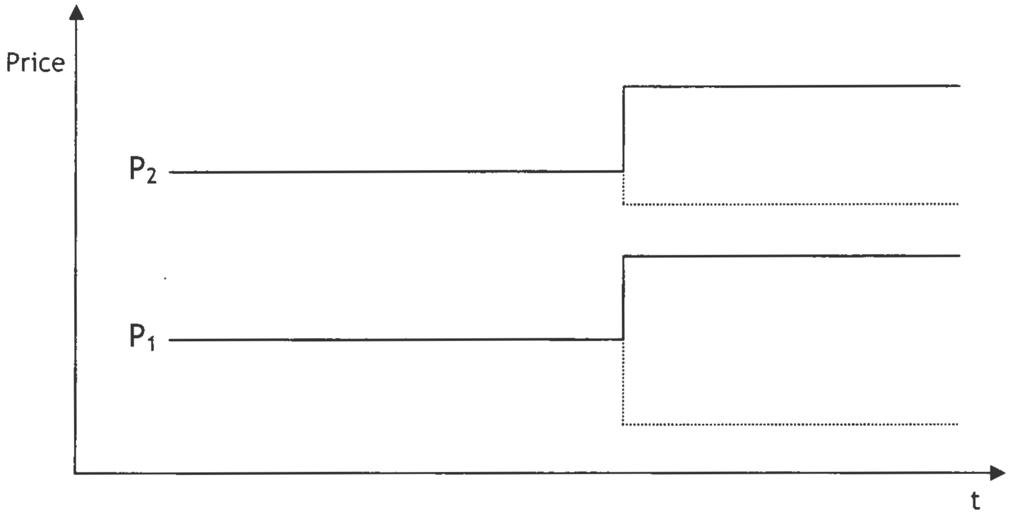


Figure 3.4: Positive Asymmetric Price Transmission

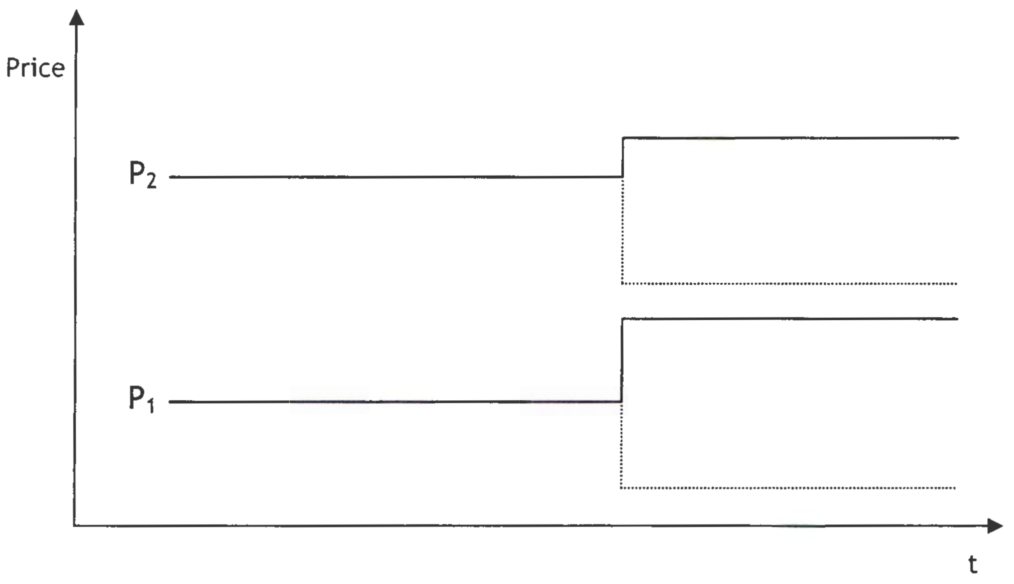


Figure 3.5: Negative Asymmetric Price Transmission

Throughout this discussion, no assumption has been made to the effect that price transmission has to flow from the input price to output price or vice versa. It is likely that changes in output prices be transmitted to input prices. Hence, it still makes sense to differentiate between the speed and magnitude of asymmetric price transmission. However, the difference between positive and negative asymmetric price transmission - explained above in relation to how pout reacts to a change in P_{2t} - must be generalized.

We recommend that positive asymmetric price transmission be explained as a set of reactions according to any price movement that squeezes the margin.

The third category of asymmetric price transmission relates to whether it is vertical or spatial. In the vertical context, for instance, farmers and consumers often complain that increases in farm prices are more rapidly transmitted to the wholesale and retail levels than equivalent decreases in farm prices. In the spatial context, for instance, a rise in the export price for wheat in one country would cause a more pronounced reaction in the export price in another country than a corresponding reduction of the same magnitude. Just as in the case of spatial asymmetric price transmission, vertical asymmetric price transmission can be classified according to speed and magnitude, and according to whether it is positive or negative.

In a spatial context, adjustment costs can include the costs of transporting goods. Spatial asymmetric price transmission might arise if the costs of transportation differ from the direction of trade. For instance, transportation facilities may be chanelled towards trade in one particular direction (Goodwin and Piggott, 2001) for historical reasons, or speed and costs of transportation might be asymmetric due to natural conditions. If two locations are divided by asymmetric transportation, then price transmission will show to be asymmetric if trades flow change from time to time originating from one or both locations are mainly positive or negative. If price movements are distributed evenly at both locations, then both faster (down-stream) and slower (up-stream) transmission will be distributed equally.

2.6 Chapter Conclusion

This chapter has presented a review of the literature relevant to this study. In the next chapter, the research methodology and procedures used in the study are extensively discussed.

CHAPTER THREE

Research Methodology and Theoretical Foundations

3.1 Introduction

This chapter describes the research methodology and theoretical foundations followed in this study. The remainder of the chapter is structured as follows.

Section 3.2 briefly discusses the research methodology while Section 3.3 discusses extensively the research processes used to address the research aims and objectives. Section 3.4 conducts a descriptive analysis of the variables used in the study and Section 3.5 concludes the chapter.

3.2 Research Methodology

The empirical analysis is conducted using thirteen major macroeconomic variables that represent fairly the South African economy.

3.2.1 Time Series Data

A time series is a set of observations on the values that a variable takes at different times. Such data may be collected at regular time intervals, such as daily, weekly, monthly, quarterly, or annually. For this study, the data, collected on quarterly basis, stretches from the first quarter of 1990 until the second quarter of 2007.

3.2.2 Sources and Accuracy of Time Series Data

Time series data used in empirical analysis may be collected by a government agency, an international agency, a private organization, or an individual. For this study, the data were obtained from the South African Reserve Bank (SARB) and are reported in Appendix A. Even though several time series data are available for macroeconometric research, the quality of the data could be of great concern. In particular, macroeconomic data are generally available at a highly aggregate level. Such highly aggregated macroeconomic data may not tell us much about the micro units that are used. Again, because of confidentiality, certain macroeconomic data can be published only in highly aggregate form. For instance, some private economic institutions are not allowed to disclose certain data. Because of these and many other problems, it is advised that the researcher should always keeps in mind that the results of research are only as good as the quality of the data.

3.3 Theoretical Foundations

Most macroeconomic time series are non-stationary over time, that is, they contain unit roots. A time series is said to be non-stationary if its mean and variance are not constant over time (Makridakis et al, 1998). Application of standard classical ordinary least square (OLS) estimation methods to non-stationary time series can result in biased estimates, inferences and spurious results. It is also important to note that even though many macroeconomic time series contain stochastic trends, and for that matter non-stationary at levels, many of them tend to move together over the long-run, suggesting the existence of a long-run equilibrium relationship.

Two or more non-stationary time series are cointegrated if there are one or more linear combinations of the time series that are stationary (Makridakis et al, 1998). This means that the stochastic trends of the time series are related over time, moving towards the same long-run equilibrium. Moreover, if a time series is non-stationary, some forecasting tools, such as Box-Jenkins Autoregressive Moving Average (ARMA) modelling cannot be directly applied. In the context of this study, it is, therefore, important that stationarity tests of prices variables be conducted.

In the literature, it is argued that responses of different economic agents to market forces may not necessarily be symmetric, implying that changes in product prices at the 'upstream' level may show different responses at the 'downstream' level, and vice versa. For instance, a large proportion of consumers complain that the retail oil prices in 2007 to mid 2008 rise more sharply when crude oil prices are rising than they fall when crude oil prices are falling. Intuitively, this means that cost increases are completely and rapidly passed on to the consumer, while there is a slower and less complete transmission of cost savings. A number of macroeconometric techniques have been applied in the literature to explain the dynamics of price transmission of goods and products. This section discusses the methods and procedures used in this thesis. These include methods used in identifying asymmetric transmission as well as its extent, the KPSS test of stationarity,

3.3.1 Stationarity Test

Of the number of unit roots tests described in the literature, the most frequently used are the Augmented Dickey-Fuller (ADF) unit root test, the Phillips-Perron (PP) unit roots test, and the Kwiatkowski-Phillips-Schmidt-Shan (KPSS) stationarity test. Given the time series $\{X_t : t = 1,2,3...n\}$, the KPSS stationarity test is started with the model:

$$X_t = \boldsymbol{\beta}'\mathbf{D}_t + \mu_t + \varepsilon_t, \qquad \varepsilon_t \sim I(0) \qquad (3.1)$$

$$\mu_t = \mu_{t-1} + e_t, \qquad e_t \sim WN(0, \sigma_e^2), \qquad (3.2)$$

where D_t is a vector of deterministic components (KPSS, 1992). The hypotheses to test are:

$$H_0 : \sigma_e^2 = 0 \quad [X_t \sim I(0)] \qquad (3.3a)$$

$$\text{vs.} \quad H_1 : \sigma_e^2 > 0 \quad [X_t \sim I(1)]. \qquad (3.3b)$$

The KPSS test statistic is the Lagrange Multiplier (LM) for testing the null hypothesis of stationarity:

$$KPSS = \frac{1}{n^2 \hat{\sigma}_\varepsilon^2} \sum_{t=1}^{n} S_t^2, \qquad (3.4)$$

where $$\hat{S}_t = \sum_{j=1}^{t} \hat{\varepsilon}_j, \quad t=1,2,...,n, \qquad (3.5)$$

and $\hat{\varepsilon}_t$ is the residual from the regression of X_t on the deterministic trend, D_t, only, while $\hat{\sigma}_{\varepsilon}^2$ is the consistent estimate of the long-run variance of ε_t using $\hat{\varepsilon}_t$. If the deterministic trend, D_t, contains only a constant then the residuals come from regressing X_t on the intercept, c, while if a linear trend is also present, then the residuals result from the regression of X_t on the intercept, c, as well as the time trend, t. In the same sense, if a quadratic trend is present, then the residuals are obtained from the regression of X_t on the constant term, c, as well as time trends, t and t^2.

Asymptotic results are obtained if the null hypothesis is true and the critical values from the asymptotic distributions are obtained by simulation methods (KPSS, 1992). The stationarity test is a one-sided right-tailed test so that one rejects the null hypothesis of stationary at the $[100\alpha]$% level if the KPSS test statistic is greater than the $[100(1-\alpha)]$% quantile from the appropriate asymptotic distribution.

Prior to performing the KPSS stationarity test, it is important to know whether the time series contains any trend components. Including too many deterministic regressors in the KPSS stationarity test will result in lost power, while not including enough of them will bias the test in favour of the non-stationary alternative. Based on the regression results of trend, we include intercept and trend in the equation. In order to select an appropriate number of lags, p, in the KPSS stationarity test, we use up to 4 lags and select the best model based on univariate information criteria given by:

- Univariate Akaike Information Criterion: $AIC_p = -\ln(\hat{\sigma}_p^2) + \frac{2p}{n}$ (3.6)
- Univariate Bayesian Information Criterion: $SBC_p = \ln(\hat{\sigma}_p^2) + \frac{p.\ln(n)}{n}$ (3.7)
- Univariate Hannan-Quinn Criterion: $HQC_p = \ln(\hat{\sigma}_p^2) + \frac{2p.\ln[\ln(n)]}{n}$, (3.8)

where n is the sample size, and $\hat{\sigma}_p^2 = \frac{1}{(n-p-1)}\sum_{t=1}^{n}\hat{\varepsilon}_t^2$ is the variance.

3.3.2 Cointegration and Long-Run Equilibrium

The Johansen-Juselius cointegration test is based on the VAR(p) and VECM representations in equations (3.1) and (3.2). From equation (3.2), we can test the null hypothesis that there are $r = 1,2,\ldots,R$ cointegrating vectors using either the 'trace test' or the 'maximal eigenvalue test' shown in equation (3.9) and equation (3.10):

$$J_{trace} = -n.\sum_{j=r+1}^{M} \ln(1-\hat{\lambda}_j^2), \tag{3.9}$$

where n is the sample size, M is the number of variables, r is the number of cointegrating vectors, and $\hat{\lambda}_j$ is the i correlation between the i-th pair of variables; and

$$J_{max} = -n.\ln(1-\hat{\lambda}_{r+1}). \tag{3.10}$$

The trace test tests the null hypothesis r cointegrating vectors against the alternative hypothesis of M cointegrating vectors while the maximum eigenvalue test tests the null hypothesis of r cointegrating vectors against the alternative of r + 1 cointegrating vectors. The null hypotheses are rejected in favour of the alternative if a test statistic is larger than the 5% critical value (Johansen and Juselius, 1990). Asymptotic critical values are provided by most econometric software packages including EViews, Gretl, and SAS. Once a set of variables have been found to cointegrate, a Vector Error Correction Model (VECM) is appropriate to simultaneously assess the long and short run dynamics of the system. In equation (3.2), the term, δY_{t-1}, called the error correction terms, represent deviations from the long-run equilibrium relationship. If the term, $\delta Y_{t-1} = 0$, then it represents a convergence to the long-run equilibrium in the system. If, on the other hand, $\delta Y_{t-1} \neq 0$, the system is out of equilibrium.

3.3.3 Determination of Asymmetric Price Transmission and Elasticity

The discussion on price transmission provided in the section above encompasses the case of perfect market integration and the inherent dynamic market relationships that arise due to discontinuities in trade. More importantly, it implies hypotheses, through its components, that are testable within a cointegration-error correction model framework. A number of macroeconometric techniques can be used to test each of the components of price transmission and thus ultimately assess the extent of price transmission. The techniques include:

- Cointegration;
- Causality;
- Error Correction Mechanism; and
- Symmetry.

Each of the above tests can be used to examine evidence about the components of transmission thus providing particular insights into its nature. Collectively, these macroeconometric techniques offer a framework for the assessment of price transmission and market integration.

In Chapter 2, the causes of asymmetric price transmission were extensively discussed. Devising appropriate tests for the presence of asymmetric price transmission and measuring its extent presents a challenge to researchers. In this section, the method used in identifying asymmetry in price transmission is discussed.

Besides agricultural markets, especially those for gasoline and financial products have been tested for asymmetric price transmission. Nonetheless, a defining characteristic of the literature on asymmetric price transmission, and especially estimation techniques, is the strong focus on agricultural markets. More than other fields, agricultural economics is characterized by a long running interest in testing for asymmetric price transmission. Surprisingly, however, this extensive literature appears to have had little impact on research in other areas of economics.

In a number of research papers, for example von Cramon-Taubel (1997), Miller and Hayenga (2001), Goodwin and Holt (1999), Azzam (1999), and Abdulai (2002) various empirical techniques were used to price transmission asymmetries in food marketing chains. Findings from these researchers indicated, among others, that:

- Changes in farm and wholesale prices are either not fully, or they are more than fully transmitted to consumer prices;

- Changes in consumer prices are not related to short-run changes in farm prices and follow medium- and long-run changes in farm prices with a time lag; and

- Downstream changes in consumer prices show a longer time lag than upstream changes do.

A number of possible explanations can be put forward to explain this asymmetry depending on the market structure and the nature of the product. The general explanation attributed to these scenarios relates to the issue whether retailers pass on price increases, while decreases in price are not completely transferred to the consumer. There are basically three main reasons put forward by these authors. First, that price increases are passed on to the consumer faster than decreases, and that firms often react faster to decreases in profit margins than increases. The second reason is the presence of search costs in locally imperfect markets. The third possible reason relates to the issue of market power. In his paper, Von Cramon-Taubadel (1997) argued that asymmetry in the German pork market was caused by market power and inventory holding.

In the literature, a number of different techniques have been proposed when testing for asymmetric price transmission. The selection of technique depends on the data available and the types of questions that need to be addressed. The most widely used method for testing market power and asymmetric price transmission in macroeconometric literature is the use of time-series models. This section presents brief theoretical underpinnings in the analysis of price transmission within the context of this study.

A macroeconomic variable $\{Y_t : t = 1,2,..n\}$, which depends on its own lags, Y_{t-i}, i=1,2, ... and on another macroeconomic variable $\{X_t : t = 1,2,..n\}$, both contemporaneous and lagged, X_{t-j}, j=1,2,.., has an Autoregressive Distributed Lag (ARDL) representation given by:

$$Y_t = \sum_{i=1}^{p} \phi_i Y_{t-i} + \sum_{j=0}^{q} \theta_j X_{t-j} + \varepsilon_t , \qquad \varepsilon_t \sim WN(0, \sigma_\varepsilon^2) . \tag{3.11}$$

By assuming that X_t has a different impact on Y_t, equation (3.11) can be generalized to incorporate asymmetries according to whether its sign is positive (+) or negative (-):

$$Y_t = \sum_{i=1}^{p} \phi_i Y_{t-i} + \sum_{j=0}^{q} \theta_j^+ X_{t-j}^+ + \sum_{k=0}^{r} \theta_k^- X_{t-k}^- + \varepsilon_t . \tag{3.12}$$

In equation (3.12), a test of the null hypothesis,

$$H_0 : \theta_0^+ = \theta_0^- , \tag{3.13}$$

provides information about the contemporaneous impact of X_{t-j}^+ and X_{t-k}^- on Y_t, which is defined to be asymmetric or symmetric according to whether the null is rejected or not. Equation (3.12) can also be used to check whether the impact of X_{t-j}^+ and X_{t-k}^- is the same at any lag by testing the null hypothesis,

$$H_0 : \theta_j^+ = \theta_k^- , \qquad j = 1,2,\ldots,q \quad \text{and } k = 1,2,\ldots r \tag{3.14}$$

The rejection (non-rejection) of the null hypothesis in equation (D) means asymmetry (symmetry) due to the distributed lag effect (Frey and Manera, 2005). Lastly, equation (3.14) can, again, be used to test whether the cumulated effect of X_{t-j}^+ and X_{t-k}^- at lags $t-j$ and $t-k$, by jointly testing the two hypotheses in equations (3.13) and (3.14).

If the two macroeconomic variables, Y_t and X_t, are stationary, then ARDL can be consistently estimated using the method of ordinary least square (OLS); but if they are nonstationary then the standard linear regression analysis can lead to spurious results (Granger and Newbold, 1974). In their research paper, Engle and Granger (1987) established that, if $Y_t \sim I(1)$ and $X_t \sim I(1)$, and provided the two macroeconomic variables cointegrated, an equilibrium correction mechanism (ECM) of the form:

$$\Delta Y_t = c.\Delta X_t + \zeta(Y_{t-1} - \delta X_{t-1}) + \varepsilon_t , \qquad (3.15)$$

can be developed with cointegrating vector $(1-\delta)$ to correct the situation. In equation (3.15) the term $(Y_{t-1} - \delta X_{t-1})$ represents the error correction term, ECT_{t-1}. Granger and Lee (1989) incorporated asymmetries in equation (3.15) by adding lagged variables and autoregressive effects:

$$\Delta Y_t = \sum_{i=1}^{p} \phi_i Y_{t-i} + \sum_{j=0}^{q} \theta_j^+ X_{t-j}^+ + \sum_{k=0}^{r} \theta_k^- X_{t-k}^- + \zeta^+ .ECT_{t-1}^+ + \zeta^- .ECT_{t-1}^- + \varepsilon_t , \qquad (3.16)$$

where ECT_{t-1} is the error correction term split into positive and negative parts. Equation (3.16) considers all the asymmetries which are testable within the ARDL specification. In this study, the author appeals to a modified version of the Engle-Granger ECM (EG-ECM) where the independent variable, X_t, and the error correction term, ECT_{t-1}, is split into increasing and decreasing phases by dummies. The condition that Y_t and X_t be cointegrated forms the basis. The modified EG-ECM approach involves the following steps:

Step 1: Estimate the long-run equilibrium relationship between Y_t and X_t as:

$$Y_t = \alpha_0 + \alpha_1 .X_t + e_t , \qquad t = 1,2,\ldots,n . \qquad (3.17)$$

Step 2: The error correction term, ECT, obtained as

$$ECT_t = e_{t-1} = Y_{t-1} - \alpha_0 - \alpha_1 .X_{t-1} , \qquad (3.18)$$

and enters the ECM as

$$\Delta Y_t = c + \sum_{i=1}^{p} \phi .\Delta Y_{t-i} - \sum_{j=1}^{q} \theta_j .\Delta X_{t-j+1} + \zeta .ECT_t + \varepsilon_t . \qquad (3.19)$$

Step 3: To allow for symmetry in transmission between Y_t and X_t, change and equilibrium effects caused by variable increases are separated from those caused by variable decreases by including additional dummies in the model:

$$\Delta Y_t = c + \sum_{i=1}^{p} \phi_i . \Delta Y_{t-i} + \sum_{j=1}^{q} \theta_j^{+} . D_{t-j+1}^{+} . \Delta X_{t-j+1}^{+} + \sum_{j=1}^{q} \theta_j^{-} . D_{t-j+1}^{-} . \Delta X_{t-j+1}^{-} + \zeta^{+} . B_t^{+} . ECT_t^{+} + \zeta^{-} . B_t^{-} . ECT_t^{-} + \varepsilon_t , \quad (3.20)$$

where $D_{t-j+1}^{+} = \begin{cases} 1, & \text{if } \Delta X_{t-j+1} > 0 \\ 0, & \text{Otherwise} \end{cases}$

$$D_{t-j+1}^{-} = \begin{cases} 1, & \text{if } \Delta X_{t-j+1} < 0 \\ 0, & \text{Otherwise} \end{cases}$$

$$B_t^{+} = \begin{cases} 1, & \text{if } ECT_t > 0 \\ 0, & \text{Otherwise} \end{cases}$$

$$B_t^{-} = \begin{cases} 1, & \text{if } ECT_t < 0 \\ 0, & \text{Otherwise} \end{cases} .$$

Asymmetry in transmission is present if the null hypothesis that the estimated coefficients of the respective positive and negative variables are equal is rejected by an F-test (von Cramon-Taubadel and Goetz, 2007).

3.3.4 The Engle-Granger Two-Step Causality Test

To establish the causal relationships between two price variables, Y_t and X_t, the Engle-Granger two-step causality test will be appeal to (Granger, 1988). The complete dynamic Engle-Granger Vector Error Correction Model (VECM) specifications are of the form:

$$\Delta Y_t = c_1 + \sum_{i=1}^{p} \phi_i \Delta Y_{t-i} + \sum_{j=1}^{q} \theta_j \Delta X_{t-j+1} - \zeta_1 . ECT_{1,t} + \varepsilon_{1,t} \quad (3.21)$$

$$\Delta X_t = c_2 + \sum_{i=1}^{p} \phi_i \Delta Y_{t-i+1} + \sum_{j=1}^{q} \theta_j \Delta X_{t-j} - \zeta_2 . ECT_{2,t} + \varepsilon_{2,t} . \quad (3.22)$$

- To check whether there exists a feedback long-run relationship between Y_t and X_t, test the null hypothesis:

$$H_0: \zeta_1 \neq 0, \ \zeta_2 \neq 0.$$

- To check whether X_t, in the long-run, causes Y_t, test the null hypothesis:

$$H_0: \zeta_1 \neq 0, \ \zeta_2 = 0.$$

- To check whether X_t, in the long-run, causes Y_t, test the null hypothesis:

$$H_0: \zeta_1 = 0, \ \zeta_2 \neq 0.$$

3.3.5 Vector Autoregression and Vector Error Correction Model

Prior to testing the existence or non-existence of asymmetries in price transmission between two variables, Y_t and X_t, the two variables must be cointegrated. This study appeals to the Johansen-Juselius cointegration analysis technique employed in the vector autoregression (VAR) set-up (Johansen and Juselius, 1990).

Given a $n \times 1$ vector of endogenous variables, $\mathbf{Y}_t$, that are integrated of order 1, i.e., $\mathbf{Y}_t \sim I(1)$, the p-dimensional Vector Autoregressive, VAR(p), model is given by:

$$\mathbf{Y}_t = \boldsymbol{\mu}_0 + \sum_{j=1}^{p} \boldsymbol{\mu}_j \mathbf{Y}_{t-j} + \boldsymbol{\varepsilon}_t \ , \qquad (3.24)$$

where $\boldsymbol{\mu}_0$ is a vector of constants and $\varepsilon_t \sim iid(\mathbf{0}, \boldsymbol{\Omega})$. The order of the VAR(p) model, p, is selected based on either of the three information criteria, AIC, SBC, or HQC. Equation (3.24) has a Vector Error Correction Model (VECM) representation if it can be expressed as:

$$\Delta \mathbf{Y}_t = \boldsymbol{\mu}_0 + \boldsymbol{\delta} \mathbf{Y}_{t-1} + \sum_{j=1}^{p-1} \boldsymbol{\Phi}_j \Delta \mathbf{Y}_{t-j} + \boldsymbol{\varepsilon}_t \ , \qquad (3.25)$$

where $\delta = \sum_{j=1}^{p} \mu_j - I$ and $\Phi_j = - \sum_{k=j+1}^{p} \mu_k$,

and **I** is the identity matrix. The choice of the optimal lag length, p, for the VAR model can be addressed using any of the multivariate information criteria:

- Multivariate Akaike Information Criterion (AIC): $MAIC = \ln|\hat{\Sigma}| + \frac{2p}{n}$
- Multivariate Bayesian Information Criterion (BIC): $MBIC = \ln|\hat{\Sigma}| + \frac{p.\ln(n)}{n}$
- Multivariate Hannan-Quinn Criterion (HQC): $MHQC = \ln|\hat{\Sigma}| + \frac{2p.\ln[\ln(n)]}{n}$

where $\hat{\Sigma}$ is the estimated variance-covariance matrix of residuals and n is the sample size.

3.3.6 Impulse Response Function

In a situation where an unanticipated shock hits any of the error term, ε_t, in the VECM (i.e. equation 3.2), the shock will affect the dependent variable, Y_t, and since the error terms may be correlated with each other, the other equations of the VECM. In such a scenario, the responses of the dependent variable, Y_t, in the VECM due to the initial shock to the error term, ε_t, becomes what is known as 'impulse response'. For simplicity, the Impulse Response Function (IRF) is used graphically to depict the influence of a shock upon the VAR variables. An IRF show the dynamic response path of a variable due to a one-period standard deviation shock to another variable.

The VAR(p) representation of Y_t in equation (3.26):

$$Y_t = \mu_0 + \sum_{j=1}^{p} \mu_j Y_{t-j} + \varepsilon_t \ , \tag{3.26}$$

has a moving average representation of the form:

$$\mathbf{Y}_t = \mathbf{\Gamma}_0 + \sum_{j=0}^{\infty} \mathbf{\Gamma}_j \mathbf{e}_{t-j} , \tag{3.37}$$

where $\mathbf{\Gamma}_0 = B^{-1}\boldsymbol{\mu}_0$, $\mathbf{\Gamma}_j = B^{-j}\boldsymbol{\mu}_j$ for $j=1,2,\dots$, $\mathbf{e}_t = B^{-1}\boldsymbol{\varepsilon}_t$, and B is the lag operator such that $B^{-j}\mathbf{Y}_t = \mathbf{Y}_{t-j}$. Following Pesaran and Shin (1998), equation (3.27) can be re-written as:

$$\mathbf{Y}_t = \sum_{j=0}^{\infty} \mathbf{Z}_j \mathbf{e}_t , \tag{3.28}$$

where the matrices, $\mathbf{Z}_j$ for $j=1,2,\dots,n$ are recursively calculated using the relations:

$$\mathbf{Z}_n = \boldsymbol{\xi}_1 \mathbf{Z}_{n-1} + \boldsymbol{\xi}_2 \mathbf{Z}_{n-2} + \boldsymbol{\xi}_3 \mathbf{Z}_{n-3} + \dots + \boldsymbol{\xi}_p \mathbf{Z}_{n-p} ,$$

$\mathbf{Z}_n = 0$, for $n < 0$,

$\mathbf{Z}_0 = \mathbf{I}_p$, the $p \times p$ identity matrix,

$$\boldsymbol{\xi}_1 = \mathbf{I} - \boldsymbol{\delta} + \boldsymbol{\Phi}_1$$

and $\boldsymbol{\xi}_j = \boldsymbol{\Phi}_j - \boldsymbol{\Phi}_{j-1}$, for $j = 2,3,\dots,p$.

The Generalized Impulse Response Function (GIRF) of $\mathbf{Y}_j$ relating to a unit (one standard deviation) shock in the $i-th$ variable at time t is given as:

$$GIRL_i = \frac{\mathbf{Z}_n \Omega \varepsilon_i}{\sqrt{\sigma_i^2}} , \qquad n = 0,1,2,\dots \tag{3.29}$$

where $\boldsymbol{\Omega} = E(\mathbf{e}_t \mathbf{e}_t') = (\sigma_{ji})$. By updating equation (3.5), we obtain the response of $\mathbf{Y}_{t+j}$ to a one-unit impulse at time t. If each element of $\mathbf{Z}_j$ is plotted against j periods, one obtains the response of each variable in the system from the impulse to the different structural shocks.

3.3.7 Price Levels and Business Cycles

The investigation of business cycle in macroeconomic time series begins with the processes of detrending such variables after which information can be extracted to provide an overall picture of the cycle's basic features - volatility, persistence and co-movements. In the literature, a number of detrending or smoothing procedures has been proposed of which the most commonly used are first differencing, band-pass filters (Baxter and King, 1999) and Hodrick-Prescott (Hodrick and Prescott, 1997). Researchers have shown that using a first-difference filter cannot always guarantee a total elimination of very long waves in a macroeconomic time series and that the Hodrick-Prescott (1997) (hereafter, HP) method is more robust to handle this task.

If the time series $\{Y_t : t = 1,2,\ldots,n\}$ can be decomposed into a growth component, $Y_{g,t}$, and a cyclical component, $Y_{c,t}$:

$$Y_t = Y_{g,t} + Y_{c,t}, \tag{3.30}$$

then the HP filtering task is to select the growth component, $X_{g,t}$, to minimize the expression:

$$\sum_{t=1}^{n} Y_{c,t}^2 + \lambda \sum_{t=1}^{n} \left[\left(Y_{g,t+1} - Y_{g,t} \right) - \left(Y_{g,t} - Y_{r,t-1} \right) \right]^2, \tag{3.31}$$

where λ is a constant which is set 100 for annual time series, 1600 for quarterly time series, and 14400 for monthly time series. If λ is appropriately selected, the HP-filter extracts fluctuations for which the period of the cycle is 8 years or shorter (Stock and Watson, 1999). In their influential paper, Burnside (2000) found the length of the business cycles to be widely acceptable between 1.5 years and 8 years. Since the HP-filter eliminates the trend component of the series, the cyclical component must be tested for stationarity to ensure that any long term trend is completely eliminated. Once the time series has been detrended, three basic features of the cyclical component can be tested - volatility, persistence, and co-movements.

Volatility

Volatility assesses the amplitude of fluctuations and indicates the magnitude of the contribution of the macroeconomic time series, as well as its sensitivity, to aggregate fluctuations. This is assessed by using the standard deviation, where a low standard deviation suggests the macroeconomic time series does not contribute significantly to aggregate fluctuations.

Prices naturally increase and decrease, however, these fluctuations usually occur around an average price. The volatility of prices is a measure of the uncertainty of a price. This means that the higher the volatility the more uncertain the price is because of a higher degree of variation around the mean, i.e. the standard deviation. Authors including Rand and Tarp (2001) have established that business cycles in industrialized countries are cover a period of approximately 8 years with high volatility in investments and low one in consumption. For developing countries, the authors argued the comparatively shorter and on average more volatile cycles. The authors particularly concluded from a sample of Sub-Saharan African countries, Latin American countries, and Asian and North African countries for the period 1980-1999 that business cycles covered periods of 4 years to 5 years only. Particularly outstanding erratic cycles are present in Sub-Saharan African countries.

Persistence

Persistence shows the inertia in business cycles, particularly the cyclical component, and captures the length of observed fluctuations. This is simply measured by the first-order autocorrelation coefficient where a high coefficient implies a very persistent or long economic fluctuation. A positive coefficient suggests that high values follow high values or low values follow low ones, while negative coefficients indicate reversals from high to low values or the reverse.

Most macroeconomic variables do not respond instantaneously to changes in related variables. For instance, a rise in fuel prices will not affect the prices of goods on that same day. The modern electronic nature of pricing and record keeping, however, only allows prices to be adjusted the following day, as opposed to monthly or quarterly adjustments. It is, therefore, necessary to determine the period of input or related price changes (lags) that affects the recent prices of goods and services. This, in turn, affects the correlation (the tendency of two or more variables to relate either positively or negatively) between two macroeconomic variables.

Co-Movements

Co-movements with contemporaneous macroeconomic time series show the cyclicality of the macroeconomic variable. These are simply measured by the correlation coefficients where positive coefficient means procyclicality, negative coefficient means acyclicality, and zero or near-zero coefficient means counter-cyclicality, respectively.

In their paper, King and Rebelo (1999) found that most macroeconomic variables in industrialized countries are procyclical with a particularly high degree of co-movement between aggregate output and total hours worked. Additionally, the authors found that wages, government expenditures, and the capital stock seem to display no systematic cyclicality with aggregate output in such countries. In a similar study by Kim et al (2003) between the G7 countries and a number of APEC member countries, the authors found significant similarities in the cyclicality of key macroeconomic variables.

3.3.8 The Box-Jenkins Modelling Approach

Although time series data are used in many econometric studies, they present some special problems for macroeconomists. Most empirical work based on time series data assumes that the underlying data is stationary. That is to say, a time series is stationary if its mean value and its variance do not vary systematically over time. Another problem frequently encountered in time series data is autocorrelation among the disturbances. In the classical linear regression model, one of the underlying assumptions is no autocorrelation.

Given the macroeconomic time series, $\{Y_t : t = 1,2,...,n\}$, the autocorrelation coefficient is defined as:

$$\gamma_k = \frac{\sum_{t=k+1}^{n}(Y_t - \bar{Y})(Y_{t-k} - \bar{Y})}{\sum_{t=1}^{n}(Y_t - \bar{Y})^2}, \tag{3.32}$$

where $k = 1,2,...$ is a given time lag and $\bar{Y}$ is the mean of the series. The partial autocorrelation coefficient is the same as the ordinary partial correlation coefficient that is derived from the multiple regression of Y_t on Y_{t-k}:

$$\gamma_{kk} = \frac{\gamma_k - \sum_{j=1}^{k-1}\gamma_{k-1,j}\cdot\gamma_{k-j}}{1 - \sum_{j=1}^{k-1}\gamma_{k-1,j}\cdot\gamma_{k-j}}, \quad k = 2,3,.... \tag{3.33}$$

The Ljung-Box Q-statistic is a test statistic for the null hypothesis that there is no autocorrelation up to order k:

$$Q = n(n+2)\sum_{j=1}^{k}\frac{\gamma_j^2}{(n-j)}, \tag{3.34}$$

which is asymptotically distributed as a χ^2. If there is no autocorrelation in the residuals, the autocorrelations and partial autocorrelations at all lags should be nearly zero, and all Q-statistics should be insignificant with large p-values.

To model a macroeconomic variable, one of the most widely used method methodologies is the Box-Jenkins method. Also known as the Autoregressive Integrated Moving Average (ARIMA), the non-seasonal Box-Jenkins model is given as:

$$(1 - \phi_1 L - \phi_2 L^2 - ... - \phi_p L^p)(1 - L)^d Y_t = \alpha_0 + (1 - \theta_1 L - \theta_2 L^2 - ... - \theta_q L^q)\varepsilon_t, \tag{3.35}$$

where $\phi_1, \phi_2, \ldots, \phi_p$ are the coefficients of the autoregressive part of order p, and $\theta_1, \theta_2, \ldots, \theta_q$, are the coefficient of the moving average part of order q. α_0 is the intercept term, d is the differencing order that induces stationary, L is the lag operator, and ε_t, the error term at time t=1,2,...,n.

Having determined the correct order of differencing needed to render the series stationary, the next step is to find an appropriate ARMA form of the model to the stationary series. The Box-Jenkins method, which involves an iterative process of model identification, model estimation, and model evaluation, is the most commonly approach used to find the appropriate ARMA model. The Box-Jenkins approach to modelling a time series is summarized in the flowchart in Figure 3.1.

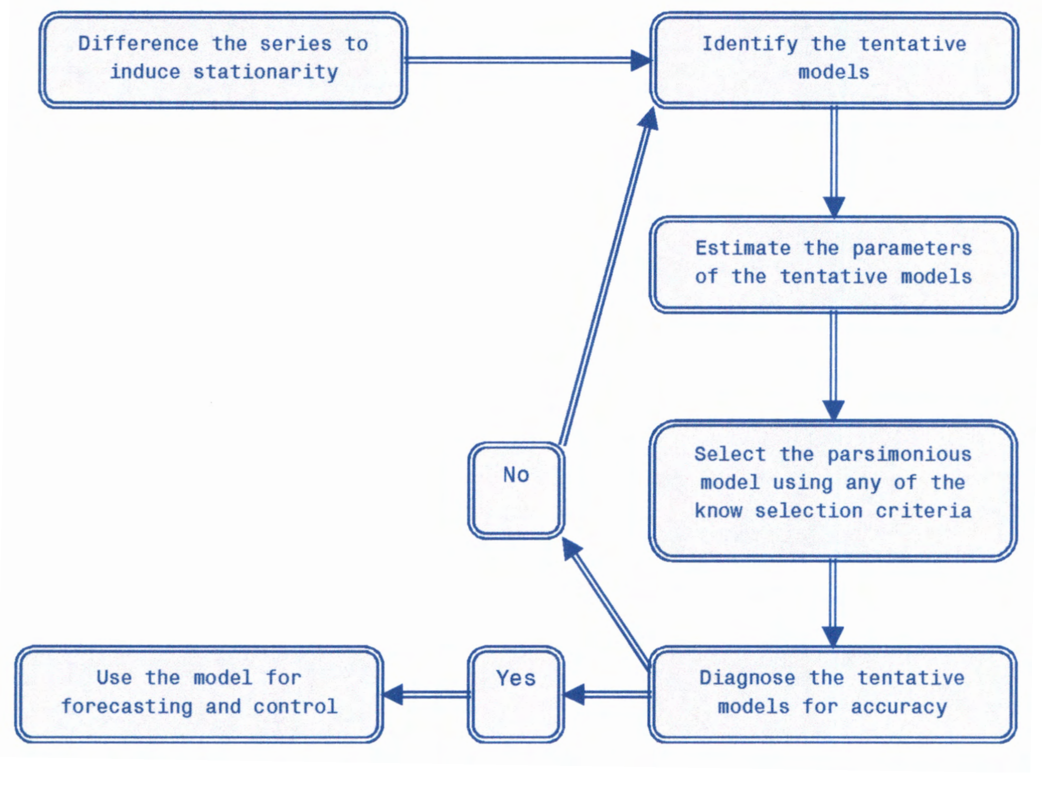


Figure 3.1: The Box-Jenkins Model

Table 3.1: Theoretical Patterns of ACF and PACF

Model Type	Typical Pattern of ACF	Typical Pattern of PACF
AR(p)	Decays exponentially or with damped sine wave pattern or both	Significant spikes through lags p
MA(q)	Significant spikes through lags q	Declines exponentially
ARMA(p,q)	Exponential decay	Exponential decay

The theoretical patterns of the autocorrelation function and partial autocorrelation functions presented in Table 3.1 are utilized in the model identification step. Model diagnostics in the context of Box-Jenkins involves the use of the Ljung-Box Q-statistic as discussed above or by plotting the residuals of the competing models. If the model is correctly specified, the residuals should follow a white noise process. Therefore, a plot of the autocorrelogram should immediately die out from one lag onwards. Any significant autocorrelations may indicate that the model has been misspecified.

3.4 Descriptive Analysis of Macroeconomic Variables

Table 3.2 presents the summary statistics of the twelve macroeconomic variables. The following remarks are worth making about the variables:

- The standard deviations imports (IMP=29.3392) and crude oil (OIL=30.3301) appear to move closely together.
- The negative skewness statistics for imports and money supply suggest that the two macroeconomic variables are skewed to the left while the positive skewness statistics for the remaining variables suggest that they are skewed to the right.
- The coefficients of variation (CV) indicate that changes have been relatively more in money supply M1, GDP, and OIL than changes in CPI, PPIT, CPIG, PPIG, and PPIMF.
- All the macroeconomic variables appear to exhibit kurtosis since all differ significantly from 3.

- The reported probabilities for the Jarque-Bera statistics, which are comparatively small, suggest the rejection of the null hypothesis that each of the variables is normally distributed.

Table 3.2: Summary Statistics of Raw Data

Statistic	IMP	OIL	M1	EXR	GDP	CPI
Mean	91.0585	91.4866	94.2624	94.1564	548.4330	874108.1
Median	92.7970	88.5530	97.7815	84.4100	589.1400	753016.5
Maximum	141.6530	145.5400	127.8870	183.6400	1152.8700	1919895.0
Minimum	40.4670	38.9530	62.4370	43.1300	253.3400	275892.0
Std. Dev.	29.3392	30.3301	20.3389	41.0801	223.6826	464378.3
Skewness	-0.0272	0.0568	-0.1670	0.4473	0.5521	0.6
Kurtosis	1.7878	1.8395	1.6355	1.8603	2.6856	2.2
CV	42.4136	52.3307	69.9834	40.7858	53.1260	32.2
Sample Size	70	70	70	70	70	70

Table 3.2 continuation: Summary Statistics of Raw Data

Statistic	PPIT	CPIG	PPIG	PPIMF	CPIH	EXP
Mean	88.5999	238709.6	28.8710	94.2930	96.4997	94.2930
Median	80.4650	220632.0	21.7687	89.5130	92.6000	89.5130
Maximum	157.8300	657543.0	70.5300	157.2400	163.7900	157.2400
Minimum	39.8600	47035.0	12.8400	45.0530	43.6930	45.0530
Std. Dev.	37.5784	167057.2	15.1084	31.5059	35.3190	31.5059
Skewness	0.2961	0.7	1.4744	0.2124	0.1870	0.2124
Kurtosis	1.6104	2.5	4.0565	1.8389	1.7369	1.8389
CV	33.4128	33.2	33.4128	36.6001	21.5769	43.6296
Sample Size	70	70	70	70	70	70

3.5 Chapter Conclusion

This chapter has presented the research methodology and procedures that has been followed in this study. The chapter has also investigated some basic features of the macroeconomic variables by conducting a descriptive analysis. The next chapter applies the procedures discussed in this chapter to address the research aims and objectives.

CHAPTER FOUR

Data Analysis and Discussions

4.1 Introduction

In this chapter, the data are analyzed and discussions of findings presented with the aim of addressing the study objectives. The remainder of the chapter comprises of four subsections. Section 4.2 focuses on the CPI-PPI price transmission dynamics while Section 4.3 examines the exchange rate transmission effects on prices of housing and food. In Section 4.4, attention shifts to the transmission effects of oil price and exchange rates on consumer prices whereas Section 4.5 investigates the cyclical dynamics of import and export prices. Section 4.6 concludes the chapter.

4.2 Price Transmission Dynamics of CPI and PPI of Goods

This section examines the vertical price relationships in South Africa as well as the nature of price transmission along the supply chain from producer to consumer. Variables under investigation are consumer prices of goods (CPIG) and the producer prices for goods for domestic use produced in South Africa (PPIG).

4.2.1 Tests of Stationarity

Table 4.1 is a summary of the KPSS stationarity test results of the two variables at levels and after one differencing. The upward trends of the two variables at levels imply that the KPSS stationarity tests should include a linear time trend. The results suggest that the null hypothesis of stationarity should be rejected (i.e. KPSS test statistics are greater than the 5% critical value). Thus, the two variables are non-stationary at levels.

The first-differenced KPSS stationarity test results, which included intercept terms due to the fact that the means of the two variables after one differencing are greater than their corresponding standard deviations (D1CPIG: mean = 1.5443, standard deviation = 0.8668; D1PPIG: mean = 1.6259, standard deviation = 1.1499), however, suggest that the null hypothesis of stationarity cannot be rejected (.e. KPSS test statistics are less than the 5% critical value), and so the two variables are stationary after one differencing. We have therefore established that both variables are integrated of order 1, that is, CPIG~I(1) and PPIG~I(1).

Fig. 4.1: Overlay Display of CPIG and PPIG at Levels

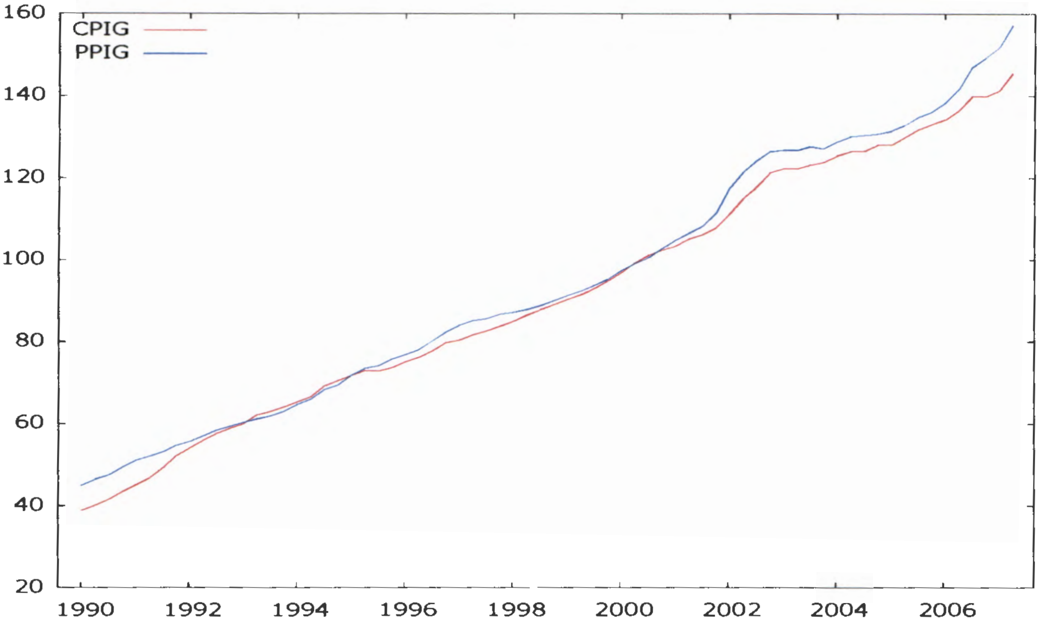


Table 4.1: KPSS Stationarity Tests of CPIG and PPIG

Number of Differencing	Variable	Included in KPSS Test Equation	KPSS statistic at lag truncation parameter ...			
			1	2	3	4
0	CPIG PPIG	Linear Trend Linear Trend	0.3276 0.4716	0.2282 0.3315	0.1792 0.2630	0.1510 0.2239
	5% Critical Value = 0.146					
1	CPIG PPIG	Intercept Intercept	0.1029 0.4574	0.0936 0.3636	0.0844 0.3083	0.0824 0.2797
	5% Critical Value = 0.463					

4.2.2 Cointegration Analysis

In this section, the objective is to examine whether there is any long-run equilibrium relationships between CPIG and PPIG using the Johansen-Juselius and Engle-Granger cointegration tests. Fig. 4.1 is a graphical representation of the two variables in their original forms.

Next, we proceed to investigate whether there is any cointegrating relationship between CPIG and PPIG using the Engle-Granger cointegrating technique. The linear upward trend being exhibited by the two variables suggests the incorporation of a linear trend in the usual Engle-Granger cointegration model. A summary of the Engle-Granger cointegration results reported in Table 4.2 suggests that the null hypothesis that the residual term is stationary cannot be rejected (KPSS statistic is less than the 5% critical value). The resulting cointegrating relationship is, therefore, given by:

$$\hat{CPIG_t} = 21.8360 + 0.8323 * t + 0.4253 * PPIG_t. \quad (4.1)$$

Table 4.2: EG Cointegration Modeling of CPIG and PPIG and KPSS Stationarity Test of Residuals

Dependent variable: CPIG

VARIABLE	COEFFICIENT	STDERROR	T STAT	P-VALUE
const	21.8360	2.15010	10.156	<0.00001 ***
time	0.8323	0.08257	10.079	<0.00001 ***
PPIG	0.4253	0.05334	7.974	<0.00001 ***

Unadjusted R-squared = 0.997412   Adjusted R-squared = 0.997335

	KPSS statistic at lag truncation parameter ...			
Variable	1	2	3	4
Residual term, $\hat{\varepsilon}_t$	0.191124	0.135295	0.108166	0.0925852
5% Critical Value = 0.463				

4.2.3 Causality Analysis

Once cointegration has been established between CPIG and PPIG, it will important be important to define the direction of causality between the two variables. A complete dynamic Engle-Granger Vector Error Correction Mechanism (EG-VECM) type of the form:

$$\Delta CPIG_t = \mu_1 + \sum_{j=1}^{p} \beta_{j1} \Delta CPIG_{t-j+1} + \sum_{j=1}^{q} \gamma_{j1} \Delta PPIG_{t-j} + \pi_1 ECT_{1t-1} + \varepsilon_t , \qquad (4.2a)$$

and $$\Delta PPIG_t = \mu_2 + \sum_{j=1}^{p} \beta_{j2} \Delta CPIG_{t-j} + \sum_{j=1}^{q} \gamma_{j2} \Delta PPIG_{t-j+1} + \pi_2 ECT_{2t-1} + e_t , \qquad (4.2b)$$

where ECT is the error correction term, will have to be implemented. In selecting the optimal lag length, the VAR system that incorporates a linear time trend has been used and the report summarized in Table 4.3, which suggests the optimal lag length of 2.

Table 4.3: VAR Optimal Lag Selection for Test of Causality between CPIG and PPIG

VAR system, maximum lag order 8, linear trend included

The asterisks below indicate the best (that is, minimized) values of the respective information criteria, AIC = Akaike criterion, BIC = Schwartz Bayesian criterion and HQC = Hannan-Quinn criterion.

lags	loglik	p(LR)	AIC	BIC	HQC
1	-145.33805		4.946389	5.220858	5.054152
2	-131.51607	0.00001	4.629551*	5.041254*	4.791196*
3	-130.65958	0.78836	4.730954	5.279892	4.946481
4	-128.45290	0.35295	4.788803	5.474976	5.058212
5	-125.90649	0.27790	4.835693	5.659100	5.158983
6	-125.17895	0.83457	4.941256	5.901898	5.318428
7	-123.80082	0.59941	5.025833	6.123709	5.456887
8	-116.12545	0.00403	4.907272	6.142383	5.392208

The complete EG-VECM specifications are, therefore, given by:

$$\Delta CPIG_t = \mu_1 + \beta_{11} \Delta CPIG_{t-1} + \beta_{21} \Delta CPIG_{t-2} + \gamma_{11} \Delta PPIG_{t-1} + \gamma_{21} \Delta PPIG_{t-2} + \pi_1 ECT_{1t-1} + \varepsilon_t , \qquad (4.3a)$$

and $$\Delta PPIG_t = \mu_2 + \beta_{12} \Delta CPIG_{t-1} + \beta_{22} \Delta CPIG_{t-2} + \gamma_{12} \Delta PPIG_{t-1} + \gamma_{22} \Delta PPIG_{t-2} + \pi_2 ECT_{2t-1} + e_t . \qquad (4.3b)$$

Table 4.4: EG-VECM Analysis of CPIG and PPIG

Standard errors in parentheses		
Cointegrating Eq:	ECT_{t-1}	
$CPIG_{t-1}$	1.000000	
$PPIG_{t-1}$	-0.665763 (0.15965)	
t	-0.427624 (0.25048)	
constant	-13.71840	
Error Correction:	$\Delta CPIG_t$	$\Delta PPIG_t$
ECT_{t-1}	-0.166026 (0.05922)	-0.031028 (0.06971)
$\Delta CPIG_{t-1}$	0.072813 (0.16199)	-0.333441 (0.19070)
$\Delta CPIG_{t-2}$	-0.060595 (0.16915)	-0.264253 (0.19912)
$\Delta PPIG_{t-1}$	0.241062 (0.14621)	0.744687 (0.17212)
$\Delta PPIG_{t-2}$	0.017217 (0.15510)	0.165218 (0.18257)
constant	1.126953 (0.24451)	1.109588 (0.28783)
Null hypothesis:	ΔPPIG(-2)) = 0 ΔPPIG(-1)) = 0 ECT_{t-1} = 0 F-Stat: 4.8433 Prob(F-Stat): 0.0043 Chi-Square: 14.5298 Prob(Chi-Square): 0.0023	ΔCPIG(-2)) = 0 ΔCPIG(-1)) = 0 ECT_{t-1} = 0 F-Stat: 2.3418 Prob(F-Stat): 0.0820 Chi-Square: 7.0253 Prob(Chi-Square): 0.0711

The EG-VECM results are presented in Table 4.4 from which we test the null hypothesis that 'PPIG does not Granger-cause CPIG' which is equivalent to testing the linear restrictions, $\Delta PPIG_{t-1}=0$, $\Delta PPIG_{t-2}=0$, and $ECT_{1t-1}=0$, in equation 4.3a, and to test the null hypothesis that 'CPIG does not Granger-cause PPIG' in equation 4.2b, which is also equivalent to testing the linear restrictions, $\Delta CPIG_{t-1}=0$, $\Delta CPIG_{t-2}=0$, and $ECT_{2t-1}=0$, in equation 4.3b. The Wald F-statistic based on equation 4.3a suggests that we can decisively reject the null hypothesis and conclude that PPIG Granger-causes CPIG [i.e., prob(F-stat) = 0.0043 < 0.05]. In the case of equation 4.3b, we fail to decisively reject the null hypothesis at the 5% level of significance but decisively reject it at the null hypothesis at the 10% level of significance [prob(F-stat)=0.0820 is greater than 0.05, but less than 0.10]. We therefore conclude that, at the 5% level, CPIG does not Granger-causes PPIG but does Granger cause PPIG at the 10% level. Thus, at the 10% level, there appears to be a feedback long-run relationship between CPIG and PPIG.

4.2.4 Price Transmission Asymmetry Test

In the previous section, it was established that, at the 5% level, PPIG causes CPIG. In this section, the objective is to investigate the existence of any asymmetries between the two variables. Different authors have applied different techniques to test for the presence of asymmetric price transmission and the extent of asymmetry. To test for the presence of asymmetric price transmission, we appeal to the von Cramon-Taubel (1998) EG-ECM specification, based on the EG-VECM specified in equation 4.3a:

$$\Delta CPIG_t = c + \sum_{j=1}^{2} \phi_j \Delta CPIG_{t-j} + \sum_{k=1}^{2} \theta_k^+ D_{t-k+1}^+ \Delta PPIG_{t-k+1} + \sum_{k=1}^{2} \theta_k^- D_{t-k+1}^- \Delta PPIG_{t-k+1} + \zeta^+ B_t^+ ECT_t + \zeta^- B_t^- ECT_t + \varepsilon_t , \quad (4.4)$$

where $D_{t-k+1}^+ = \begin{cases} 1, & \text{if } \Delta PPIG_{t-k+1} > 0 \\ 0, & \text{Otherwise} \end{cases}$ $\quad D_{t-k+1}^- = \begin{cases} 1, & \text{if } \Delta PPIG_{t-k+1} < 0 \\ 0, & \text{Otherwise} \end{cases}$

$B_t^+ = \begin{cases} 1, & \text{if } ECT_t > 0 \\ 0, & \text{Otherwise} \end{cases}$ $\quad B_t^- = \begin{cases} 1, & \text{if } ECT_t < 0 \\ 0, & \text{Otherwise} \end{cases}$.

Table 4.5 presents the backward elimination regression estimates (which retains four of the ten independent variables) of the asymmetrical representation and some diagnostics (complete backward elimination regression estimation results are reported in the Appendix). The probability value of the F-statistic for the model suggests that the estimated ECM model is highly significant (prob=0.0001<0.05), while the probability value for the Breusch-Godfrey serial correlation LM statistic strongly indicates the absence of serial correlation in the residuals (prob=0.854748>0.05). The large probability value for the Jarque-Bera (JB) statistic leads to the acceptance of the null hypothesis of a normal distribution (prob=0.139201>0.05) while the effectively small probability value for the White heteroskedasticity F-statistic rejects the null hypothesis of homoskedasticity (prob=<0.0001). The small probability of the F-statistic suggests that the null hypothesis that the estimated coefficients of the respective positive and negative variables are equal can be rejected at the 5% level of significance (prob=<0.0001). This means that there is asymmetrical transmission between CPI of goods and PPI of goods produced in South Africa.

Table 4.5: Least Square Estimation Results of Asymmetric EG-ECM

Dependent Variable: $\Delta CPIG_t$

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
C	0.67913	0.18217	4.5780	13.90	0.0004
$\Delta CPIG_{t-1}$	0.34459	0.11883	2.7701	8.41	0.0052
$D^+.\Delta PPIG_t$	0.59183	0.08048	17.8109	54.07	0.0001
$D^+.\Delta PPIG_{t-1}$	-0.27321	0.11328	1.9162	5.82	0.0188
$B^+.ECT_t$	-0.46029	0.13776	3.6773	11.16	0.0014

Adjusted R-squared	0.5995	F-statistic	23.2000
Durbin-Watson Statistic	1.9910	Prob(F-statistic)	<0.0001

Residual Tests:

Jarque-Bera Normality Statistic	3.943667
Prob(Jarque-Bera Normality Statistic)	0.139201
BG Serial Correlation F-statistic	0.157353
Prob(BG Serial Correlation F-Statistic)	0.854748
White Heteroskedasticity F-statistic	6.462136
Prob(White Heteroskedasticity F-statistic)	0.000005

Price Asymmetry Test:

$D^+.\Delta PPIG_t = D^+.\Delta PPIG_{t-1} = D^+.ECT_{t-1}$

Asymmetry Test Results for Dependent Variable D1CPIG

Source	DF	Mean Square	F Value	Pr > F
Numerator	2	8.04319	24.81	<.0001
Denominator	63	0.32421		

4.2.5 Price Transmission Elasticity Determination

At time t, the long-run mark-up and mark-down price relationships between LCPIG and LPPIG are, respectively, given by:

$$LCPGI_t = \alpha_0 + \alpha_1 * LPPIG_t, \quad (4.5)$$

and

$$LPPIG_t = \beta_0 + \beta_1 * LCPGI_t, \quad (4.6)$$

where α_1 are β_1 are, respectively, the mark-up price transmission elasticity and mark-down price transmission elasticity. Fig. 4.2 is the overlap plot of the two variables expressed in logarithmic terms.

To investigate the nature of transmission between CPI and PPIG, the OLS regression analyses of the original mark-up and mark-down models specified in equations 4.5 and 4.6 were done and summaries reported in Table 4.6. Fig. 4.3 presents the graphs of the residual series from the two original models. The residuals do not appear to be random, suggesting the presence of autocorrelation in the residual series. This implies that the OLS estimates are inefficient and so the parameter estimates may be inaccurate.

Fig. 4.2: Overlay Display of CPIG and PPIG at Levels

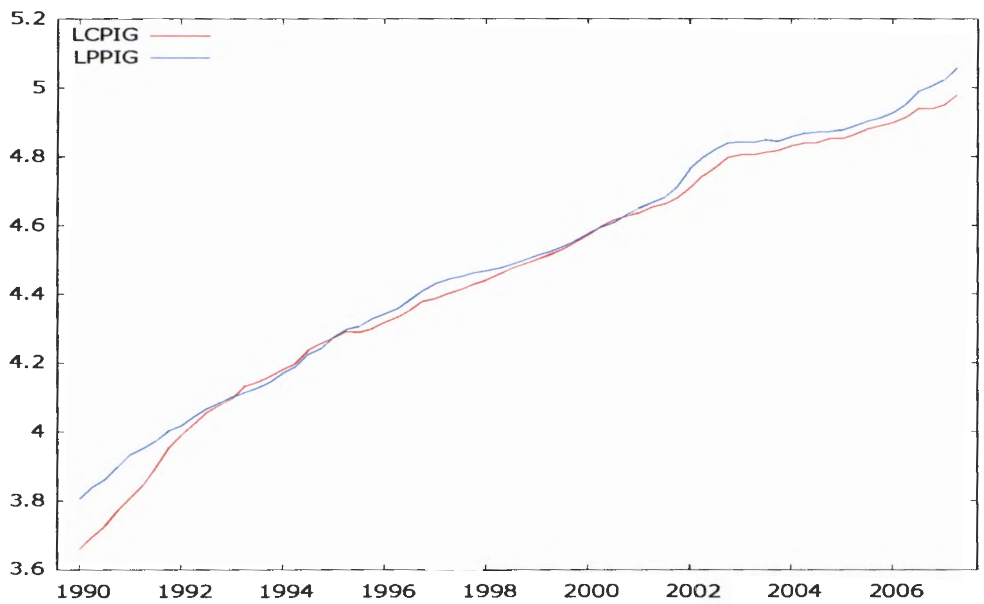


Table 4.6: OLS Estimation of Price Elasticity (Original Models)

Dependent variable: LCPIG

VARIABLE	COEFFICIENT	STDERROR	T STAT	P-VALUE
const	-0.13315	0.05714	-2.330	0.02278 **
LPPIG	1.02255	0.01269	80.553	<0.00001 ***

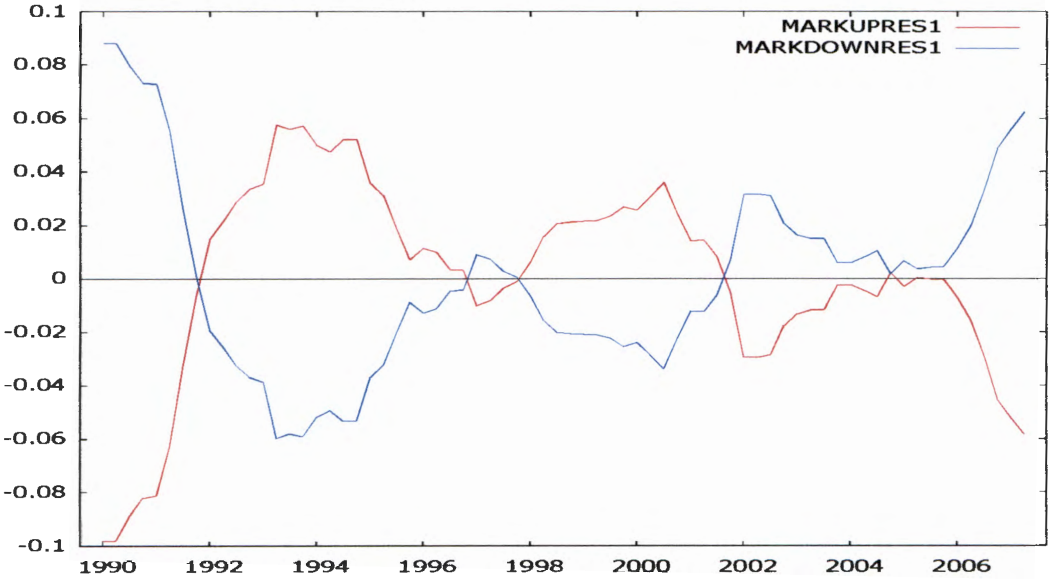
Adjusted R-squared = 0.9895 Durbin-Watson statistic = 0.0687

Dependent variable: LPPIG

VARIABLE	COEFFICIENT	STDERROR	T STAT	P-VALUE
const	0.17541	0.05371	3.266	0.00171 ***
LCPIG	0.96780	0.01201	80.553	<0.00001 ***

Adjusted R-squared = 0.9895 Durbin-Watson statistic = 0.0683

Fig. 4.3: Overlay Display of Residual Series from Original Mark-Up and Mark-Down Models



To improve the efficiency of the estimated parameters, we have corrected for autocorrelation by running the following specifications:

$$LCPIG_t = \alpha_0 + \alpha_1 * LPPIG_t + \varepsilon_t , \quad (4.7a)$$

where $\varepsilon_t = \sum_{j=1}^{p} \phi_j \varepsilon_{t-j} + u_t$, $u_t \sim iid(0, \sigma_u^2)$; (4.7b)

and $LPPIG_t = \beta_0 + \beta_1 * LCPIG_t + e_t$, (4.8a)

where $e_t = \sum_{k=1}^{q} \theta_k e_{t-k} + v_t$; $v_t \sim iid(0, \sigma_v^2)$ (4.8b)

In equations 4.7 and 4.8, $\phi_j : j = 1,2,...p$ and $\theta_k : k = 1,2,...q$, are coefficients to be estimated using the most parsimonious correction models selected on the basis of the SBC selection criterion. Table 4.7 presents a summary of the relevant statistics from the running of the two corrected models using up to 4 lags in each of the two autoregressive components. The SBC selection criterion recommends that 2 lags be included in the autoregressive components of the price transmission models, i.e., $p = 2$ and $q = 2$. The estimated corrected models are summarized in Table 4.8. The accompanying residual graphs in Fig. 4.4 clearly show that residual series is random. In addition, the OLS results from running the corrected mark-up model show an increase in the Durbin-Watson statistics from 0.0687 to 2.1528 and from 0.0683 to 2.2633, in the case of the mark-down model. These changes suggest an improvement in model specifications. In absolute terms, the estimated elasticities, $\alpha_1 = 0.9177$ and $\beta_1 = 0.7611$, suggesting an elastic and perfect transmission in the markup model and inelastic and imperfect price transmission elasticity in the markdown price transmission model.

Table 4.7: Lag Length Selection of Price Transmission Elasticity (Corrected Models)

Variable			Lag Length			
Dependent	Independent	Estimate	1	2	3	4
LCPIG	LPPIG	SBC	-436.7394	-461.8933	-459.9593	-456.2551
		R-Square	0.9993	0.9995	0.9996	0.9996
		Durbin-Watson Stat	0.9026	2.1528	1.8964	1.8664
		F-Stat	188.7800	96.1500	68.4900	325.9500
		Prob(F-Stat)	<0.0001	<0.0001	<0.0001	<0.0001
LPPIG	LCPIG	SBC	-447.4044	-471.1040	-468.1059	-464.0354
		R-Square	0.9994	0.9996	0.9996	0.9996
		Durbin-Watson Stat	0.9358	2.2633	2.0453	2.0544
			336.4600	112.8100	89.9700	76.5200
			<0.0001	<0.0001	<0.0001	<0.0001

Table 4.8: Maximum Likelihood Estimation of Price Elasticity (Corrected Models)

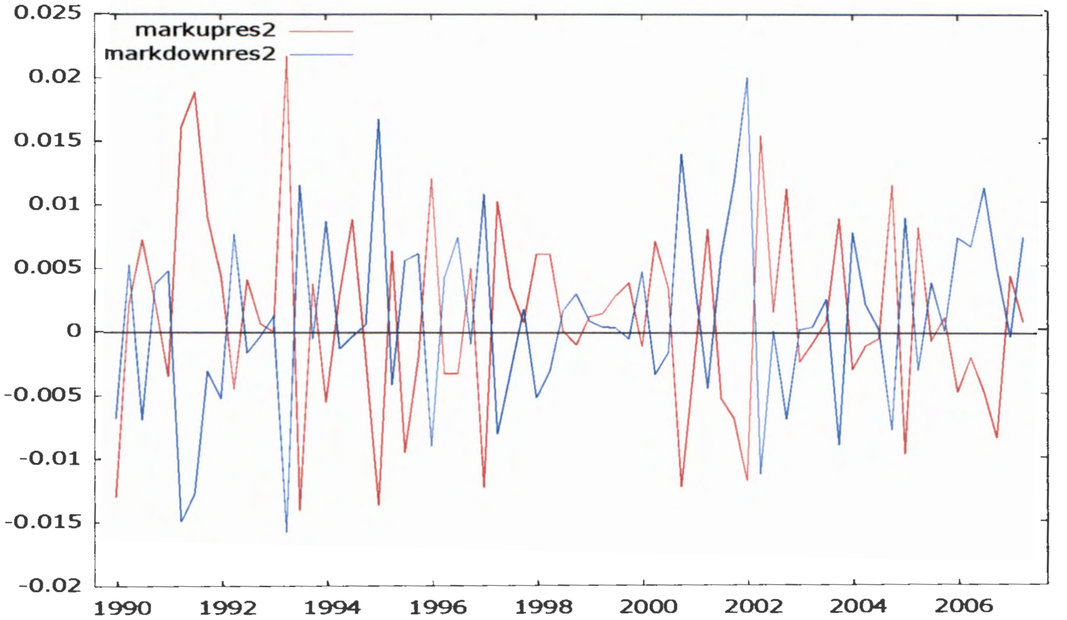
Dependent Variable: LCPIG
Maximum Likelihood Estimates

Variable	DF	Estimate	Standard Error	t Value	Approx Pr > |t|
Intercept	1	0.2972	0.4272	0.70	0.4891
LPPIG	1	0.9177	0.0936	9.81	<.0001
AR1	1	-1.5997	0.0976	-16.38	<.0001
AR2	1	0.6126	0.0965	6.35	<.0001

Dependent Variable: LPPIG
Maximum Likelihood Estimates

Variable	DF	Estimate	Standard Error	t Value	Approx Pr > |t|
Intercept	1	1.1327	0.3511	3.23	0.0020
LCPIG	1	0.7611	0.0717	10.62	<.0001
AR1	1	-1.6070	0.1091	-14.73	<.0001
AR2	1	0.6116	0.1121	5.46	<.0001

Fig. 4.4: Overlay Display of Residual Series from Corrected Mark-Up and Mark-Down Models



4.3 Exchange Rate Transmission Effects on Prices of Housing and Food

Assessing the impact of the exchange rate transmission on prices has received considerable attention in recent theoretical and empirical studies because of the anecdotal evidence that suggests that there was little transmission of large exchange rate movements to prices in the 1990s (Taylor, 2000; Choudhri and Hakura, 2001). A variety of mechanisms through which exchange rate affects prices are thoroughly discussed by a number of authors including Lafleche (1996), Parsley and Popper (1998), Marston (1990), Knetter (1993), and Goldberg and Knetter (1997). This section examines the exchange rate transmission effects on a number of prices in South Africa over the period 1990Q1-2007Q2.

4.3.1 Stationarity Tests

This section examines the transmission effects of exchange rates on housing and food prices. Fig. 4.5 presents graphical displays of six variables, all expressed in natural logarithms - PPI for manufacturing food (LPPIMF) and CPI for housing (LCPIH) as the two main dependent variables and four independent variables, namely, money supply (LM1), rand/dollar exchange rate (LEXR), GDP (LGDP), and Brent crude oil prices (LOIL). Four variables exhibit upward linear trend while the remaining two do not.

Table 4.9 present the KPSS stationarity tests of the six variables and concluded that all the variables are integrated of order 1 (i.e. one differencing induces stationarity in each variable). Fig. 4.6 is an overlay plot of the once-differenced variables. Once the four endogenous variables in the VAR model have been found to be stationary, we proceed to conduct impulse response function analysis to examine the degree of transmission of each shock to CPIH. We first examine the VAR model including LCPIH as the price variable and perform the impulse response function analysis. The lag order of the VAR model (results reported in the Appendix) reported in Table 4.10 suggested by the SBC and HQC selection criteria was selected to be 1.

4.3.2 Impulse Response Function and Variance Decomposition Analyses

Fig. 4.7 presents the accumulated impulse responses presented over sixteen quarters (4 years) time horizon. All the shocks are standardized to one-percent shocks, and hence, the vertical axes report the approximate percent change in the four other variables in response to a one-percent shock from CPIH. As observed from Fig. 4.7, the CPIH's response to exchange rate shocks accumulates to 0.003% in 8 quarters (2 years), but starts to decline thereafter.

Similarly, the CPIH's responses to monetary (LM1), and GDP shocks accumulates to 0.011% in 8 quarters (2 years), and to 0.011% in 8 quarters (2 years), respectively. The response from CPIH to OIL shocks accumulates to 0.003% in 4 quarters (1 year) and to zero in 8 quarters (2 years), but becomes negative, thereafter. Overall, the response of CPIH is much faster to exchange rate and monetary shocks than to oil price shock.

In the case of PPIMF, its response to exchange rate shocks accumulates to 0.013% in nearly 8 periods (2 years) while the PPIMF's response to GDP shocks accumulates to 0.008% in nearly 8 periods (2 years). PPIMF's response to OIL is negative from period one until about period 13 where it basically remains constant at -0.004% while there monetary shocks (LM1) induces negative response in PPIMF (i.e. about -0.001%) in nearly 4 periods (year) but accumulates to about 0.007% in nearly 5 periods.

For further analysis of the effects of various shocks on CPIH, we conduct the variance decomposition analysis, which provides the information on the percentage contribution of various shocks to the 16-step-ahead forecast errors of respective variables. Fig. 4.8a is a graphical representation of the variance decomposition of LCPIH. Table 4.11 reports the variance decompositions of the various variables. As observed from these results, monetary and GDP shocks are the most important determinants in the CPIH variance where LM1 accounts for about 10%, 25%, and 31%, while GDP accounts for about 12%, 27%, and 31% after 4 periods (1 year), 8 periods (2 years), and 12 periods (3 years), respectively. Interestingly, exchange rates shocks do not account for much of the variance decomposition in CPIH (only 0.7%, 2.2%, and 2.7% after 4 periods, 8 periods, and 12 periods, respectively).

Fig. 4.5: Graphical Display of Relevant Variables

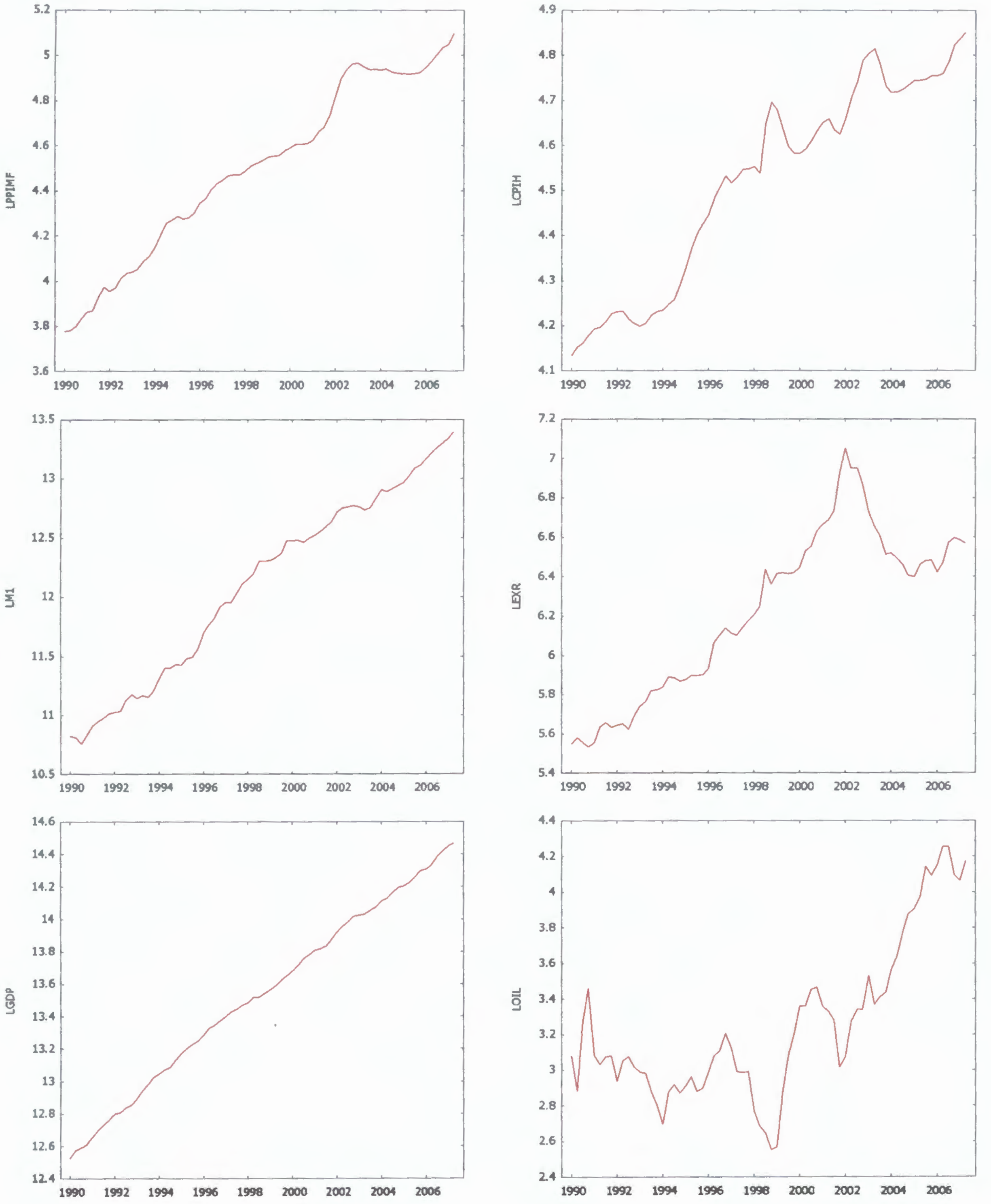


Table 4.9: KPSS Stationarity Tests of Transmission Variables

Number of Differencing	Variable	Included in KPSS Test Equation	KPSS statistic at lag truncation parameter ...				5% Critical Value
			1	2	3	4	
0	LPPIMF	Linear Trend	0.4012	0.2791	0.2200	0.1862	0.1460
	LCPIH	Linear Trend	0.4723	0.3302	0.2612	0.2208	
	LM1	Linear Trend	0.5786	0.4009	0.3112	0.2569	
	LGDP	Linear Trend	0.5799	0.4064	0.3199	0.2683	
	LEXR	Intercept	3.0415	2.0576	1.5663	1.2726	0.4630
	LOIL	Intercept	2.2691	1.5612	1.2043	0.9918	
1	LPPIMF*	Intercept	0.1695	0.1396	0.1235	0.1150	0.4630
	LCPIH*	Intercept	0.0835	0.0739	0.0739	0.0779	
	LM1*	Intercept	0.0904	0.0943	0.1000	0.1080	
	LGDP*	Intercept	0.2309	0.2358	0.2548	0.2688	
	LEXR*	Intercept	0.2428	0.2158	0.1966	0.1844	
	LOIL*	Intercept	0.1862	0.2033	0.1944	0.1849	

(Asterisk indicates variable is stationary after 1 differencing at the 5% level of significance)

Fig. 4.6: Overlay Display of Once-Difference Prices

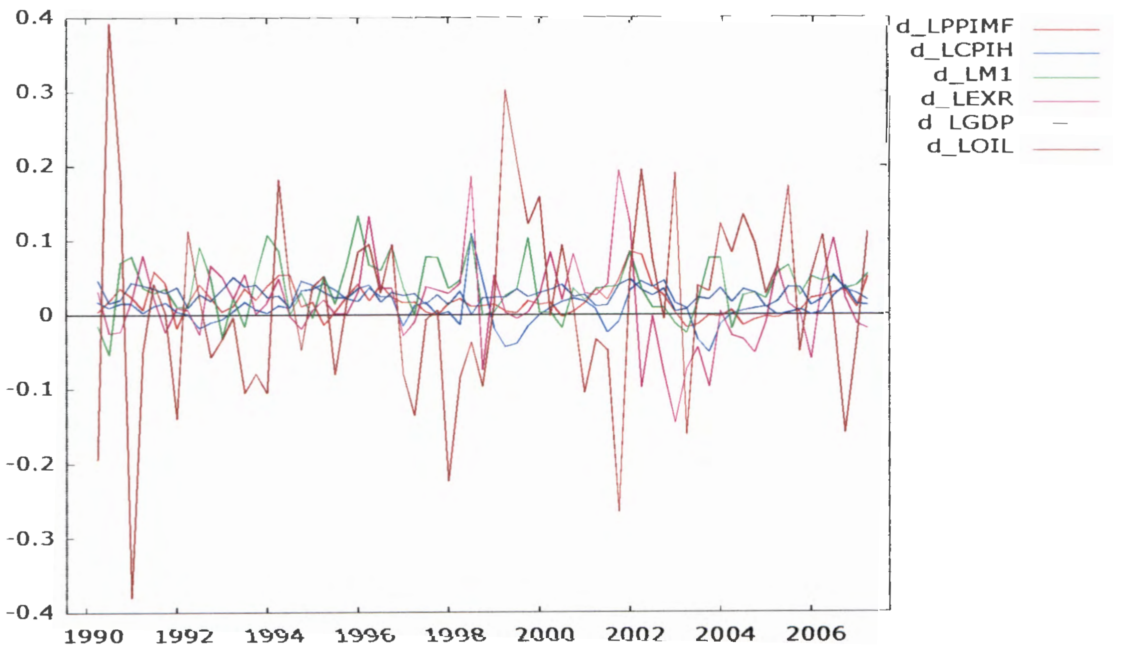


Table 4.10: VAR Optimum Lag Selection Results

lags	loglik	p(LR)	AIC	SBC	HQC
Variables: LCPIH LM1 LEXR LGDP LOIL					
1	636.27064		-19.395827	-18.195026*	-18.924362*
2	666.65201	0.00008	-19.569420*	-17.510902	-18.761194
3	686.99568	0.02476	-19.419215	-16.502983	-18.274229
4	713.81203	0.00074	-19.477807	-15.703859	-17.996060
5	736.64351	0.00702	-19.407855	-14.776192	-17.589347
Variables: LPPIMF LM1 LEXR LGDP LOIL					
lags	loglik	p(LR)	AIC	SBC	HQC
1	683.94047		-19.967399	-18.796575*	-19.505434*
2	713.62134	0.00013	-20.111426	-18.104299	-19.319486
3	747.54496	0.00001	-20.385999	-17.542569	-19.264083
4	779.02352	0.00004	-20.585339	-16.905607	-19.133449
5	809.96185	0.00006	-20.768057*	-16.252022	-18.986191

VAR System Including a Linear Trend, Maximum Lag Order = 5. The asterisks below indicate the best (that is, minimized) values of the respective information criteria, AIC = Akaike criterion, BIC = Schwartz Bayesian criterion and HQC = Hannan-Quinn criterion.

Fig. 4.8b is a graphical representation of the variance decomposition of LPPIMF. Table 4.11 reports the variance decompositions of the various variables. The variance decompositions reveal that the most important determinants in the PPIMF variance are exchange shocks (about 24%, 49%, and 50% after 4 periods, 8 periods, and 12 periods, respectively) and GDP shocks (about 11%, 20%, and 22% after 4 periods, 8 periods, and 12 periods, respectively).

Fig. 4.7: Impulse Responses of LCPIH (Exogenous Variables: Constant and Trend)

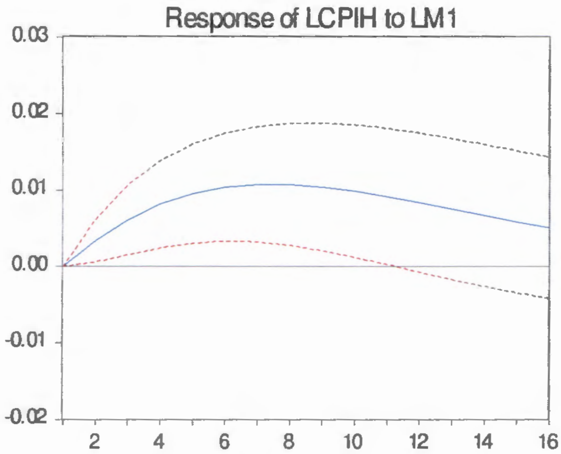


Fig. 4.7a

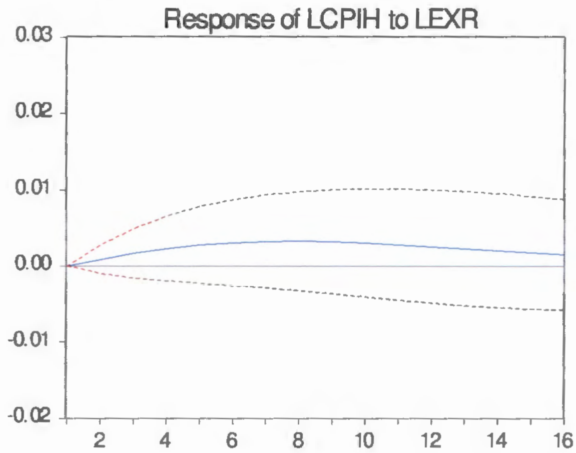


Fig. 4.7b

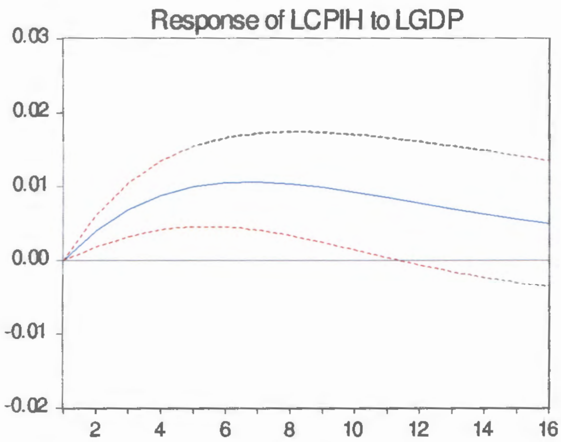


Fig. 4.7c

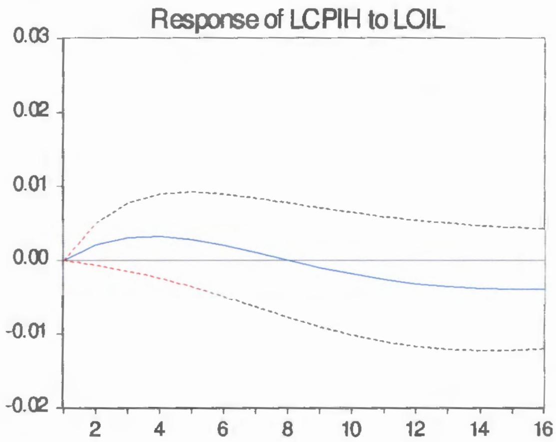


Fig. 4.7d

Fig. 4.8: Impulse Responses of LPPIMF (Exogenous Variables: Constant and Trend)

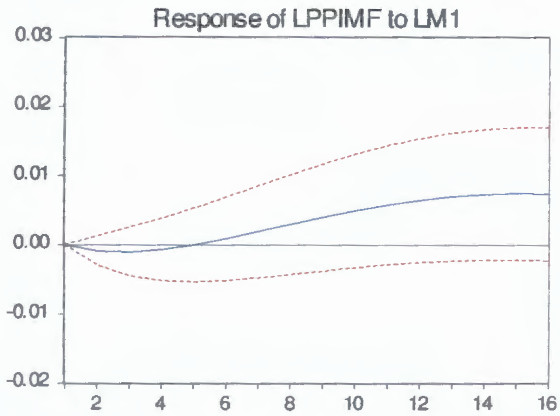


Fig. 4.8a-i

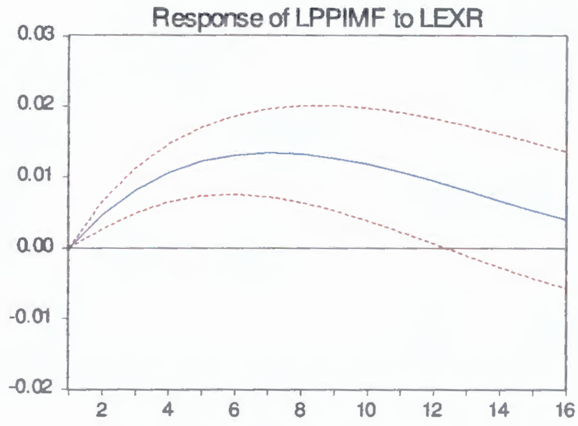


Fig. 4.8a-ii

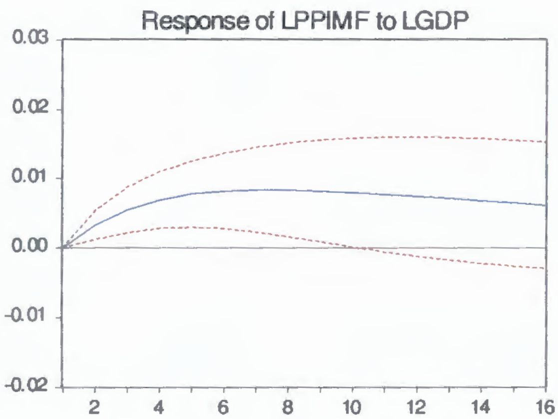


Fig. 4.8a-iii

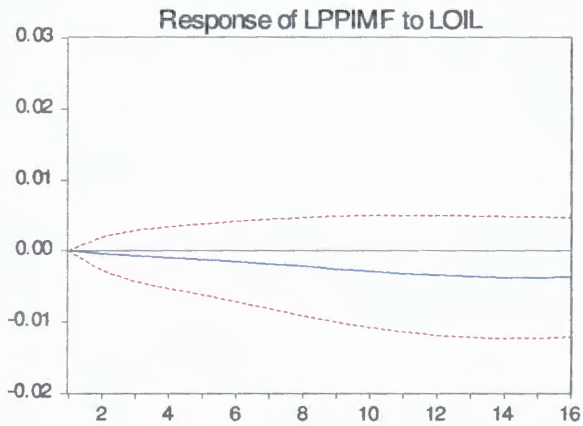


Fig. 4.8-iv

Fig. 4.8b: Variance Decomposition of LCPIH and LPPIMF

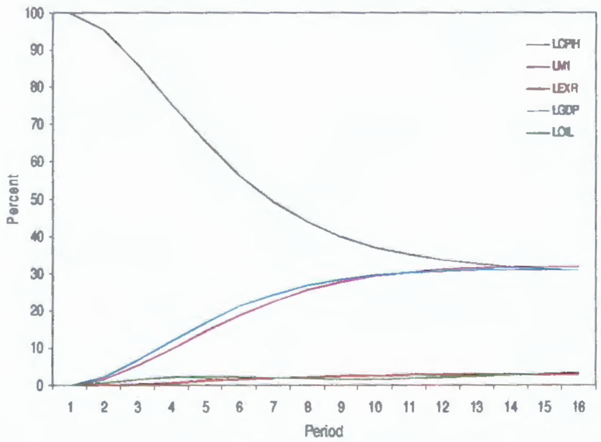


Fig. 4.8b-i: Variance Decomposition of LCPIH

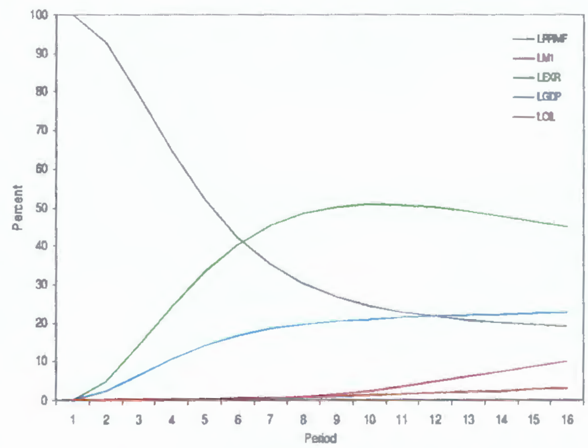


Fig. 4.8b-ii: Variance Decomposition of LPPIMF

Table 4.11: Variance Decompositions for Up to 16 Periods (4 Years)

Variance Decomposition Variable	Period	Percentage of forecast errors due to ...			
		LM1	LEXR	LGDP	LOIL
LCPIH	4	9.7419	0.7380	11.9079	2.0925
	8	25.4295	2.1637	26.7692	1.7625
	12	31.0861	2.7335	30.5354	2.0273
LPPIMF	4	0.25845	24.2619	10.6570	0.20133
	8	0.83217	48.4803	19.6367	0.76159
	12	4.68796	50.0415	21.7756	1.84895

4.4 Oil Price - Consumer Price Transmission Dynamics

Following McCarthy (2000), this section examines the transmission of oil price and exchange rate shocks into import and consumer prices over the period 1990Q1-2007Q2. It is assumed that prices are set along the distribution chain:

$$\text{OIL} \rightarrow \text{EXR} \rightarrow \text{IMP} \rightarrow \text{GAP} \rightarrow \text{PPIT} \rightarrow \text{CPI}, \qquad (4.9)$$

that is, oil price shocks are initially transmitted to exchange rate (EXR), then to import prices (IMP) and total producer prices for domestic use (PPIT), and finally to a reaction in total consumer prices (CPI). In the model, oil price (OIL) serves as a proxy for supply shocks while the output gap (GAP) models demand shocks. The output gap, GAP, is computed as the deviation of actual GDP series from potential GDP, which is calculated by means of a Hodrick-Prescott (HP) filter. Fig. 4.9 is the overlay display of the variables at levels. Table 4.12, which presents the KPSS stationarity test of the variables, shows that the variables integrated of order 1, excluding GAP.

A KPSS stationarity test of the output gap, GAP, suggests that it is stationary at levels (KPSS test statistics at lags 1 to 4 range between 0.0606 and 0.0921 while the 5% critical value is 0.463). Fig. 4.10 presents the graphical representations of the once-differenced variables.

Fig. 4.9: Overlay Display of Variables at Levels

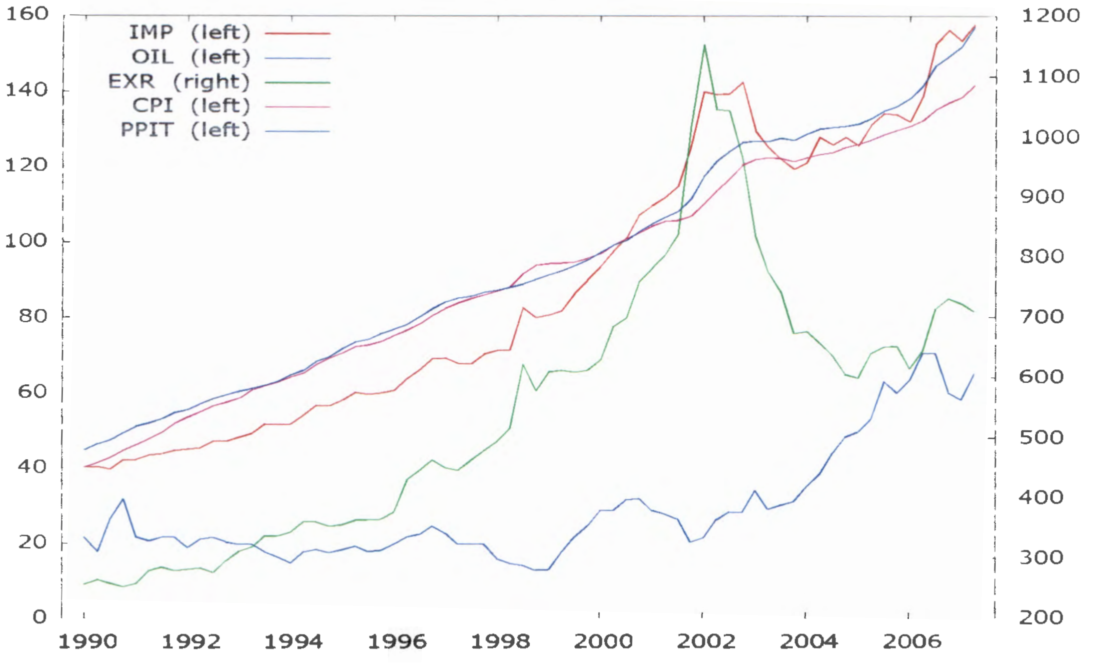
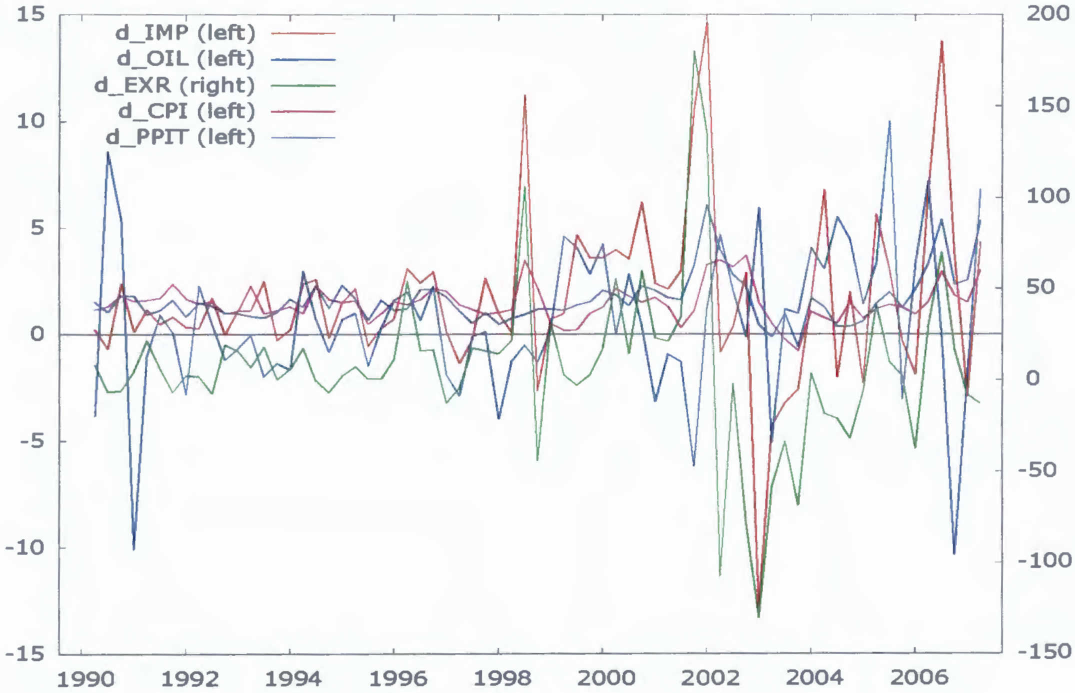


Table 4.12: KPSS Stationarity Tests of Transmission Variables

Number of Differencing	Variable	KPSS statistic at lag truncation parameter ...				5% Critical Value	Status
		1	2	3	4		
0	IMP	0.3311	0.2329	0.1845	0.1565	0.146	Nonstationary
	OIL	2.2250	1.5253	1.1725	0.9631	0.463	Nonstationary
	EXR	2.6727	1.8130	1.3848	1.1297	0.463	Nonstationary
	CPI	3.5744	2.4257	1.8501	1.5046	0.463	Nonstationary
	PPIT	0.4716	0.3315	0.2630	0.2239	0.146	Nonstationary
1	IMP	0.1554	0.1474	0.1401	0.1363	0.463	Stationary
	OIL	0.3234	0.3626	0.3487	0.3200	0.463	Stationary
	EXR	0.1338	0.1174	0.1056	0.1000	0.463	Stationary
	CPI	0.0424	0.0366	0.0349	0.0368	0.463	Stationary
	PPIT	0.4540	0.3636	0.3083	0.2797	0.463	Stationary

(All variables are stationary after 1 differencing at the 5% level of significance)

Fig. 4.10: Overlay Display of Once-Difference Variables



4.4.1 Cointegration Tests

The main part of our task is to construct a vector error correction model (VECM) after which impulse-response function analyses will be conducted to estimate the transmission shocks from oil prices through exchange rate down to consumer prices. The first step in vector error correction modelling involves the investigation of cointegration equations, the existence of which allows the conduct of VECM analysis to proceed. To determine whether the five I(1) variables and the GAP variable, which is I(0), are cointegrated, we employ the Johansen-Juselius cointegration technique. The five nonstationary variables and one stationary variable will all be included based on the argument put forward by Hansen and Juselius (1995).

According to Hansen and Juselius (1995), the selection of variables to be included in cointegration tests should be based on economic reasoning, but not statistical. More specifically, the two authors argue that stationary variables should be included in a cointegration test, if reasonable, but only on condition that at lease two of the variables are nonstationary. Should nonstationary variables be included, the cointegration rank increases by the number of stationary variables and that the number of cointegrating equations (CEs) to be included in the VECM analysis is, therefore, equal to the number of CEs found by the Johansen-Juselius test minus the number of stationary variables (Hansen and Juselius, 1995). Table 4.13 presents the VAR lag order selection results, which the SBC and HQC suggest a lag order of 1. Table 4.14, which summarizes the Johansen-Juselius cointegration test results, finds 2 cointegrating vectors, inclusive of the one stationary variable. Thus, the actual number of cointegrating equations is 2 - 1 = 1.

Table 4.13: VAR Optimum Lag Selection Results

VAR system, maximum lag order 5

Variables: OIL EXR CPI PPIT GAP

lags	loglik	p(LR)	AIC	SBC	HQC
1	-1419.22334		44.960718	46.365707*	45.515076*
2	-1371.45937	0.00000	44.598750	47.208015	45.628272
3	-1330.20106	0.00002	44.436956	48.250497	45.941642
4	-1268.67130	0.00000	43.651425	48.669241	45.631275
5	-1226.37707	0.00001	43.457756*	49.679849	45.912770

VAR System Including a Linear Trend, Maximum Lag Order = 5. The asterisks below indicate the best (that is, minimized) values of the respective information criteria, AIC = Akaike criterion, BIC = Schwartz Bayesian criterion and HQC = Hannan-Quinn criterion.

Table 4.14: Johansen-Juselius Cointegration Test Results

Sample: 1990:1 - 2007:2
Included observations: 68
Test assumption: Linear deterministic trend in the data
Series: OIL EXR IMP GAP PPIT CPI
Lags interval: 1 to 1

Eigenvalue	Likelihood Ratio	5 Percent Critical Value	1 Percent Critical Value	Hypothesized No. of CE(s)
0.541522	148.68840	114.90	124.75	None **
0.389766	95.65912	87.31	96.58	At most 1 *
0.325431	62.07308	62.99	70.05	At most 2
0.211380	35.30280	42.44	48.45	At most 3
0.180648	19.15479	25.32	30.45	At most 4
0.079140	5.60639	12.25	16.26	At most 5

*(**) denotes rejection of the hypothesis at 5%(1%) significance level.
L.R. test indicates 2 cointegrating equation(s) at 5% significance level

4.4.2 Impulse Response Functions Analysis

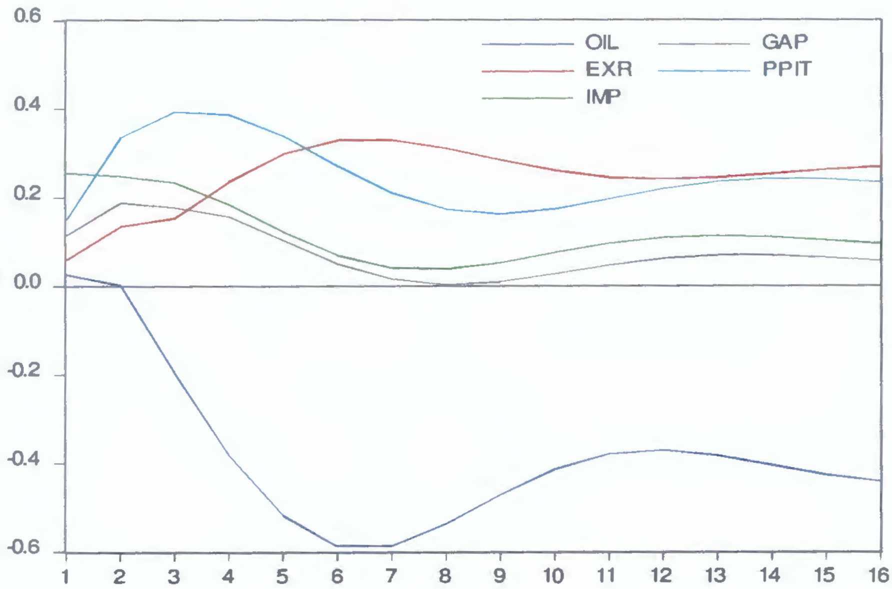
Table 4.15 and Fig. 4.11 display the responses of CPI to a one-standard-deviation shock in oil price, exchange rate, import price, output gap, and total producer price after 2 periods (0.5 year), 4 periods (1 year), up to 16 periods (4 years). As observed from the results, the fastest exchange rate shock effect is observed with a CPI increase of about 0.33% after 6 periods (1.5 years) while the fastest producer price shock effect is observed with a CPI increase of about 0.39% after 4 periods (1 year).

Table 4.15: Effects of One-Standard-Deviation Shocks on Total Consumer Prices

Period	OIL	EXR	IMP	GAP	PPIT
2	0.002954	0.135061	0.249080	0.188468	0.336351
4	-0.381715	0.236748	0.185434	0.158417	0.387620
6	-0.587085	0.329101	0.069326	0.050327	0.271647
8	-0.537411	0.311620	0.039069	0.003900	0.173186
10	-0.414135	0.260679	0.075847	0.027657	0.174139
12	-0.371431	0.241300	0.109689	0.062034	0.219281
14	-0.405353	0.254329	0.110766	0.069378	0.242860
16	-0.443100	0.270205	0.095770	0.057484	0.234623

Ordering: OIL → EXR → IMP → GAP → PPIT → CPI

Fig. 4.11: Response of CPI to One-Standard-Deviation Innovations



4.4.3 Variance Decomposition Analysis

While Impulse Response Function (IRF) analysis examines the effects of a shock to one endogenous variable onto other variables in the VECM, Variance Decomposition (VDC) separates the variation in an endogenous variable into the component shocks to the VECM. In other words, VDC provides information about the relative importance of each of random innovation in effecting the variables in the system. Table 4.16 displays the percentages of the price variable variances that result in response to a one-standard deviation shock in exchange rate. It is observed that exchange rates explain a fairly large part of the variation of import prices while this effect declines along the distribution chain. Over the next four years (16 periods), nearly 44% of the import price variance is explained by exchange rate movement per period (quarter). Exchange rates explain only a fairly small part of the variation of oil prices.

Table 4.16: Exchange Rate Contribution to Variance Decompositions

Variance Decomposition for ...	... at period							
	2	4	6	8	10	12	14	16
CPI	2.4697	5.4525	10.1900	12.5664	13.9602	14.8528	15.5081	16.1078
PPIT	15.8781	15.3581	15.5482	15.5914	15.6375	15.6492	15.6554	15.6655
IMP	67.8570	46.0743	39.1385	38.1645	39.0947	39.9976	40.2861	40.2190
OIL	2.8363	4.0337	4.1784	4.4581	4.7198	4.8751	4.9473	4.9869

Ordering: OIL → EXR → IMP → GAP → PPIT → CPI

4.5 Cyclicality, Modelling, and Forecasting of Import and Export Prices

Economies constantly undergo significant cyclical fluctuations of distinct pattern and origin with varying lengths. The purpose of this section is to investigate the empirical regulations in short-term economic fluctuations and dynamics of in South Africa. This type of investigation is important in a number of ways. First, understanding cyclical fluctuations is important to macroeconomic policymaking. Large cyclical swings might call for stabilization over and above what is achieved by automatic stabilizers, especially in developing economies such as South Africa, where domestic financial markets are relatively less developed and a larger segment of the population is at risk of poverty (Carmignani, 2005). In that context, the investigation of the cyclicality of macroeconomic variables is not only relevant for monetary and fiscal policymaking, but also for the design of social welfare systems and labour-market policies. For this investigation, we focus only on one kind of short-term fluctuation, that is, business cycles. The macroeconomic variables we consider are export and import prices.

The study of short-term fluctuations begins with the processes of detrending/smoothing the key macroeconomic variables. From there, information can be extracted to provide an overall picture of the cycle's basic characteristics - volatility, persistence, cyclicality, and co-movement. The literature provides a number of detrending/smoothing techniques which includes once-differencing, band-pass filters (Baxter-King filter, 1999), and Hodrick-Prescott filters (Hodrick and Prescott, 1997). The latter is the most frequently used filtering technique and is the same technique that we employ here with smoothing parameter, λ = 1600, which is appropriate for quarterly macroeconomic time series (Hodrick and Prescott, 1997).

Table 4.17: Spectral Densities of HP-Filtered Log of Import and Export Prices

FREQ	hp_LIMP	hp_LEXP	FREQ	hp_LIMP	hp_LEXP
0.00000	0.0005402	0.0004231	1.62147	0.0000327	0.0001887
0.10134	0.0013526	0.0009722	1.72281	0.0000532	0.0001337
0.20268	0.0042308	0.0033572	1.82415	0.0001547	0.0001379
0.30403	0.0032081	0.0040816	1.92549	0.0001307	0.0001300
0.40537	0.0013374	0.0017728	2.02683	0.0000397	0.0000828
0.50671	0.0006491	0.0005228	2.12818	0.0000396	0.0000577
0.60805	0.0006876	0.0005324	2.22952	0.0000910	0.0000280
0.70939	0.0005054	0.0004123	2.33086	0.0000550	0.0000218
0.81073	0.0007234	0.0005866	2.43220	0.0000171	0.0000190
0.91208	0.0003817	0.0004996	2.53354	0.0000216	0.0000088
1.01342	0.0000757	0.0002582	2.63488	0.0000332	0.0000102
1.11476	0.0000493	0.0001008	2.73623	0.0000408	0.0000568
1.21610	0.0000344	0.0000196	2.83757	0.0000476	0.0002001
1.31744	0.0001278	0.0000909	2.93891	0.0000550	0.0000750
1.41878	0.0002045	0.0003512	3.04025	0.0000413	0.0000777
1.52013	0.0000954	0.0001671	3.14159	0.0000158	0.0000458

Fig. 4.12: Spectral Densities of HP-Filtered Prices

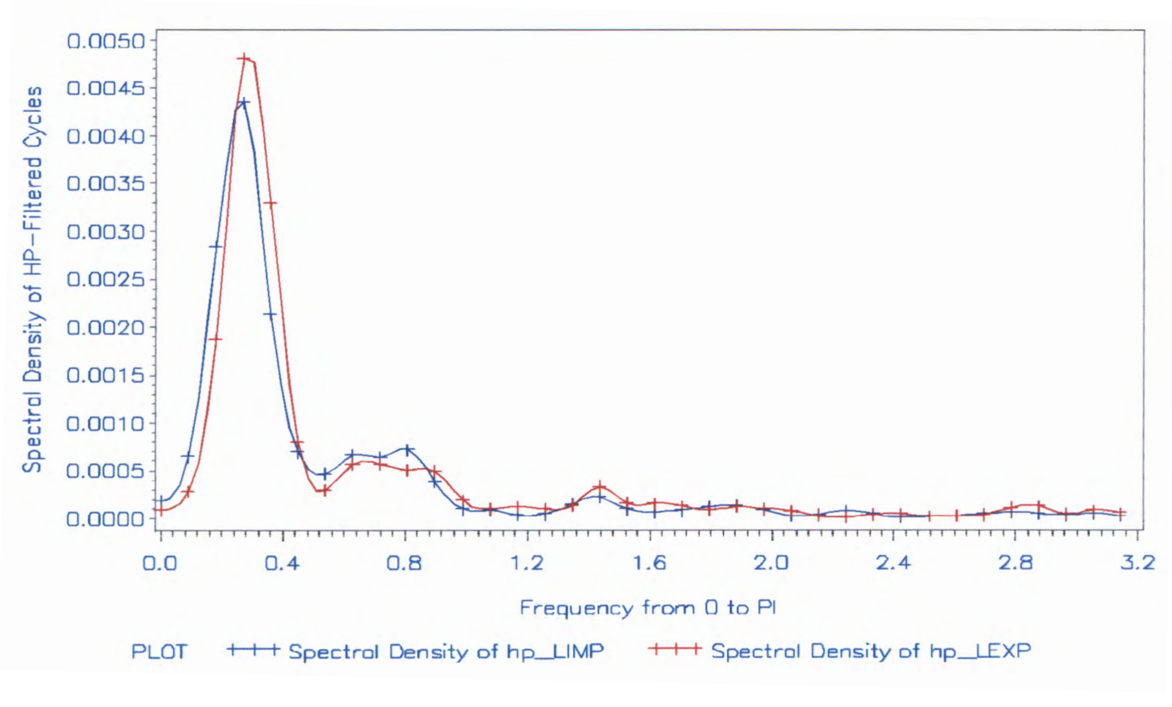


Fig. 4.12 and Table 4.17 display the estimated spectra of the HP-filtered logarithm of import and export prices. As a result of the application of the filter, two outstanding humps appear at the frequencies around 0.20268, 0.30403, and 0.81073. Using the relation

$$c = \frac{2\pi}{d \times \text{freq}}, \tag{4.10}$$

where c is the period of the cycle and d is number of observations per unit time. If the unit time is expressed in 'years', then since our data are quarterly, the corresponding cycle periods are 8 years, 5 years, and 2 years.

4.5.1 Stationarity Tests of Cycles

Fig. 4.13 is an overlay picture of the HP-filtered import and export prices at levels and after one differencing. The KPSS stationarity test results reported in Table 4.18 suggest that both cycles are stationary at the 5% level of significance.

Fig. 4.13: Overlay Plots of HP-Filtered Prices at Levels and After One Differencing

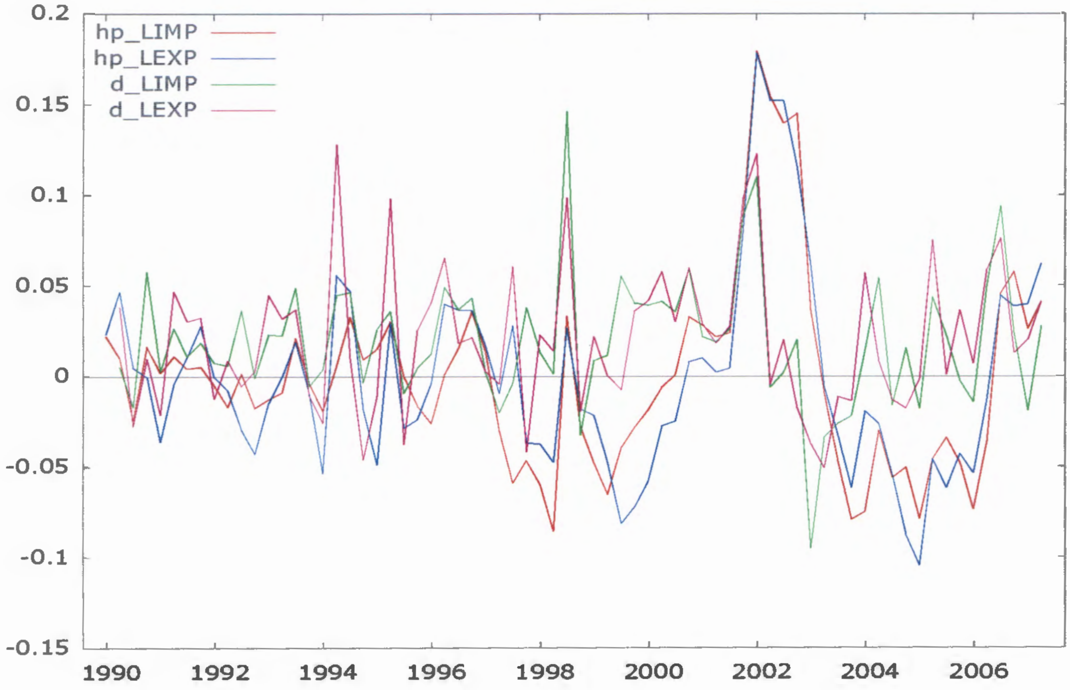


Table 4.18: KPSS Stationarity Tests of Log Import and Export Prices

Variable	KPSS statistic at lag truncation parameter ...				5% Critical Value	Status
	1	2	3	4		
LIMP (At level)	3.5384	2.3962	1.8249	1.4823	0.463	Nonstationary
LEXP (At level)	3.5505	2.4070	1.8342	1.4907	0.463	Nonstationary
LIMP (Once-Difference)	0.0826	0.0816	0.0799	0.0782	0.463	Stationary
LEXP (Once-Difference)	0.0765	0.0783	0.0830	0.0806	0.463	Stationary
HP_LIMP	0.1100	0.0811	0.0671	0.0595	0.463	Stationary
HP_LEXP	0.0862	0.0646	0.0542	0.0484	0.463	Stationary

LIMP and LEXP are variables at level
d_LIMP and d_LEXP are once-difference variables
HP_LIMP and HP_LEXP are Hodrick-Prescott filtered variables

4.5.2 Persistence, Volatility, and Cyclicality

Macroeconomic variables tend to be serially correlated even after time trends are eliminated (Cooley and Prescott, 1995; Stock and Watson, 1999; Yamagata, 1998; Kose and Plummer, 2000). This finding means that the effects of a shock do not terminate instantaneously and that those effects persist for some time. In the literature, the persistence of the effects of the shock is measured using the concept of autocorrelation discussed in Chapter 3. Table 4.19 summarizes the first-order autocorrelation coefficients, ρ_1, of the two variables. The closeness of the two first-order autocorrelation coefficients to 1 suggests persistence and therefore less frequent fluctuations in the two variables. The low standard deviations of the two cyclical components, 0.0524 and 0.0536, suggests that import and export cycles are highly volatile.

Table 4.19: Summary of Statistics of Import Cycle and Export Cycle Fluctuations

i	Correlation, ρ, between HP-Filtered Logged GDP(t) and ...			
	...HP-Filtered LIMP(t+i)		... HP-Filtered LEXP(t+i)	
	ρ	Prob(ρ)	ρ	Prob(ρ)
-4	0.22072	0.0749	0.08509	0.4970
-3	0.33834	0.0051	0.29529	0.0153
-2	0.48505	<.0001	0.46282	<.0001
-1	0.59194	<.0001	0.58217	<.0001
0	0.52680	<.0001	0.57549	<.0001
1	0.34807	0.0034	0.46625	<.0001
2	0.12640	0.3044	0.27687	0.0223
3	-0.01564	0.9000	0.11137	0.3696
4	-0.16162	0.1948	0.01910	0.8790
Standard Deviation(HP-Filtered LIMP) = 0.0524 Standard Deviation(HP-Filtered LEXP) = 0.0536 Auto-Correlation(HP-Filtered LIMP) = 0.7855 Auto-Correlation(HP-Filtered LEXP) = 0.7440				

The analysis is completed by the computation of pairwise correlations between the cyclical components of a reference macroeconomic variable and import and export prices. Such pairwise correlation coefficients measure the extent to which import and export prices co-move in line with the reference macroeconomic variable and can therefore be used to characterize the two price variables as being either pro-cyclical or counter-cyclical. A macroeconomic variable is pro-cyclical if it is positively correlated with the reference macroeconomic variable while a macroeconomic variable is counter-cyclical if it is negatively correlated with the reference macroeconomic variable. Where the correlation coefficient is not statistically different from zero, the macroeconomic variable is said to be 'acyclical'. Following Carmignani (2005), the reference macroeconomic variable chosen for this investigation is GDP.

To allow for non-contemporaneous co-movements, pairwise correlations between current cyclical components of logged GDP (hp_GDP) and the cyclical components of logged import price (hp_LIMP) and export price (hp_LEXP) at time $t+i\,(i=-4,-3,..,3,4)$ are computed and the results also summarized in Table A3. The correlation coefficients between the cyclical components of logged import price and GDP, which range between 0.33834 and 0.59194, are all significant at the 5% level. The negative correlation between the current cyclical component of GDP and the third and fourth leads of the cyclical components of logged import price might be a consequence of a lagged pro-cyclical response. Similarly, the correlation coefficients between the cyclical components of logged export price and GDP, which range between 0.27687 and 0.58217, are all significant at the 5% level. These relatively high positive correlations mean that import and export prices are mildly pro-cyclical.

4.5.3 Univariate Models for Import and Export Prices

Despite the importance of producing an accurate price modelling and forecasting, just a handful of studies have been devoted to modelling import and export prices. Most academic studies have concentrate on econometric models of price formation (Buongiorno and Lu, 1989; Chas-Amil and Buongiorno, 1999; Booth et al, 1991), while some other studies have used cointegration method to study the relationship between paper price movements and exchange rate (Alavalapati et al, 1997; Naininen and Toppinen, 1999). This section employs three univariate modelling techniques - double exponential smoothing technique, Winters' multiplicative technique, and Box-Jenkins

Autoregressive Integrated Moving Average (ARIMA) technique - to model import and export prices, as well as to obtain a two-year out-of-sample forecasts.

With import prices, the double-exponential smoothing technique was optimized with smoothing constants α(level)=1.20761 and γ(trend)=0.00508, while the best results from the application of the Winters' multiplicative technique were obtained with smoothing constants α(level)=1.0, (trend)=0.3, and (season)=0.2. Similarly, with export prices, the double-exponential smoothing technique was optimized with smoothing constants (level)=1.15309 and (trend)=0.01052, while the best results from the application of the Winters' multiplicative technique were obtained with smoothing constants (level)=0.9, (trend)=0.3, and (season)=0.2. To apply the Box-Jenkins ARIMA technique, autoregressive (AR) order, p, of up to 3 and moving average (MA) order, q, of up to three were used.

Using the fact that the two prices are integrated of order 1, the AIC and SBC values from the combination of all the AR and MA orders for parsimonious results are reported in Table 4.20. As observed from the results, the AIC and SBC selects the ARIMA(1,1,1) model for both export and import prices. Fig. 4.14 and Fig. 4.15 show the actual and forecast import and export prices from 1990Q1 to 2007Q2 obtained from the three univariate methods.

Table 4.20: Parsimonious ARIMA Model Selection

Autoregressive Order, p	Moving Average Order, q	LIMP		LEXP	
		AIC	SBC	AIC	SBC
0	0	-246.973	-246.973	-236.122	-236.122
0	1	-250.302	-248.068	-236.918	-234.684
0	2	-249.332	-244.864	-236.163	-231.695
0	3	-249.224	-242.522	-234.181	-227.478
1	0	-251.808	-249.573	-237.774	-235.540
1	1	-257.562	-253.094	-245.261	-240.793
1	2	-256.363	-249.661	-243.351	-236.648
1	3	-254.627	-245.691	-234.011	-225.074
2	0	-251.202	-246.734	-237.136	-232.667
2	1	-256.541	-249.839	-243.577	-236.875
2	2	-254.417	-245.480	-235.474	-226.537
2	3	-251.946	-240.776	-233.200	-222.030
3	0	-251.457	-244.755	-235.664	-228.961
3	1	-254.585	-245.649	-241.403	-232.467
3	2	-252.579	-241.409	-235.291	-224.120
3	3	-252.415	-239.010	-236.332	-222.927

Fig. 4.14: Overlay Plots of Original and Forecast Import Prices

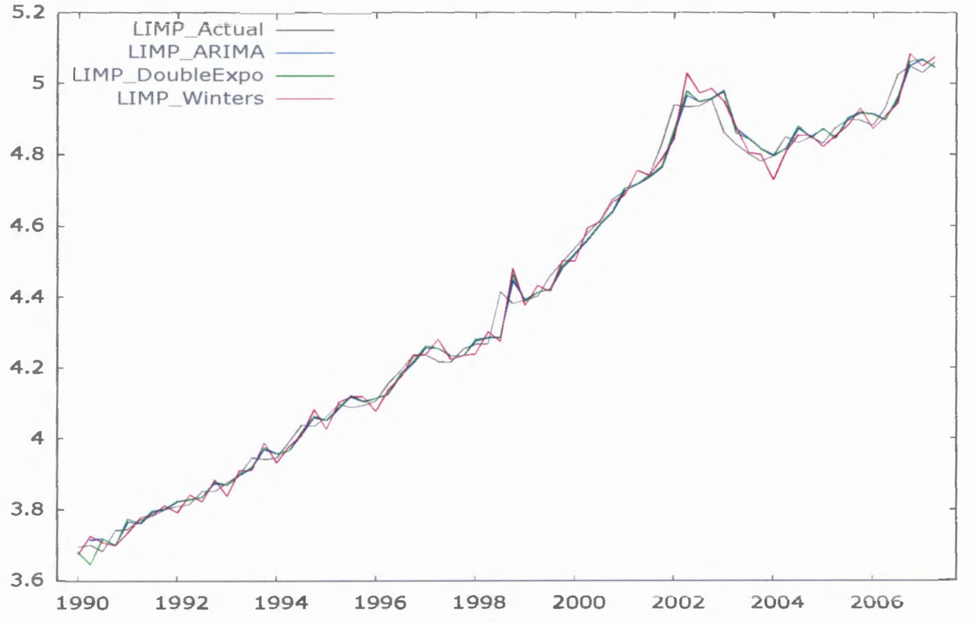
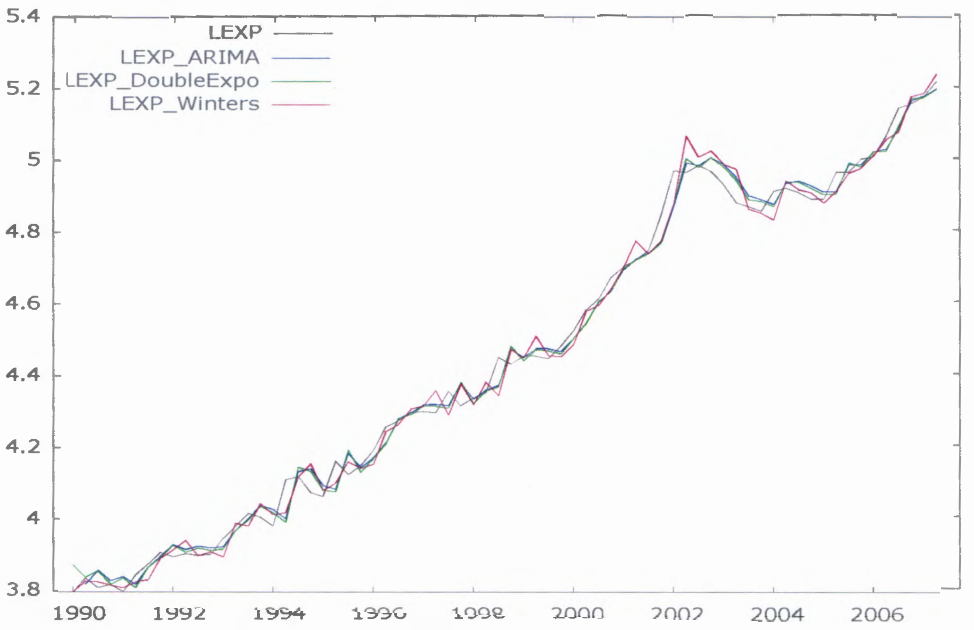


Fig. 4.15: Overlay Plots of Original and Forecast Export Prices



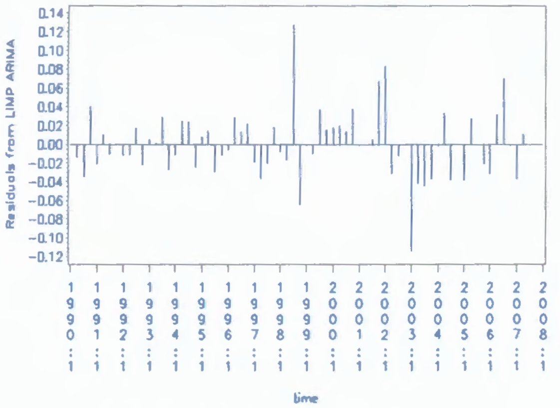
In order to investigate the accuracy of the results produced by the three univariate models, we have reported three forecast errors, namely, MAPE, MAD, and RMSE in Table 4.21. As observed from the results, the ARIMA technique produces slightly lower forecast errors than double-exponential smoothing and Winters' multiplicative techniques. This suggests that ARIMA forecasts could be slightly more efficient than forecasts from the two other techniques. The slightly variation in forecast errors means that all three models can be used to forecast price movements. However, for short-term price movements' evaluation, exponential smoothing forecasts are recommended while ARIMA forecasts are recommended for long-term evaluation of price movements (Makridakis and Hibon, 1979).

Table 4.21: Forecast Errors from Three Univariate Models

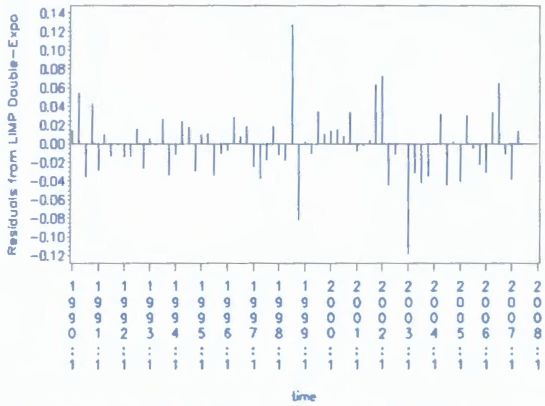
Univariate Method	Forecast Error Measure	LIMP	LEXP
Double-Exponential Smoothing	MAPE MAD RMSE	0.596464 0.026376 0.035781	0.706732 0.031281 0.039806
Winters' Multiplicative	MAPE MAD RMSE	0.674021 0.029831 0.039952	0.713113 0.031940 0.042537
ARIMA	MAPE MAD RMSE	0.572077 0.025488 0.035058	0.679372 0.030181 0.038521

To further access the efficiency of the three models from the three techniques, the residual series are subjected to normality and autocorrelation checks. The autocorrelation test of residuals from ARIMA(1,1,1) results summarized in Table 4.22 suggests that the residuals are not serially correlated at the 0.05 level of significance (i.e. prob-values of the chi-square statistics are all greater than 0.05). Additionally, a visual examination of the residual plots (Fig. 4.16) suggests that the residuals from the three techniques are not serially correlated (i.e. each set of residual points roughly lies within a horizontal band around zero). Furthermore, each of the pp-plots (Fig. 4.17) shows that the data points do not seriously deviate from the fitted line, consistently indicating that residual variables are normally distributed.

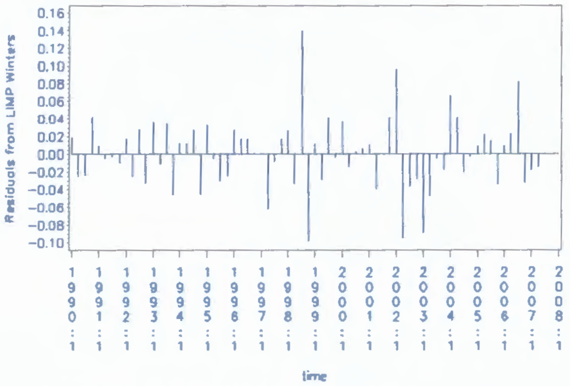
Fig. 4.16: Plots of Residuals versus Time



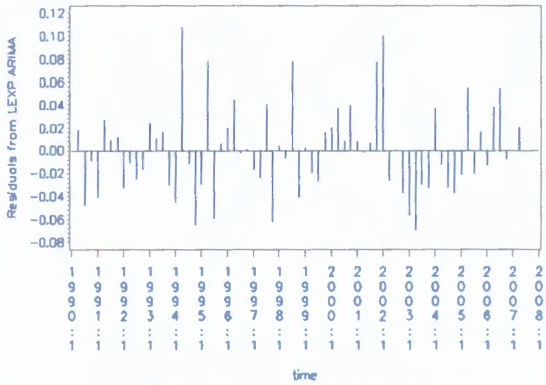
Residual Plot of LIMP from ARIMA(1,1,1)



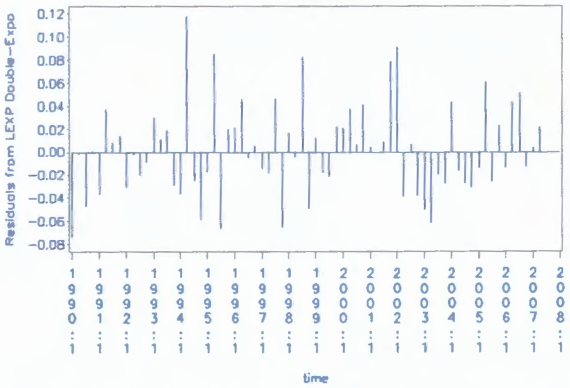
Residual Plot of LIMP from Double-Exponential Smoothing



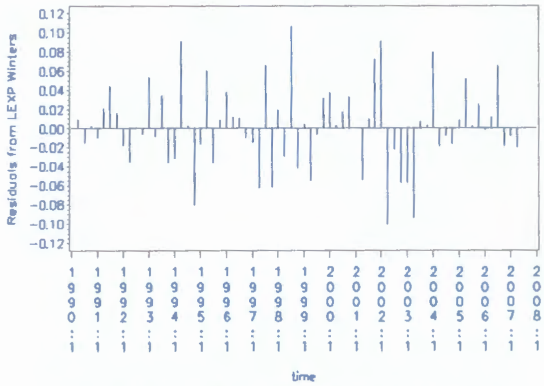
Residual Plot of LIMP from Winters Multiplicative



Residual Plot of LEXP from ARIMA(1,1,1)

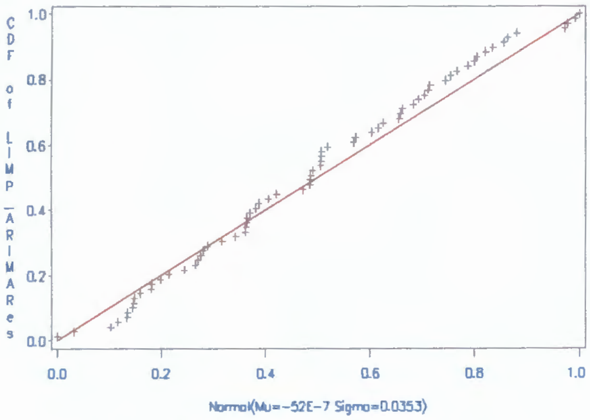


Residual Plot of LEXP from Double-Exponential Smoothing

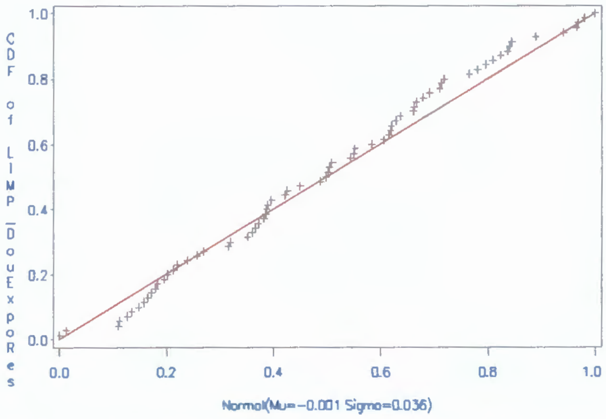


Residual Plot of LEXP from Winters Multiplicative

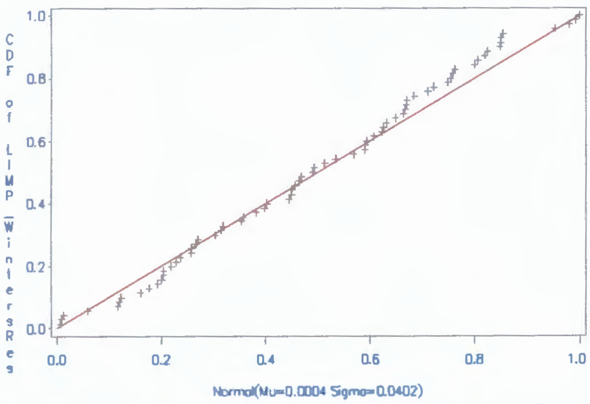
Fig. 4.17: PP-Plots of Residual Variables



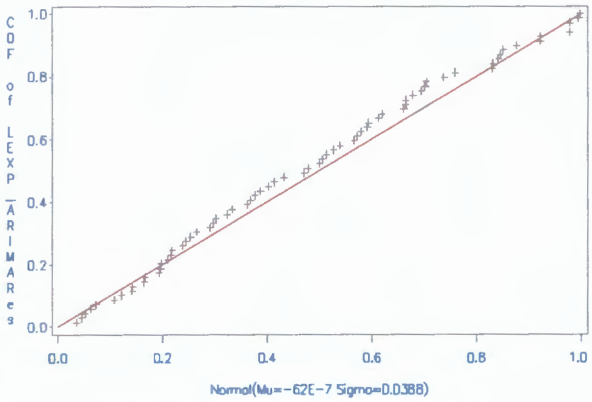
PP-Plot of LIMP Residuals from ARIMA(1,1,1)



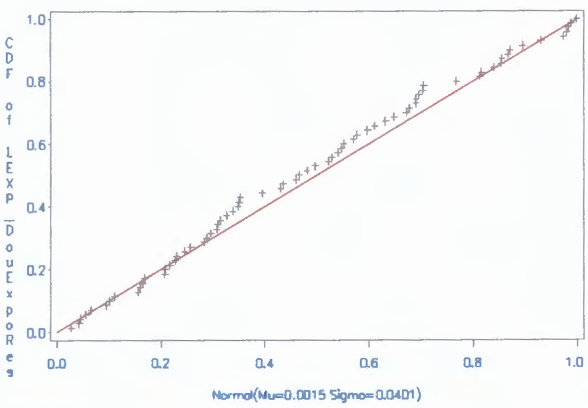
PP-Plot of LIMP Residuals from Double-Exponential Smoothing



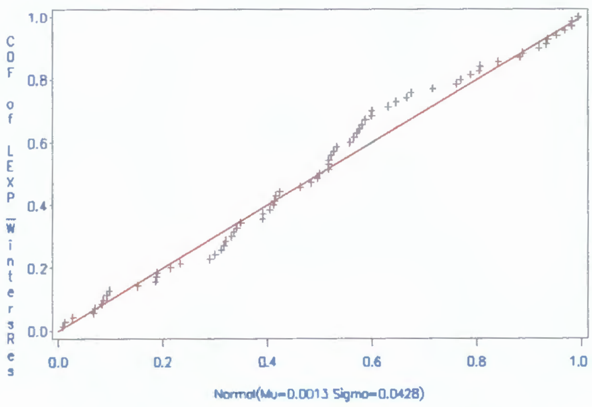
PP-Plot of LIMP Residuals from Winters Multiplicative



PP-Plot of LEXP Residuals from ARIMA(1,1,1)



PP-Plot of LIMP Residuals from Double-Exponential Smoothing



PP-Plot of LIMP Residuals from Winters Multiplicative

Table 4.22: Autocorrelation Check of Residuals

Residual Variable	To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
LIMP_ARIMA	6	0.90	4	0.9247	-0.000	-0.005	0.023	0.037	-0.093	-0.034
	12	9.23	10	0.5106	0.037	0.005	0.113	-0.067	-0.123	-0.253
	18	12.76	16	0.6906	-0.003	0.050	-0.136	-0.045	0.071	-0.100
	24	16.00	22	0.8157	-0.065	-0.001	-0.058	0.073	0.135	0.009
LEXP_ARIMA	6	3.91	4	0.4180	-0.003	-0.039	-0.091	0.159	-0.107	-0.072
	12	14.49	10	0.1517	0.056	-0.034	0.094	-0.234	-0.137	-0.199
	18	17.83	16	0.3338	0.090	-0.091	-0.091	0.047	-0.000	0.099
	24	23.97	22	0.3491	-0.105	0.092	-0.061	0.178	0.064	0.026

Lastly, we produce quarterly import price and export price forecasts using the three techniques. Table 4.23 presents the forecasts from 2007Q3 to 2009Q4. The estimated models ARIMA(1,1,) models are given by:

LIMP: $(1+0.2550B)(1-B)X_t = 0.0249 + (1+0.3530B)\varepsilon_t$, where $\varepsilon_t \sim iid(0,0.0013)$

LEXP: $(1+0.1389B)(1-B)X_t = 0.0235 + (1+0.1577B)\varepsilon_t$, where $\varepsilon_t \sim iid(0,0.0016)$,

Where B is the differencing operator and X_t is the log price variable. As observed from the results in Table 4.23, forecasts from the three techniques do not seem to differ much.

Table 4.23: Out-of-Sample Forecasts of Import and Export Prices

	Log Import Price (LIMP)			Log Export Price (LEXP)		
Quarter	ARIMA	Double-Exponential Smoothing	Winters' Multiplicative	ARIMA	Double-Exponential Smoothing	Winters' Multiplicative
2007Q3	5.08325	5.08654	5.07783	5.24728	5.24860	5.24584
2007Q4	5.10256	5.10869	5.11526	5.26790	5.26762	5.26968
2008Q1	5.12250	5.13085	5.10502	5.28858	5.28663	5.28842
2008Q2	5.14227	5.15300	5.14339	5.30925	5.30564	5.34456
2008Q3	5.16209	5.17516	5.15963	5.32992	5.32466	5.36223
2008Q4	5.18190	5.19731	5.19733	5.35059	5.34367	5.38595
2009Q1	5.20171	5.21946	5.18661	5.37127	5.36268	5.40447
2009Q2	5.22151	5.24162	5.22526	5.39194	5.38170	5.46120
2009Q3	5.24132	5.26377	5.24143	5.41261	5.40071	5.47861
2009Q4	5.26113	5.28593	5.27941	5.43328	5.41972	5.50222

4.6 Conclusion

This section has investigated price dynamics of some selected South African commodities, namely, consumer prices, producer prices, export prices, and import prices. We have particularly focused on price transmission, cyclicality, forecast models, and out-of-sample forecasts.

CHAPTER 5

Summary of Study Findings and Recommendations

5.1 Introduction

The scope of this thesis covers three areas of economic analysis - asymmetric price transmission, price cyclicality, and forecasting of prices. The price transmission elasticities of producer and consumer prices were also explored, including other factors that might influence the price mechanism. The relatively easy access of the data used in this study naturally led to debarkation of the study from price asymmetry to include important exercise like price cyclicality and price forecasting.

5.2 Summary of Findings

The thesis and the analyses run have revealed the following findings:

- By using the two-stage Engle-Granger cointegrating method, a cointegrating relationship was found to exist between producer and consumer prices of goods.
- By employing the Engle-Granger Vector Error Correction Method, it was found that producer price of goods Granger-causes consumer price of goods but not the reverse.
- By appealing to the von Cramon-Taubel Engle-Granger Error Correction Model specification, it was established that the transmission between consumer prices of goods and producer prices of goods was asymmetrical.
- Using the OLS estimation method, the price transmission elasticity was found to be elastic and perfect in the mark-up model and inelastic and imperfect in the markdown price transmission model.
- The examination of transmission effects of exchange rates on housing and food prices using producer price for manufacturing food and consumer price for housing

as the two main dependent variables using the Impulse Response Function and Variance Decomposition methods revealed some interesting results.

- The exchange rates shocks to consumer price for housing, money supply (M1), and GDP spreads over a period of 8 quarters (2 years), but starts to decay thereafter.

- Oil price shocks to consumer price for housing spread over a period of 4 quarters (1 year), but die out thereafter.

- The exchange rate shocks to consumer price for housing and M1 was much faster than the oil price shocks.

- The exchange rates shocks to producer price for manufacturing food and GDP spreads over a period of 8 quarters (2 years), but starts to decay thereafter.

- Oil price shocks to producer price for manufacturing food also spread over a period of 8 quarters (2 year), but die out thereafter.

- Shocks from M1 and GDP were the most important determinants in the variance in consumer prices for housing.

- Shocks from exchange rates and GDP were found to be the most important determinants in the variance in producer prices for manufacturing food.

- Following McCarthy (2000), the nature of price transmission from oil through other variables to consumer prices revealed the following:
  - The fastest exchange rate shock effect is observed with a total consumer price increase after 6 periods (1.5 years).
  - The producer price shock effect is observed with a total consumer price increase after 4 periods (1 year).
  - Exchange rates explain a fairly large part of the variation of import prices.

- Exchange rates explain only a small part of the variation in oil prices.

- The closeness of the autocorrelation coefficients between import and export prices to 1 suggested persistence between the two variables while the low standard deviations of the cyclical components of the two prices suggested the two prices were highly volatile.

- The relatively high positive correlations between import and export prices suggest the two prices were mildly pro-cyclical.

- In an attempt to model import and export prices, the application of the Box-Jenkins method yielded an ARIMA(1,1,1) model both prices.

5.3 Recommendation for Future Research

Findings from this research study have been based on a small area of the South African market and therefore may not be sufficient to address the existence of asymmetry in the South African market. An expansion of the research area will be needed to help improve the understanding of asymmetries in the South African market. Another avenue for further research would be to increase the range of prices included in the study, as well as including more recent data on prices of variables used.

5.4 Chapter Conclusion

This chapter has presented a summary of the findings from the study. Recommendations were also provided for further research.

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TIME SERIES DATA USED

Date	IMP	OIL	M1	EXR	GDP	CPI	PPIT	CPIG	PPIG	PPIMF	CPIH	EXP
1990/01	40.31	21.7223	50328	257.15	275892	40.467	45.053	38.953	45.053	43.693	62.437	43.13
1990/02	40.53	17.8967	49608	265.49	289185	41.613	46.577	40.317	46.577	43.897	63.573	43.49
1990/03	39.86	26.4997	47035	259.09	293968	42.927	47.607	41.603	47.607	44.737	64.197	44.43
1990/04	42.25	31.853	50462	253.34	300217	44.763	49.427	43.527	49.427	46.403	65.207	45.23
1991/01	42.38	21.7807	54627	258.3	313771	46.307	51.207	45.167	51.207	47.56	66.223	43.69
1991/02	43.53	20.7527	56742	280	326704	47.903	52.14	46.86	52.14	47.92	66.443	45.78
1991/03	44.01	21.655	58460	286.27	338601	49.61	53.257	49.35	53.257	50.843	67.297	47.09
1991/04	44.85	21.7367	60617	279.77	348844	51.977	54.857	52.227	54.857	53.08	68.45	48.38
1992/01	45.2	18.9103	61307	282.52	362388	53.65	55.69	54.173	55.69	52.15	68.783	48.62
1992/02	45.48	21.186	61921	284.52	366044	55.093	57.167	56.017	57.167	53.01	68.847	49.97
1992/03	47.18	21.6703	67877	277.15	376571	56.62	58.513	57.79	58.513	55.267	67.67	49.48
1992/04	47.16	20.479	71359	296.44	383903	57.6	59.5	59.063	59.5	56.577	67.007	49.13
1993/01	48.28	19.825	69221	312.24	397345	58.687	60.47	60.163	60.47	56.833	66.647	50.7
1993/02	49.39	19.76	70852	319.23	418517	60.96	61.323	62.39	61.323	57.55	67.023	52.11
1993/03	51.88	17.7963	69769	337.4	435178	61.937	62.1	63.1	62.1	59.673	68.223	54.21
1993/04	51.61	16.4513	73504	337.81	453492	63.053	63.137	64.257	63.137	60.943	68.767	55.46
1994/01	51.82	14.8133	81872	343.77	464580	64.35	64.793	65.513	64.793	63.423	68.973	56.67
1994/02	54.21	17.7767	89249	361.2	477196	65.33	66.087	66.687	66.087	66.93	69.893	58.96
1994/03	56.8	18.4967	89339	360.8	481902	67.583	68.377	69.357	68.377	70.677	70.633	60.08
1994/04	56.63	17.6567	92072	354.1	504802	69.24	69.613	70.653	69.613	71.5	73.013	60.02
1995/01	58.13	18.3567	91763	356.55	525795	70.743	71.917	71.85	71.917	72.79	75.667	62.54
1995/02	60.27	19.3433	96776	364.02	542660	72.313	73.573	73.203	73.573	71.837	79.023	63.73
1995/03	59.73	17.8533	98255	364.78	555452	72.803	74.253	72.99	74.253	72.203	81.767	63.62
1995/04	60.02	18.1567	105232	365.45	568493	73.777	75.86	73.74	75.86	74	83.637	63.59
1996/01	60.77	19.77	120369	376.97	589256	75.33	76.973	75.18	76.973	77.21	85.247	64.77
1996/02	63.85	21.7567	128814	430.95	613711	76.73	78.17	76.253	78.17	78.75	88.483	68.06
1996/03	66.26	22.4233	136772	446.99	624668	78.36	80.257	77.833	80.257	82.063	90.71	69.07
1996/04	69.21	24.6667	150179	463.66	644181	80.517	82.37	79.907	82.37	84.113	92.977	71.2
1997/01	69.36	22.79	155968	451.1	661183	82.553	84.143	80.587	84.143	85.573	91.627	72.65
1997/02	68.01	19.9067	156080	446.92	680757	83.937	85.227	81.807	85.227	87.127	92.753	72.74
1997/03	67.76	19.7833	168876	464.39	690911	85.117	85.757	82.707	85.757	87.54	94.38	73.8
1997/04	70.4	19.9167	182475	480.53	710069	86.057	86.77	83.907	86.77	87.527	94.443	74.49

TIME SERIES DATA USED (CONTINUATION)

Date	IMP	OIL	M1	EXR	GDP	CPI	PPIT	CPIG	PPIG	PPIMF	CPIH	EXP
1998/01	71.36	15.93	189150	494.86	720010	87.08	87.247	85.003	87.247	88.947	94.923	75.76
1998/02	71.47	14.6533	198340	516.63	743653	88.227	87.993	86.577	87.993	90.953	93.66	77.5
1998/03	82.75	14.13	220549	622.76	744451	91.707	88.923	87.933	88.923	92	104.503	85.43
1998/04	80.11	12.84	220715	578.41	761582	93.887	90.103	89.173	90.103	93.2	109.567	83.39
1999/01	80.82	13.0467	221567	610.11	780195	94.407	91.303	90.413	91.303	94.647	107.673	85.78
1999/02	81.79	17.66	227407	612.77	798840	94.59	92.42	91.583	92.42	95.157	103.163	85.86
1999/03	86.46	21.7367	235583	609.83	827418	94.81	93.8	93.13	93.8	95.45	99.263	86.31
1999/04	90.05	24.5633	261415	612.54	848279	95.79	95.31	94.98	95.31	97.313	97.78	88.55
2000/01	93.66	28.8067	262242	629.82	874150	97.067	97.377	96.973	97.377	98.74	97.783	92.28
2000/02	97.63	28.7833	263326	685.33	904844	99.23	99.22	99.34	99.22	100.413	98.767	98.28
2000/03	101.17	31.6233	258828	699.63	942974	101.037	100.553	101.247	100.553	100.19	100.587	101.43
2000/04	107.38	31.98	268311	759.33	966624	102.533	102.817	102.41	102.817	100.66	102.867	107.85
2001/01	109.78	28.81	274014	782.32	993739	104.267	104.87	103.41	104.87	102.28	104.803	112.08
2001/02	111.91	27.8833	283914	803.45	1005513	105.567	106.59	105.187	106.59	105.89	105.543	115.82
2001/03	114.88	26.6	294850	837.7	1019273	105.873	108.21	106.15	108.21	108.147	103.05	115.74
2001/04	125.46	20.4033	306687	1017.78	1061503	106.963	111.423	107.907	111.423	113.54	102.157	125.91
2002/01	140.11	21.61	333705	1152.87	1113558	110.223	117.517	111.213	117.517	123.633	105.603	141.62
2002/02	139.28	26.27	345672	1045.53	1152199	113.713	121.47	115.053	121.47	134.057	110.493	141.92
2002/03	139.61	28.33	349208	1043.58	1183082	116.877	124.267	117.867	124.267	139.357	114.733	144.08
2002/04	142.49	28.18	352476	964.62	1225957	120.583	126.51	121.36	126.51	143.083	120.18	143.65
2003/01	129.57	34.12	348375	834.29	1231921	122.057	126.947	122.33	126.947	143.587	122.14	138.02
2003/02	125.29	29.0367	339860	775.82	1241529	122.55	126.81	122.373	126.81	141.257	123.263	131.73
2003/03	122.07	30.2133	346057	742.16	1271148	122.3	127.773	123.333	127.773	139.493	119.21	130.88
2003/04	119.47	31.19	373715	673.61	1298174	121.517	127.2	123.9	127.2	139.433	113.38	128.61
2004/01	121.23	35.2567	403317	677.31	1345473	122.583	128.903	125.613	128.903	139.15	112.007	136.52
2004/02	128.03	38.33	395897	659.03	1369129	123.363	130.19	126.63	130.19	140.09	112.157	138.47
2004/03	126.01	43.86	406551	637.77	1417315	123.88	130.54	126.68	130.54	138.127	112.79	136.9
2004/04	128	48.3067	418905	605.86	1460723	125.367	130.903	128.207	130.903	137.267	113.777	133.94
2005/01	125.72	49.7067	428358	599.87	1475555	126.11	131.527	128.163	131.527	136.983	115.03	133.93
2005/02	131.36	53.0433	453339	641.12	1502110	127.297	132.97	130.027	132.97	136.523	115.013	144.42
2005/03	134.38	63.08	484525	650.88	1559825	128.68	134.96	131.947	134.96	136.91	115.31	144.37
2005/04	134.07	60.0333	497419	653.07	1618386	129.947	136.21	133.17	136.21	137.683	116.15	149

TIME SERIES DATA USED (CONTINUATION)

Date	IMP	OIL	M1	EXR	GDP	CPI	PPIT	CPIG	PPIG	PPIMF	CPIH	EXP
2006/01	132.19	63.3467	523895	615.37	1638963	130.883	138.313	134.357	138.313	140.823	116.177	149.42
2006/02	138.9	70.53	548205	644.89	1675342	132.407	141.623	136.473	141.623	144.423	116.677	157.4
2006/03	152.65	70.4433	577455	714.98	1766779	135.353	147.023	139.943	147.023	148.813	119.69	169.62
2006/04	156.42	60.0933	598242	731.61	1828828	137.163	149.37	139.93	149.37	153.977	124.38	172.24
2007/01	153.5	58.13	622276	723.5	1882392	138.65	151.917	141.403	151.917	155.593	126.21	175.71
2007/02	157.83	64.97	657543	710.4	1919895	141.653	157.24	145.54	157.24	163.79	127.887	183.64