



**AN ANALYSIS OF THE RELATIONSHIP BETWEEN
REMUNERATION AND LABOUR PRODUCTIVITY IN SOUTH
AFRICA**



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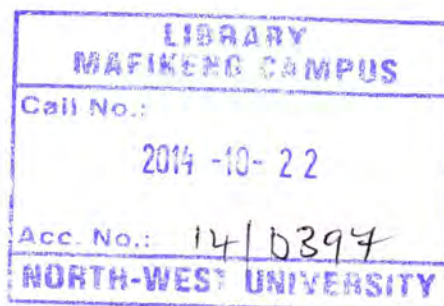
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JOHANNES TSHEPISO TSOKU

A Dissertation submitted for the requirement for the degree of Master of
Commerce in Statistics at the North West University (Mafikeng Campus)

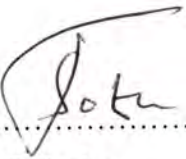
Supervisor: Dr F Matarise

April 2014



DECLARATION

I, Tshepiso Tsoku, hereby declare that this research report is my own original work and that all sources have been accurately reported and acknowledged, and that this document has not previously in its entirety or in part been submitted at any university in order to obtain an academic qualification.



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J. T Tsoku

22/09/2014

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Date

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ABSTRACT

This study analyses the relationship between remuneration (real wage) and labour productivity in South Africa at the macroeconomic level, using time series and econometric techniques. The results depict that there is a significant evidence of a structural break in 1990. The break appears to have affected the employment level and subsequently fed through into employees' remuneration (real wage) and productivity. A long run cointegrating relationship was found between remuneration and labour productivity for the period 1990 to 2011. In the long run, 1% increase in labour productivity is linked with an approximately 1.98% rise in remuneration. The coefficient of the error correction term in the labour productivity is large, indicating a rapid adjustment of labour productivity to equilibrium. However, remuneration does not Granger cause labour productivity and vice versa.

Keywords: Remuneration, Labour Productivity, Unemployment, Employment, Cointegration, Error Correction Model.

LIST OF ACRONYMS

ADF	Augmented Dickey-Fuller
AIC	Akaike Information Criterion
ARCH	Autoregressive Conditional Heteroskedasticity
CPI	Consumer Price Index
ECM	Error Correction Models
ECT	Error Correction Term
FPE	Final Prediction Error
GDP	Gross Domestic Product
HQ	Hannan-Quinn Information Criterion
LM	Lagrange Multiplier
LR	Likelihood Ratio
ML	Maximum Likelihood
OECD	Organisations for Economic Co-operation and Development
OLS	Ordinary Least Square
PP	Phillips and Perron
SARB	South African Reserve Bank
SBC	Schwarz Bayesian Criterion
StatsSA	Statistics South Africa
US	United States
UK	United Kingdom
VECM	Vector error correction model
VAR	Vector autoregressive

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CHAPTER 1

ORIENTATION OF THE STUDY

1.1 INTRODUCTION

Remuneration (real wage), rate of unemployment and productivity are important economic indicators or measures in an economy. Productivity measures the output produced by workers in various sectors of the economy while remuneration is the cost of producing that output in the form of salaries and wages. Unemployment is a measure of the number of people in the workforce who are out of work or are without jobs. Numerous economic theories have been put forward justifying a relationship between the above mentioned variables, including bargaining, efficiency wage, search and contract theories (Wakeford, 2004).

There has been an increasing volume of empirical studies regarding the association between labour productivity and remuneration (Goh, 2009). Most of these empirical studies found positive long run relationships between labour productivity and remuneration, although the relationship between labour productivity and remuneration has not been one to one. The studies by Hall (1986), Wakeford (2004), Alexander (1993), Strauss and Wohar (2004) for instance, found positive long run relationships between labour productivity and remunerations in the respective countries which they studied, and the increases in labour productivity are linked with a less than unit increase in remunerations (MacKinnon, 1991).

The marginal productivity theory proposes that exceedingly productive employees are highly remunerated, and less productive employees are less remunerated. At the macroeconomic level, an increase in remuneration is expected to increase the cost of workforce and therefore cause factor substitution from labour to capital. This could increase marginal productivity and, hence, average labour productivity output. Therefore, it is hypothesized that real wages are positively affected by productivity (Goh, 2009). Employees that are highly remunerated are less likely to move from one company to the other. Thus employers can keep more productive and experienced employees than newly employed employees who may not be as productive as experienced employees. For instance, it has been debated that increasing remuneration can stimulate employees' determination and reinforce long term employment relationships. Akerlof (1982) also proposed that when companies increase employees' remuneration, they put forth greater efforts out of a sense of loyalty to those employers.

These relationships can be investigated using various procedures developed by various researchers in the literature discussed in the next section.

1.2 BACKGROUND LITERATURE

The discovery of cointegration, like several scientific discoveries, is a fascinating tale involving incorrect avenues, half-understood solutions, persistent anomalies and partial insights which were finally resolved by Granger's breakthrough. The economic analysis of time series dates back to the foundations of statistics. The study by Klein (1997) records the 1662 contribution by John of Graunt on time series of London's childbirths and deaths, and the invention by the Bank of England in 1797 of moving averages to conceal the accurately hazardous state of its bullion reserves are an initial example of creative accounting. In the year 1862, succeeding up work by Charles Babbage, the computer inventor, Jevons (1884) studied a variety of weekly financial time series over the period of 1825 – 1860, as well as currency circulation, discount rates and bankruptcies: implying that 'high frequency' monetary econometrics is not new.

The real action started towards the end of the nineteenth century, in an endeavour to understand why 'peculiar' correlations often turned up surprisingly frequently, as well as the fictional infamous high correlation among Stockholm's number of storks nesting and the number of children born there. The first step was pioneered by Hooker (1901), but first analytical results were provided by Yule (1926), displaying the risks inherent in regressions between nonstationary variables, or what he named nonsense correlations. The work by Yule (1926) was based on a statistical model recommended by the experiments of a biologist Brown (1828) to describe the random movements of pollen grains floating on water, which is currently called Brownian motion. This has been frequently used for equity price movements as suggested by Bachelier (1900), in the appearance of a random walk, the basic integrated process. Yule (1926) indicated that any two integrated series would be significantly correlated, although their initial positions and shocks were not related.

Granger (1969) was originally critical of a class of econometric models introduced by Sargan (1964), and since called equilibrium correction, following an least square estimator traditional approach which Bill Phillips had introduced using proportional, derivative and integral control mechanisms (Phillips, 1954, 1956). The Sargan (1964) formulation added the disequilibria suggested by economics in first differenced models. Sargan (1964) in his study of prices and wages assumed that the deviation from its mean of the log of real wages adjusted for productivity progress would have an impact in future wage inflation. Granger (1969) argued that the stationarity of that combination was not established, but was simply assumed. More significantly, the properties of integrated data were taken as given, as in Davidson, Hendry, Srba and Yeo (1978), rather than entailed by the model.

Granger, in *Economic Theory Interview* by Phillips (1997), set out to prove that linear combinations of integrated variables would actually remain integrated, so equilibrium correction was not a feasible model class. In the way, Granger alternatively established the conditions under which 'cointegration' could occur; therefore some linear combinations were of a lower order of integration than the original variables. The theorem by Granger (1969) representation is the main result, and is the centrepiece of current econometric analyses of integrated processes. The condition that there are less levels of response than variables generates a condensed rank in the dynamics of the long run matrix and leads to the multivariate cointegration methodology developed by Johansen (1988, 1995). To complete the cointegration discovery, Engle and Granger (1987) proposed a way of estimating equations containing potentially cointegrated relationships. Engle and Granger (1987) two-step estimation method established a platform for numerous new applications and theories. Since the original levels of series are integrated, but several combinations are not, cointegration must cancel any 'common trends' that drive all the correlated variables in the long run (Hendry, 2010).

Cointegration is basically a linear concept, and the classical assumption in empirical work has been that the drift towards the steadiness (equilibrium), assumed by models with cointegrated variables, is symmetric, implying that the strength of attraction is a linear function of the distance of the system from the equilibrium. Granger (1969) has also established non-linear cointegration, loosening the symmetry assumption, as is rarely necessary in macroeconomics.

Macroeconomists build time series models for testing theories of economics, for policy analysis and for forecasting. Such models are constructed and applied by economists at universities, banks and economic research institutes, etc. There is a long tradition of building large macroeconomic models with many equations and variables but more recently the use of smaller models with only few equations and variables have become more common. It must be noted that since many of the economic and business time series models are nonstationary, analysing them requires a modelling approach and statistical inference different from the one used in stationary series. The concept of cointegration has become useful in practice because of the availability of theory of statistics for testing and estimating parameters of cointegrated linear systems.

Engle and Granger (1987) together formulated the necessary methods in their classical and remarkably influential paper, where the theory of cointegrated variables is proposed. They considered the problem of testing the null hypothesis of no cointegration between a set of $I(1)$ economic variables. They estimated the coefficients of a stationary relationship between these variables by ordinary least squares (OLS) and applied the well-known unit root tests to the residuals. Rejecting the null hypothesis of a unit root is evidence in favour of stationarity. The two common trend removal or de-trending procedures are first differencing and time-trend regression. First differencing is appropriate for $I(1)$ time series and time-trend regression is appropriate for trend stationary $I(0)$ time series. Unit root tests can be used to determine whether trending data should be first differenced or regressed on deterministic functions of time to render the data stationary. Moreover, economic and finance theory often suggests the existence of long run equilibrium relationships among nonstationary time series variables. If these variables are $I(1)$, then cointegration techniques can be used to model these long run relations (Zivot & Wang, 2003).

Nelson and Plosser (1982) argued that practically all macroeconomic time series data that are normally used have a unit root. The absence or presence of unit roots helps to identify certain features of the underlying data generating process of a series. In case the series does not have a unit root, it fluctuates around a constant long run mean and indicates that the series has a finite variance which is independent on time. If the original series is not stationary and the first order difference of the series is stationary, then the series contains a unit root. The most frequently used methods to test for the presence of unit roots are the Augmented Dickey-Fuller (ADF) tests (Dickey & Fuller, 1979 and 1981). Failure to reject the null hypothesis

implies that the series is not stationary; whereas the rejection of the null hypothesis indicates that the time series is stationary. The Akaike Information Criterion (AIC) and the Schwarz Bayesian Criterion (SBC) are used to determine the optimal lag length denoted by letter “k”.

Following the influential approach by Box and Jenkins (1970), most statisticians have advocated transforming integrated time series into stationary ones by successive differencing of the series before modelling. Therefore, from their point of view, eliminating unit roots through differencing should to be a requirement for regression analysis.

However, some authors, particularly Sargan (1964), Hendry and Mizon (1978) and Davidson *et al.* (1978), among others, started to criticise the approach on a number of grounds especially the specifications of models’ dynamics in terms of only differenced variables and because of the difficulties in inferring the long run equilibrium from the estimated model. In view of this, if deviations from that equilibrium association affect future changes in a set of variables, omitting the previous, i.e. estimating a differenced model, should result in a misspecification error. However, for some time it was difficult to understand how both variables in differenced data and original could coexist in regression models. Engle and Granger (1987) formalized the idea of integrated variables sharing an equilibrium relation which turned out to be either stationary or have a lower degree of integration than the original series. They indicated this property by cointegration, signifying co-movements between trending variables which could be exploited to test for the presence of equilibrium relationships within a fully dynamic specification framework.

Since the 1990s, a maximum likelihood estimation procedure proposed by Johansen (1988, 1995) has been frequently used in estimating long run equilibrium relationships. In contrast to single-equation methods, such as the Engle and Granger cointegration, the procedure efficiently includes the short run dynamics in the estimation of the long run model structure. The main advantage of the Johansen’s vector autoregressive estimation procedure is the testing and estimation of the multiple long run equilibrium relationships. Also, the testing of various economic hypotheses via linear restrictions in cointegration space is possible when using Johansen’s estimation method (Toppinen, 1998).

1.3 RESEARCH PURPOSE

The purpose of this study is to use econometrics and statistical methods described above to determine the relationship between employee-remuneration, labour productivity and unemployment and to determine the directions of causality between the series. This study aims to contribute to this debate by analysing statistically the relationship between remuneration, labour productivity and unemployment in the context of the South African sectors. As such, it builds on similar studies by other researchers who analysed similar variables in the formal, non-agricultural sector of the economy.

1.4 DEFINING REMUNERATION, PRODUCTIVITY AND UNEMPLOYMENT

Remuneration is defined either as the real consumption wages, where consumption wages consist of the wage rate measured in terms of consumption of goods (the nominal wage divided by the price of goods) or as real product wages, where product wage is the wage rate in terms of output (the nominal wage divided by the output price). From the employee's point of view it is the consumption wage that matters, whereas firms will be concerned with the product wage. If the researcher is concerned with classical unemployment, therefore, the product wage must be used, not the consumption wages. The suitable choice of remuneration measure depends on the precise relationship being investigated. Therefore, the study uses real product wages, where the Gross Domestic Product (GDP) deflator is used to deflate the nominal wage rate, because real production wages are most closely related with the measure of productivity used, which is based on real value added (Godsell *et al.*, 1990).

In theory, an appropriate concept of labour productivity in economics is marginal productivity, i.e., the contribution to production of the previous employee employed, though this cannot be readily measured. It may be useful to measure output per hour of labour contribution, but again, such a measure is not easily obtainable. In practice, practitioners resort to the use of average labour productivity. This may be computed in numerous ways. For instance, total production (either in monetary or physical terms) divided by total employment. The value added per employee measure is adopted in this study. This follows the model in South Africa set by Fallon and Pereira da Silva (1994), in which the logarithm of non-government GDP expressed as a ratio of formal, non-government occupation is taken as an index of productivity. Evidently, the 'productivity' series is affected positively by value

added and negatively by employment levels (Fallon & Pereira da Silva, 1994; Wakeford, 2004).

The unemployment data used in this study are based on the broad definition, in recognition of the arguments put forward by Nattrass (2000) where unemployment incorporates those actively seeking jobs but still unemployed, the network-searching unemployed and discouraged workers. The narrow definition excludes both the network-searching unemployed and discouraged workers, and so does not permit passive job search methods (Nattrass, 2002). For instance, given the low likelihood of getting employed, low incomes and high transport costs, one would anticipate a labour surplus economy like South Africa to manifest a high level of discouraged job seekers. This is contradictory to the government's stance, namely that the 'official rate' of unemployment is defined as the strict measure (Godsell *et al.*, 1990).

1.5 PROBLEM STATEMENT

As mentioned before, remuneration, the unemployment rate and labour productivity are significant economic measures in any economy. A rise in remuneration may increase workers' productivity and could lead to an increase in unemployment rate. This implies that there is a link between remuneration, the unemployment rate and labour productivity and there is a need to confirm whether the variables are at an equilibrium point. Thus, this study will look at the behaviour of each of these using trend analyses and then determine if they are related by looking at the cointegration between them (long and short term relationship) and also to confirm whether the three variables are at an equilibrium point.

1.6 AIMS AND OBJECTIVE OF THE STUDY

- To model the data and determine the general trend of each variable,
- To determine the relationship (cointegration) among remuneration, labour productivity and unemployment in South Africa,
- To check whether there is a long or short term connection among variables,
- To check the directions of causality between the variables.

1.7 RESEARCH QUESTIONS

- What are the trends of each of the variables?
- Is there a long term relationship (cointegration) between remuneration, labour productivity and unemployment?
- What are the short term associations between these variables?
- Can econometric and/or statistical techniques shed some light on the directions of causality between these variables?
- What models are obtained for these relationships?

1.8 SIGNIFICANCE OF THE STUDY

The importance of this study lies in the attempt to analyse the short or long term relationship (cointegration) among remuneration, labour productivity and unemployment and to test whether there is a structural break in the variables. Another importance of this study is to contribute to the body of knowledge which could also assist future researchers in the same field of the study. The findings of the study will inform the policy-makers on these relationships if they exist and the general behaviour of the variables for use in forecasting.

1.9 DATA SOURCE

This study examines the relationship existing among remuneration, labour productivity and unemployment in South Africa. Existing sources of literature on this study are used as reference materials. Information has been extracted from professional publications, books, articles, South African Reserve Bank publications and Statistics South Africa publications.

Time series data consisting of 42 observations for the years 1970 to 2011 are used in this study. This data were obtained from the World Bank, Statistics South Africa (StatSA) and the South African Reserve Bank (SARB). The main series used in this study consists of an index of remunerations per worker and the average labour productivity index. Remuneration and labour productivity series pertain to the formal, non-agricultural sector of the economy and they both have year 2000 as the base year. The third variable is the total, economy-wide rate of unemployment, calculated according to the broad definition is the number of unemployed

persons who are eligible to work. This study makes no adjustment to these data and the results should therefore be treated with caution.

1.10 RESEARCH LIMITATIONS

Limitations of this study are that data are scarce and can mostly be found at Statistics South Africa, the World Bank and the South African Reserve Bank. No interviews or surveys using questionnaires were conducted in this study. The study is limited to remuneration and labour productivity in the non-agricultural sectors only. The results of the study may not be generalized as they only apply to the said series. Very few related studies have been conducted in the world and this limited availability of relevant literature.

1.11 DEFINITION OF TERMS

- Cointegration – is a relationship between two variables which exists if there is a stationary linear combination of nonstationary random variables.
- The Engle-Granger test - Runs a static regression suggested by Engle and Granger (1987) and it is sometimes called the EG test.
- The Johansen ML estimator - A technique of testing for unit roots by using the system Maximum Likelihood estimator of Johansen (1988, 1991). It is a test for cointegration restrictions in a VAR representation. This estimator also gives asymptotically efficient estimates of the cointegrating vectors (the β 's) and of the adjustment parameters (the α 's).
- Vector error correction model (VECM) - is a representation of the dynamic system governing the joint behaviour of y_{1t} and y_{2t} over time.
- Unit Root/stationary - A series is referred to as (weakly or covariance) stationary if its mean and variance are constant over time and “the value of the covariance between the two time periods depends only on the distance or lag between the two time periods, not on the time at which the covariance is calculated” (Gujarati, 2003).
- Causality – this is the relationship between cause and effect.
- Granger causality methodology - Is used to investigate lead-lag relationships between construction activity and aggregate economy.

- Dickey-Fuller test - It tests the residual sequence ($\hat{z}_t$) to determine whether it has a unit root or not.
- Vector autoregressive (VAR) - Is a flexible, and easy to use models to analyse multivariate time series. It is an extension of the univariate autoregressive model to dynamic multivariate time series. The VAR model has proven to be useful for describing the dynamic behaviour of economic and financial time series and for forecasting.
- Gretl - is an acronym for Gnu Regression, Econometrics and Time-series Library, is an easy to use, reasonably powerful software package for doing econometrics (Hill *et al.*, 2011).

1.12 RESEARCH LAYOUT

The research consists of five chapters whose contents are detailed below.

Chapter one outlines the introduction, background literature, research purpose, problem statement of the study, aim and objectives of the study. It also explains the research questions of the study, significance of the study, research methodology, limitations of the study and definition of terms.

Chapter two discusses the relevant literature and gives a theoretical background as well as the econometric approach used in the study. It discusses the variables used in the study and reviews some relevant local and other studies for comparative purposes. It also discusses the evidence of structural breaks and the numerous possible causal relations between remuneration, labour productivity and unemployment.

Chapter three outlines the research methodology. It looks at the possible econometric methods employed to study the relationship between remuneration and labour productivity on the case study of South Africa. It also includes how ADF and PP unit root tests and other tests are conducted to determine the type of trend, whether the series is stationary or nonstationary and the type of data used as well the different steps in econometric data analysis required in this study.

Chapter four provides the statistical analysis and interpretation of results and Chapter five identifies key conclusions and recommendations and areas for further studies.

CHAPTER 2

LITERATURE REVIEW AND THEORETICAL BACKGROUND

2.1 INTRODUCTION

This chapter discusses the variables used in the study and reviews some relevant local and other studies for comparative purposes. It also discusses the evidence of structural break. A structural break appears when there is an unexpected shift in a (macroeconomic) time series. In conclusion, the numerous possible causal relations between remuneration, labour productivity and unemployment are discussed.

Remuneration, labour productivity and employment are very essential variables in labour economics and have received significant attention in literature on economics. Economic theories have explained the inter-relationships among the above-mentioned variables. Examples are the classical, neoclassical and Keynesian theories of employment which assume a close relationship between employment level and remuneration and it is hypothesised that there is a long run inverse relationship between employment levels and remuneration. On the other hand, the theories differ in terms of the direction of causal flow. Neoclassical and classical models deduce that the causal mechanism runs from wages to employment while in the Keynesian theories, the causality runs more the other way (Mazumdar, 2003).

2.2 INTERNATIONAL PERSPECTIVE

The relationship between remuneration, unemployment and labour productivity has received ample attention in the South African and international literature, although a number of different methods have been proposed. The purpose of this review is to provide a brief overview of some of these methods/approaches undertaken by different researchers.

Hypothetically a positive relationship between remuneration and labour productivity is often followed by higher remuneration which implies an increase in the opportunity cost of job loss and it stimulates greater work effort to avoid redundancy. This positive relationship is because the higher remuneration exerts upward pressure on labour costs and causes firms to

substitute capital for labour, thereby increasing the marginal productivity of labour (Wakeford, 2004).

Blanchflower and Oswald (1993, 1994, and 1995) established an international body of wage curve literature where a negative relationship between remunerations and unemployment was hypothesised and substantiated empirically. That approach represented a departure from preceding views on the subject (Harris & Todaro, 1970). Their argument is based on compensating differentials which say that the connection among remunerations and unemployment is likely to be positive across space. The technique taken in this study is different from that of Blanchflower and Oswald (1994) in two significant respects. Firstly, the main focus is on the relationship between remuneration and labour productivity, which is different from the one by Blanchflower and Oswald (1994). Secondly, in contrast to their spatial methodology, an econometric methodology is applied to macroeconomic data; in contrast to the panel data they used. However, their micro evidence provides a testable hypothesis, which states that there is a negative relationship between wages and unemployment.

Erenburg (1998) investigated the long run connection between labour productivity and real wages in the United States (US) from 1948 to 1990 and identified a long run, counter-cyclical relationship between real wages and labour productivity once the empirical stance had controlled for capital stocks. The main findings of Erenburg's study suggest that if the public capital stock had remained constant then both labour productivity and real wages would have increased. On the other hand, Alexander (1993) examined the relationship between labour productivity, unemployment and wages in the United Kingdom (UK) for the years 1955 to 1991 at a macroeconomic level. She found evidence of a structural break in 1979 and as a result split her sample into two sub periods and then applied the cointegrating vector autoregression (VAR) approach developed by Johansen (1988), to test for long term relationships between the variables of interest, and then applied the Granger causality concept in an attempt to establish empirically the causal relations between the three variables. Hondroyannis and Papapetrou (1997) and Gneezy and Rustichini (2000) found that the relationship between labour productivity and real wages is not monotonic and that offering higher remuneration does not always encourage labour productivity (Brown *et al.*, 1976).

Ho and Yap (2001) studied wage formation in the Malaysian manufacturing industry from the year 1975 to 1997 and they found a very significant relationship between labour productivity and wages for the Malaysian manufacturing industry where in the long run the rise in real wage exceeded the increase in labour productivity. Using the Engle and Granger (1987) two-step procedure, Hall (1986) found that remuneration, unemployment and labour productivity formed a cointegrated system in the UK. Lindbeck (1983), and Giersch and Wolter (1983) studied the negative bearing of inflation on labour productivity. The rise in inflation pushed employees into higher tax brackets and it may have impaired employee incentives. Since higher rates of inflation can misrepresent the price mechanism they can also reduce the economic efficiency, resulting in a negative impact on technological progress and capital accumulation.

In another study, Strauss and Wohar (2004) found the long run association between real wages and labour productivity at the industry level for a group of US manufacturing industries from 1956 to 1996, and the rises in labour productivity were linked with a less than unity increase in real wages. Meghan (2002) used Geweke's linear feedback technique to estimate the relationship between wages and labour productivity for numerous industrialized countries to differentiate between conventional and efficiency wage behaviours. Meghan's results suggested that efficiency wages were being compensated in Italy, Canada and the UK. In contrast, Sweden, France and the US presented no efficiency wage setting, with very negligible wages and productivity feedback measures. The study by Meghan (2002) also found that economic institutions such as workers unions played a significant role on the wage-productivity settings for this group of industrialized countries (Goh, 2009).

Gordon (1997) in his study found a connection between unemployment and labour productivity which presumes a time frame especially when it is observed at from the long run perspective. Gordon's (1997) study was carried out in the Europe and US from 1979 to 1994 where he identified categorically that a greater productivity development was experienced in Europe which is measured by output per hour. The researcher also detected that there appeared to be a correlation between productivity and a higher unemployment rate in Europe as presumed. The researcher further reinforced the fact that, the change in wages and the wage share resulting from shocks in wage setting, though accompanied by a high output growth rate could also cause decay in the demand for labour as observed by Evan (1992). Sumner and Silver (1989) also investigated the relationship between employment and

real wages by estimating simple regressions over several sample periods and found that the results differ depending on the chosen sample period. Employment changes due to aggregate supply shocks result in pro-cyclical movement in real wages, while during periods dominated by aggregate demand changes, real wages were extremely counter-cyclical.

Millea (2002) obtained empirical evidence about the bi-directional relationship between labour productivity and wages, in particular bearing in mind the nature of the wage setting process in different countries. This empirical evidence as well as the more detailed study by Fuess and Millea (2006) for Germany, can be interpreted in the light of efficiency wages, i.e. elucidating labour productivity as resulting from particular wage levels, for given labour market characteristics (e.g. the total unemployment level). It depicts that the effects of labour productivity on wages differ substantially among the six countries of the analysis, but there is evidence of conventional wage bargaining following labour productivity in most countries with the exception of the US. The authors interpret this in the light of labour union coverage, with the US having the least share of employees covered by collective bargaining. This study also displays the evidence of efficiency wages which is strongest in the Canada, Italy and US, the countries with the shortest duration of unemployment benefits.

According to Bender and Theodossiou (1999), there is evidence of cointegration between wages and labour productivity for Denmark, Norway, Sweden, the Netherlands and the UK. Cointegration also exists between productivity and employment for Canada and the US, while both cointegrating relations apply to Italy. Nevertheless, there is no relationship between employment and wages for the ten Organisations for Economic Co-operation and Development (OECD) countries under study. The study by Huh and Trehan (1995) also found the cointegration relationship between labour productivity and real wages. Using the implicit price deflator for business sector output, and analysing the US data, they showed that productivity and real wages were cointegrated. There are numerous explanations why labour productivity or effort may depend on wages. In the shirking model of Shapiro and Stiglitz (1984), if workers receive higher wage, the cost of losing their occupation becomes higher, and this acts as an incentive for workers not to shirk and risk being fired. Hence, labour productivity rises.

According to Mortensen and Pissarides (1998), an increase in output increases the value of an employee to the firm by means of gearing the creations of job vacancies which in turn, causes

decline in unemployment and this is known as the capitalization effect. On the other hand, they also concluded that higher productivity growth has the potential to be accompanied by structural change. This is because old jobs are destroyed and replaced by new ones; hence these are referred to as the “creative destruction effect”. This then results in accelerated labour productivity which would shorten the duration of employment and in the end increase natural unemployment rate. Strauss and Wohar (2001) investigated the long run relationship between wage-adjusted productivity and prices as well as between average labour productivity and real wages at the industry level for 459 US manufacturing industries for the years 1956 to 1996. Their panel cointegration test results strongly reject the null hypothesis of no cointegration in the panel between both wage-adjusted productivity and price, and between real wages and labour productivity.

Pigou (1952) argued that increasing the income of the less well-to-do, serves to improve their productivity by improving their nutritional levels and health. Also, labour productivity is increased as one invests in the education and skills upgrading of labour through the transfer of income from the well-to-do to the less-well-to-do. Pigou (1952) argued against the dominant worldview that an individual’s capabilities were predetermined biologically. For him, increasing wages is not the ideal means of improving the capabilities of the poor, although he notes that improvements in wages might encourage employers to increase productivity through organizational and technological change and that increasing wages per se can enhance productivity by improving workers’ nutritional levels (Altman, 2001).

Neftci (1978) used a distributed-lag method to capture the lagged effect of remunerations on employment and found that the relationship between employment and real wages is negative but non-contemporaneous for the manufacturing industry in the US. A similar result was also found by Sargent (1978) who employed the partial-adjustment, rational-expectation model of the competitive firms’ employment behaviour using the US data. However, Geary and Kennan (1982) argued that the significant relationship between employment and wages found by Neftci (1978) and Sargent (1978) was valid since the consumer price index (CPI) was used as the deflator to measure real wages. However, in their study they utilized the wholesale price index which is assumed to provide a better measure of the firm’s demand price of labour than the alternative CPI. Their results showed that employment and real wages are statistically independent for the manufacturing sector of 12 OECD countries.

Bewley (1999) was puzzled by the question “why wages did not fall during the 1990 to 1991 recession”, and it occurred to him that he might learn something by simply asking the people whose behaviour was so puzzling why they behaved the way they did. During 1992 and 1993, he interviewed 336 managers, employment counsellors and labour leaders, mostly in Connecticut but some in other nearby states, asking them not only why they thought nominal wage cuts were so rare but also a variety of other questions designed to bring about their views on nearly every known theory of wage adjustment and unemployment. Bewley (1999) found that according to intelligent and knowledgeable participants in labour markets, the most important factor constraining wage cuts is one that has nothing to do with any conventional economic theory, namely the psychological factor of morale. According to his findings, good morale among a firm’s employees has a positive effect on the firm’s profits, by increasing the employees’ productivity, creativity, effort and cooperativeness, and by reducing absenteeism and turnover; well-motivated employees also tend to provide good customer service, giving the firm a good reputation. However, morale is fragile, and will deteriorate quickly if employees feel they are being slighted or treated unfairly or if, for whatever reason, they cease to identify with the goals of their organization.

In Canada, a number of analysts have explored the relationship between real wages and labour productivity. The study by Fisher and Hostland (2002) found that while the relationship was stable for 1956 – 2001, labour productivity development had significantly outperformed real wage development from 1994 to 2001. These recent growths could potentially call into question the stability of the association going forward. They concluded that the divergence in current years was little cause for concern since labour and non-labour earnings shares tend to revert to their respective means over the long term. In contrast with Fisher and Hostland (2002), Russel and Dufour (2007) argued that the development of real wages has not kept up with the development of labour productivity in the long term, and that the divergence between real wages and labour productivity is thus a legitimate cause for concern. However, they used a narrow measure of labour reimbursement as a proxy for real wages (Sharpe *et al.*, 2008).

2.3 SOUTH AFRICAN PERSPECTIVE

In the South African literature, the relationship between remuneration, unemployment and labour productivity has been addressed frequently in terms of a real wage equation, in which wages are determined by a diversity of factors. These determinants include unemployment, productivity, number of strikes, extent of unionisation, intensity of apartheid and (in pooled time series cross-section regressions) legislated minimum wages and year and industry dummy variables (Fallon, 1992; Fallon & Lucas, 1998; Fallon & Pereira da Silva, 1994).

The study by Wakeford (2004) found that there exists long run equilibrium between real wages and labour productivity in South Africa but unemployment was apparently not linked to the two variables. In the short run, real wages had a negative impact on labour productivity but not for the reverse case (Hall, 1986; Alexander, 1993 and Wakeford, 2004). In their study of 48 South African economic sectors Fedderke and Mariotti (2002) found that “where the real wage is less closely related to real labour productivity, the growth in employment also tends to be lower”. In addition, when remunerations grow faster than productivity, employment declines from which may be inferred that unemployment will increase, *ceteris paribus*. Another finding of Fedderke and Mariotti’s (2002) analysis is that “for all the sectors with a strong improvement in real labour productivity, there is a strong improvement in the real per labour remuneration”, signifying that productivity may drive remunerations.

Du Toit and Koekemoer (2003) developed a neoclassical model of the labour market and estimated its equations separately using a single equation residual based procedure, presumably applying the Engle and Granger (1987) approach. Their model consist of separate labour demand and wage determination equations for skilled and unskilled labour, as well as equations explaining total and skilled labour supply. Both skilled and unskilled (real consumption) wages are specified as a function of aggregate labour productivity and the economy-wide unemployment rate. In both cases they found a negative long run relationship between the unemployment rate and real wages, and a positive connection with labour productivity.

Wakeford (2004) also argued that technological change had been a key driver in recent structural changes in the labour market and associated variables (in addition to overall economic growth). Increasing international competition following South Africa’s integration

into the global economy from 1994 appears to have prompted firms concurrently to become more capital-intensive, adopt more advanced technologies, employ more skilled employees, and retrench unskilled employees. Comparing the performance of South African manufacturing to that of the US and other selected countries, Van Dijk (2003) found that South Africa's labour productivity dropped relative to that of the US between 1970 and 1999. Furthermore, Van Dijk (2003) argued that the high wage level in South Africa makes us uncompetitive relative to certain other developing countries, which could be another reason why SA organisations have continued to invest in capital and technology while decreasing their use of unskilled labour in particular.

Fedderke and Mariotti (2002) alludes that during 1990 there was evidence of a structural break in their analysis at sectorial level. This phenomenon accrued from changes in employment and an accumulating skills intensity of production. Numerous factors may elucidate a structural break in or around 1990. Firstly, in 1990 the South African economy experienced a rigid recession until 1994 when the democratic election stimulated the economy. This recession was the stimulated factors such as drought, sanctions against South African economy and global recession. Recession had a crucial effect on the labour market and on employment levels in precisely. Secondly, since 1989, the SARB was governed by Dr Chris Stals, who came up with a policy to decrease inflation through contra-dictionary monetary policy. This policy possibly reduced the rate of production growth and consequently stifled job creation. Thirdly, the 1990s was a period in which many firms gradually began to substitute capital machinery and relatively scarce high-skilled labour for relatively abundant unskilled labour (Fedderke & Mariotti, 2002).

From 1994 onwards it can be claimed that growing competition resulting from South Africa's reintroduction to the world economy stimulated this factor substitution. Fedderke and Mariotti (2002) state that "technological change has effectively been capital, rather than labour-augmenting over time, thus decreasing the capacity of South African industry to expand employment". Finally, the break has been driven by cumulating labour market intervention by the government, which elevated the wage and non-wage costs of labour (Barker, 1999). Fedderke and Mariotti (2002) pointed out that the structural shift as a result of policy changes was unlimited to the labour market. On the basis of this reasoning and the above evidence, the possible presence of a structural break will be tested in the econometric modelling.

2.4 CAUSALITY ISSUES

Based on theory and preceding empirical evidence, a number of causal relations between remuneration, labour productivity and unemployment may be hypothesised for the South African economy.

Changes in labour productivity may cause changes in remunerations for at least two reasons. Firstly, it may happen when individual's pay is performance-based; and secondly, it may happen when labour unions bargain for remuneration increase on the basis of previous improvements in productivity (Wakeford, 2003). Higher output means that more goods and services can be derived from the same factor inputs. A rise in labour productivity is always a ground for employees to press their claims for higher remunerations. If the rise in labour productivity is due to the hard work of workforce or their improved efficiency, then it will positively cause remuneration. The improvement in productivity will lead to higher earnings and better standard of living of the employees. Thus, better standards of living will lead to long run economic growth. According to efficiency wage theory, an increase in real wages may encourage higher employee productivity by raising the costs of occupation loss. Productivity of an industry may be increasing, but if it suffers a fall in the prices of its product it would not be possible for it to adequate increase in money wage rates. So, an increase in product wages brings the wage burden on the industry. The consequence of an increase in average labour productivity on employment is not clear. It could reduce the demand for labour, as employees are more efficient. Alternatively, an increase in productivity could have a significant impact on occupation through an "output effect", which shifts the demand for labour curve outwards (Wakeford, 2004).

The performance-based pay scheme predicts higher remuneration for higher productivity. In addition, changes in productivity may affect employment in two opposite ways. Even though the impact of a rise in productivity is to reduce the demand for labour as employees are more efficient, it also leads to greater employment through a rise in production due to high output. The efficiency wage theory also hypothesises the relationship between real wages and productivity, but hypothesises that the causal relationship runs from wages to productivity (Akerlof & Yellen, 1986). The level of employees' productivity is directly related to the wage they received since a higher wage/salary allows employees to improve their physical ability

to work through improved nutrition and health, and a wage increase is likely to stimulate better work effort and higher self-confidence among workers. Furthermore, the increase in remuneration may have a negative effect on employment through higher cost of labour that in turn may result in capital being substituted for labour (Yusof, 2008).

If the rate of unemployment increases as a result of factors other than remuneration or labour productivity increases, it may deteriorate union bargaining power and as a result dampen remunerations. Also, an increase in joblessness may incentivise employees to increase effort and hence improve output to secure their jobs. In addition, as less productive employees are mostly the first to be retrenched, increased unemployment may be linked with higher average productivity among the remaining employees (Arkerlof, 1982). An understanding of the causal relationship between labour productivity and real wages is of greatest importance for decision-makers to improve labour productivity, long term economic growth maintaining and international competitiveness. For instance, if the finding is in favour of wages Granger causes labour productivity; hence a rise in wages may enhance labour productivity and this in due course generates economic development. On the other hand, policy to increase wages may affect international competitiveness; economic growth and ultimately deteriorate development (Tang, 2012).

The causality between labour productivity and remuneration has vast policy implications for the distribution of South African income. If an increase in wages (e.g. due to strong bargaining council) are driving productivity improvements through the replacement of capital and technology for labour, then it can be concluded that employees/unions are at least partially responsible for increasing unemployment rate, poverty and inequality. If productivity is increasing faster than wages, then business/capital is capturing an ever larger share at the expense of workforce, both the employed and the unemployed (Alexander, 1993).

The Granger causality tests are employed to establish the direction of short run relationships between variables. Granger causality says "if A causes B, then changes in A should lead to changes in B. In particular, to say that A causes B, two conditions should be met. First, A should help to forecast B; i.e. in a regression of B against past values of B, the addition of previous values of A as independent variables should contribute significantly to the explanatory power of the regression. Second, B should not help to predict A, it is likely that

one or more other variables are in actual fact causing the observed changes in both A and B” (Pindyck & Rubinfeld, 1998).

2.5 LABOUR MARKET THEORIES

According to different wage determination theories, the evolution of wages is not only influenced by labour productivity but also influenced by unemployment (Blanchard & Katz, 1999, Blanchflower & Oswald, 1994, Bell *et al.*, 2002). Remuneration, labour productivity and unemployment represent a significant link within labour markets. Blanchard and Katz (1999) suggest the following specification:

$$w_t - p_t^e = \alpha + \beta prod_t + \lambda(w_{t-1} - p_{t-1}) + \gamma \mu_t + \varepsilon_t \quad (2.1)$$

where w_t is the nominal wage rate, p_t^e is the expected price level in time t , $prod_t$ is the level of productivity, μ_t is the unemployment rate, $(w_{t-1} - p_{t-1})$ is the lagged term of the real wage which acts as a proxy for reservation wage.

The coefficient on the productivity and unemployment term is expected to be positive and negative respectively. Even though the sign of the coefficient of productivity and unemployment on wages is fairly clear in theory. A number of causal relations between real wages, productivity and unemployment are suggested based on theory and previous empirical evidence (Goh & Wong, 2010).

The marginal productivity theory recommends that highly productive employees are highly compensated, and less productive employees are less highly compensated. Higher productivity in turn could cause remunerations to rise. Therefore, it is hypothesized that labour productivity has a positive impact on remuneration. However, the effect of an increase in labour productivity on unemployment is ambiguous. As labour productivity rises, employees are more efficient (which implies lower demand for labour), hence, the rate of unemployment could increase. Alternatively, an increase in labour productivity could have a positive impact on employment via its contribution to higher output (which implies higher demand for labour), thereby decreasing the rate of unemployment, *ceteris paribus* (Alexander, 1993 and Wakeford, 2004). A rise in labour productivity is a basic source of improvement in remuneration and thus living standards (Du Plooy, 1988).

If wages should increase rapidly, but productivity increases more even more rapidly, then the net impact on the economy would normally be positive. This is because the cost-increasing impact of wages would be neutralised by the productivity increases. The sharp increases in labour productivity were achieved by reducing the work force, which in turn might have been caused by the sharp increases in real wages that took place in earlier years. There might thus be a link between the increases in the real wages in earlier years and the sharp increases in productivity in later years. It should also be taken into account that a wage increase could under certain circumstances lead to an equivalent productivity increase, which is called the efficient wage hypothesis (Barker, 2002).

The efficiency wage theory suggests that wages affect both labour productivity and unemployment. Firms remunerate their personnel more than the market clearing wages in order to increase their workers' efficiency or productivity. The theory also proposes that the higher the wage level of an employee, the higher the effort level of his employee. This implies that raising the wage level of employees enables them to increase productivity, because employees make a great effort to respond to high incentives provided by employers. Akerlof (1982) argued that increasing wages can stimulate employee exertion and strengthen long term employment relationships. High wage employees are less likely to resign. Thus firms can retain more skilled and productive employees than newly-hired workers who may not be as productive as experienced workers. This could also have an impact on unemployment rate. Hence, it is hypothesized that wages positively affect both productivity and unemployment (Akerlof, 1982).

A first model of efficiency wages assumes that firms pay remunerations in order to minimize turnover costs. If firms must bear part of the costs of turnover, and if turnover is a decreasing function of the wages firms pay, there may be an incentive to raise wages in order to minimize turnover costs. A second possibility is that increasing wages raises workers' level of effort. Workers who are paid only their opportunity costs have little incentive to perform well since losing their jobs would not be costly. By raising wages, firms may make the cost of job loss larger and thereby increase productivity. Alternatively, a third model assumes that workers' feelings of loyalty to their firm increase with the extent to which the firm shares its profits with them. These feelings of loyalty may have a direct effect on productivity. As explained by Akerlof (1984) such a model relies on notions about gift relationships that are

not well captured by traditional utility functions. A final model is based on selection rather than incentive efforts. Firms which pay higher wages will find that they attract a higher quality pool of applicants. If quality is not directly observable, this will be desirable (Krueger & Summers, 1988).

The gift-exchange model of Akerlof (1982, 1984) argued that a higher wage is seen by workers as a gift from the employer, and they will return this gift in the form of higher effort (being more productive). The fair wage-effort model of Akerlof and Yellen (1990) documented that if workers were compensated a wage below what they perceived as fair, they would not put as much effort as they would if they get a “fair” wage. Therefore, the efficiency wages theory proposes that real wages induce labour productivity rather than the reversal.

If the firm continues employing as long as the value produced by each additional worker is greater than the additional labour cost then increases in productivity will increase the firm’s demand for labour as employing more labour is profitable for the firm; and *ceteris paribus*, an increase in the demand for labour will tend to push up the wage rate. Therefore, an increase in labour productivity increases labour income. Once the firm again reaches the inflection point at which additional labour cost is more than value of the incremental goods produced, it will stop employing additional labour (Cashell, 2004).

2.6 CONCLUSION

The focus of this study is to use econometric techniques to analyse the relationship between remuneration, labour productivity and unemployment in South Africa, as they have been used in international literature (Erenburg, 1998; Alexander, 1993; Ho & Yap, 2001; Hall, 1986; Strauss & Wohar, 2004; Meghan, 2002; Gordon, 1997; Sumner & Silver, 1989; Millea, 2002; Fuess & Millea, 2006 and Huh & Trehan, 1995). Several studies revealed that there is a link/relationship between wages and labour productivity. The study adopts econometric approach than those adopted by Fedderke and Mariotti (2002), Du Toit and Koekemoer (2003) and Van Dijk (2003). It does not impose pre-determined assumptions about causal directions between key variables, but rather tests for them using the above-mentioned technique.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 INTRODUCTION

This chapter looks at the econometric methods employed to study the relationship between remuneration and labour productivity on the case study of South Africa. These range from a general description of the data to univariate and multivariate data-handling procedures. The univariate procedures consist of time series plots to determine trends, tests for the stationarity of remuneration, labour productivity, unemployment and employment series using the graphical plots and formal tests for unit roots like the Augmented Dickey–Fuller (ADF) and the Phillips-Perron (PP) tests. Multivariate procedures consist of cointegration tests using the Johansen maximum likelihood procedure and estimation of error correction models including diagnostic tests. All the data analyses are done using E-Views, Jmulti and Gretl.

3.2 DATA SOURCE

The study uses a yearly secondary data set consisting of 42 observations from 1970 to 2011 obtained from the World Bank and the South African Reserve Bank (SARB). The basic source of the SARB's data is Statistics South Africa (StatsSA), which in turn collects its data via yearly surveys. The study initially aimed to use quarterly data, unfortunately these were not available. The principal series used in the investigation are:

- I. An index of total remuneration per worker in the non-agricultural sector.
- II. An index of total labour productivity per worker in the non-agricultural sector.

The series refer to the formal sector of the South African economy, and have year 2000 as the base date. The SARB (2003) is not fully transparent about how these two indexes are calculated, but presumably they involve ratios between total employment and the wage bill, and between total employment and value-added, respectively. Remunerations were deflated by the non-agricultural gross domestic product deflator.

- III. The third variable is the total, economy wide rate of unemployment, calculated according to the broad definition.

3.3 UNIVARIATE DATA ANALYSIS

Several macroeconomic time series contain unit roots dominated by stochastic trends as developed by Nelson and Plosser (1982). Unit roots are significant in examining the stationarity of a time series because a nonstationary regressor invalidates numerous empirical results. The existence of a stochastic trend is determined by testing the presence of unit roots in time series data. In this study, the unit root test is tested using Augmented Dickey Fuller (1979, 1981) and Phillips and Perron (1988). If the series is nonstationary and its first difference is stationary, then the series contains a unit root. The commonly used methods to test for the presence of unit roots are the Augmented Dickey Fuller (ADF) tests (Dickey & Fuller, 1979, 1981). A framework for testing unit root is represented by the following model:

$$X_t = \varphi X_{t-1} + \varepsilon_t \quad (2.2)$$

where ε_t denotes a serially uncorrected white noise error term with a mean of zero and a constant variance. If $\varphi = 1$, equation 2.2 becomes a random walk without drift model, that is, a nonstationary process. When this happens, the researcher faces what is known as the unit root problem. This means the series is nonstationary. However, if $\varphi < 1$, then the X_t series is stationary. The stationarity of the series is significant because correlation could continue in nonstationary time series even if the sample is very large and may effect in what is called spurious or nonsense regression (Yule, 1989). The unit root problem can be solved, or stationarity can be achieved, by differencing the dataset (Wei, 2006). It is essential at the start of cointegration analysis, that the problem of optimal lag length is solved because multivariate cointegration analysis which the study is going to conduct is very sensitive to lag length selection. The commonly used lag length selection criteria are the AIC and the SBC. The likelihood ratio (LR) test is also used to select the number of lags required in the cointegration.

3.3.1 Augmented Dickey-Fuller

The ADF tests use the existence of a unit root as the null hypothesis. Before the relationship between the two variables can be tested, the classical regression model requires that all the variables involved must be stationary, this means that their means and variances remain the same (are constant) over time. The time series is then first tested with the use of a unit root test developed by Dickey-Fuller (1979).

The ADF (1979) test refers to the t-statistics of δ_2 coefficient on the following regression equation:

$$\Delta X_t = \delta_0 + \delta_1 t + \delta_2 X_{t-1} + \sum_{i=1}^k \alpha_i \Delta X_{t-i} + \mu_t \quad (2.3)$$

The ADF regression tests for the existence of unit root of X_t , namely in the logarithm of all model variables at time t . The variable ΔX_{t-1} expresses the first differences with k lags and final μ_t is the variable that adjusts the errors of autocorrelation. The coefficients δ_0 , δ_1 , δ_2 , and α_i are estimated. The null and the alternative hypotheses for the existence of unit root in variable ΔX_t is:

$$H_0 : \delta_2 = 1$$

Versus

$$H_1 : \delta_2 < 1$$

The ADF test is a lower-tailed test, so if F_t is not greater than the critical value, then the null hypothesis of unit root is rejected and it can be concluded is that the variable of the series does not contain a unit root and is nonstationary. The Akaike Information Criterion (AIC) and the Schwarz Bayesian Criterion (SBC) are used to determine the optimal length (k). Non-rejection of the null hypothesis implies that the series is nonstationary, whereas the rejection of the null hypothesis indicates that the series is stationary.

3.3.2 Phillips and Perron

The Phillips Perron (PP) unit root test is employed to test the integration level and the possible cointegration among the variables (Phillips & Perron, 1988). The PP test procedures, which compute a residual variance that is robust to auto-correlation is employed to test for unit root as an alternative to the ADF unit root test. It might seem reasonable to test the existence of a unit root in the series using the most general of the model of the form:

$$\Delta X_t = a_0 + \gamma Zt - i + a_2 t + \sum_{i=2}^p \beta_i \Delta X_t - i + \varepsilon_t \quad (2.4)$$

Where X is the series, t = time (trend factor), a = constant term (drift), ε_t = Gaussian white noise and p = number of lag order (Soukhakian, 2007). The null and the alternative hypothesis for the existence of unit root in variable ΔX_t is:

$$H_0 : \gamma = 1$$

Versus

$$H_1 : \gamma < 1$$

The unit root characteristics of the variables have important implications when testing for cointegration of the variables in a specified empirical model. However, a necessary condition to finding a cointegrating relationship among nonstationary variables is that only two of the variables have to be integrated of the order one (Hansen & Juselius, 1995).

3.4 MULTIVARIATE DATA ANALYSIS

3.4.1 Cointegration Analysis

The cointegration analysis is the econometric technique that tests for the correction between nonstationary variables. If two or more series are themselves non-stationary, but a linear combination of them is stationary, then the series is called cointegrated.

The study employs the cointegration tests based on the Johansen (1991) Maximum likelihood tests that provides a test for the rank of Π , namely the trace test (λ_{trace}) and the maximum eigenvalue test (λ_{max}). The test is based on the following hypothesis:

H_0 : There are most r cointegration vectors.

Versus

H_1 : There are $r+1$ cointegrating vectors.

The dynamic interactions between the variables can be studied using a VAR representation where all variables in their level forms are allowed to be endogenous. Then depending on the order of integration of each series, the idea that certain or all variables may have mutual stochastic trends can be tested and exploited to model their dynamics within an Error Correction Model (ECM), which is useful for investigating the direction of temporal causality among the variables under study. Suppose for the moment that the variables in X_t are $I(1)$ after applying the first differencing (Khalifa, 1999).

Johansen (1988b) argued the likelihood-based cointegration theory for such a model without a seasonal dummies and constant term. It turns out, nevertheless, that the constant plays a

vital role in the statistical analysis and for the interpretation of the model. Particularly, Johansen (1991, 1994) proved that the asymptotic distributions of the statistical tests and estimators in the ECM are not invariant to the assumption made about the constant term. In addition, he provided a proof of Granger's representation theorem which explains the role of the constant term and shows that, under certain conditions, the ECM would be an $I(1)$ process. In particular, Johansen (1991, 1994) also showed that the constant enters either the ECM (as an unrestricted intercept) or the cointegrating vector as a restricted intercept depending respectively on whether or not some of the nonstationary variables contain a linear time trend. In this respect he distinguishes between two main cases:

- I. If the nonstationary variables X_t do not contain a linear time trend, then a restricted constant term R appears only as part of the cointegrating vector.
- II. If some of the variables in X_t contain a linear time trend, T_t , then the constant term appears only outside the cointegrating vector.

A simple explanation of the distinction that Johansen (1991, 1994) makes between “a trend related intercept” (that is, unrestricted intercept) and “the cointegrating vector related intercept” (that is, restricted intercept) can be found when considering the VAR model from which the ECM is derived. The cointegration methodology established by Granger (1986), Hendry (1986) and Engle and Granger (1987) proposed a new way toward testing for Granger causality. Granger (1986, 1988) suggested that if two or more variables are cointegrated, then Granger causality must exist in at least one direction. This result is a consequence of the relationships described by the ECM model (Khalifa, 1999).

On the basis of the theory that integrated variables of first difference, $I(1)$, may have a cointegration relationship, it is important to test for the presence of such a relationship. If a group of variables are separately integrated of the same order and there is at least one linear combination of these variables that is stationary, then the variables are said to be cointegrated. The cointegrated variables will certainly not move far apart, and will be attracted to their long run relationship. Testing for cointegration implies testing for the presence of such a long run relationship between economic variables.

If two or more series are themselves nonstationary, but a linear combination of them is stationary, then the series is called cointegrated. The variable makes it stationary by

difference and then it means it is integrated by difference one. The concept of cointegration is based on the principle that the linear combination of two nonstationary series results in a stationary series. Using series of the same order of integration, the relationship specified in the model is estimated with the use of the OLS method.

Johansen's technique builds cointegrated variables directly on maximum likelihood estimations instead of relying on OLS estimation. This technique relies heavily on the relationship between the rank of a matrix and its characteristic roots. Johansen (1991, 1994) derived the maximum likelihood estimation by means of sequential tests for determining the number of cointegrating vectors. This technique can be seen as a secondary generation method in the sense that it builds directly on maximum likelihood instead of partially relying on least squares. In actual fact, Johansen's procedure is nothing more than a multivariate generalisation of the Dickey-Fuller test.

The LR tests are performed to determine the lag length of the vector autoregressive system, prior to testing for the number of significant cointegrating vectors. In the Johansen technique, following a VAR model, it involves the identification of rank of the $n \times n$ matrix Π in the specification given by:

$$\Delta X_t = \delta + \sum_{i=1}^{k-1} \Gamma_i \Delta X_{t-i} + \Pi X_{t-k} + \varepsilon_t \quad (2.5)$$

where X_t is a column vector of the n variables, Δ is the difference operator, Γ and Π are the coefficient matrices, k denotes the lag length and δ is a constant. In the absence of cointegrating vector, Π is a singular matrix, which means that the cointegrating vector rank is equal to zero. Then again, in a cointegrated scenario, the rank of Π could be anywhere between zero and n . In other words, the Johansen cointegration test can determine the number of cointegrating equation and this number is named the cointegrating rank. If $0 < r < n$ then there are $n \times r$ matrices of a α and β such that:

$$\Pi = \alpha\beta' \quad (2.6)$$

where β is cointegrating vector; hence, $\beta'X_t$ is $I(0)$ although X_t are $I(1)$ and the strength of cointegration relationship is measured by α 's. In this framework, $(A_0, A_1, \dots, A_{p-1}, \Pi, \Omega)$ are

estimated through maximum likelihood procedures, such that “ Π ” can be written as in (2.6). To estimate these parameters, the two step procedures must be followed. In the first step, regress ΔX_t on $\Delta X_{t-1}, \dots, \Delta X_{t-p+1}$ and obtain the residuals $\hat{\mu}_t$. In the second step, regress X_{t-1} on $\Delta X_{t-1}, \Delta X_{t-2}, \dots, \Delta X_{t-p+1}$ and obtain the residuals $\hat{e}_t$. From the obtained residuals “ $\hat{\mu}_t$ ” and “ $\hat{e}_t$ ”, find the variance-covariance matrices as follows:

$$\hat{\Sigma}_{uu} = \left(\frac{1}{T} \right) \sum_{t=1}^T \hat{u}_t \hat{u}_t' \quad (2.7)$$

$$\hat{\Sigma}_{ee} = \left(\frac{1}{T} \right) \sum_{t=1}^T \hat{e}_t \hat{e}_t' \quad (2.8)$$

$$\hat{\Sigma}_{ue} = \left(\frac{1}{T} \right) \sum_{t=1}^T \hat{u}_t \hat{e}_t' \quad (2.9)$$

The Johansen Maximum likelihood test provides a test for the rank of Π , namely the trace test λ_{trace} and the maximum eigenvalue test λ_{max} . Firstly, the λ_{trace} statistic tests whether the number of cointegrating vector is zero or one. Then, the λ_{max} statistic tests whether a single cointegration equation is sufficient. The maximum likelihood estimator of “ β ” can be obtained by solving the following equation:

$$| \lambda \hat{\Sigma}_{ee} - \hat{\Sigma}_{eu} INV(\hat{\Sigma}_{uu}) \hat{\Sigma}_{ue} | = 0 \quad (2.10)$$

With the eigenvalues $\hat{\lambda}_1 > \hat{\lambda}_2 > \dots > \hat{\lambda}_n$.

The normalized cointegrating vectors are:

$$\hat{\beta} = (\hat{\beta}_1, \hat{\beta}_2, \dots, \hat{\beta}_n), \text{ such that } \hat{\beta}' \hat{\Sigma}_{ee} \hat{\beta} = I$$

Now the null hypothesis can test that $r = h$, $0 \leq h < n$ against the alternative of $r = n$ by obtaining the following statistics:

$$\lambda_{trace} = L_A - L_0$$

Where

$$L_0 = -\left(\frac{Tn}{2}\right) \ln(2\Pi) - \left(\frac{Tn}{2}\right) - \left(\frac{T}{2}\right) \ln \left| \hat{\Sigma}_{\mu\mu} \right| - \left(\frac{T}{2}\right) \sum_{i=1}^h \ln(1 - \hat{\lambda}_i) \quad (2.11)$$

and

$$L_A = -\left(\frac{Tn}{2}\right) \ln(2\Pi) - \left(\frac{Tn}{2}\right) - \left(\frac{T}{2}\right) \ln \left| \hat{\Sigma}_{\mu\mu} \right| - \left(\frac{T}{2}\right) \sum_{i=1}^n \ln(1 - \hat{\lambda}_i) \quad (2.12)$$

$$\text{Hence, } L_A - L_0 = -\left(\frac{T}{2}\right) \sum_{i=h+1}^n \ln(1 - \hat{\lambda}_i)$$

$$2(L_A - L_0) = -T \sum_{i=r+1}^n \ln(1 - \hat{\lambda}_i)$$

Therefore,

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^n \ln(1 - \hat{\lambda}_i) \quad r = 0, 1, 2, \dots, n-2, n-1 \quad (2.13)$$

where $\hat{\lambda}_{r+1}, \hat{\lambda}_n$ are the estimated $n - r$ smaller eigenvalues. Equation (2.13) follows χ^2 distribution and called as trace statistics. Furthermore, the null hypothesis to be tested is that there are at most r cointegrating vectors. That is, the number of cointegrating vectors is less than or equal to r , where r is 0, 1, 2... and so forth. In each case, the null hypothesis is tested against the alternative.

Alternatively, the L -max statistic is:

$$\lambda_{max}(r, r+1) = -T \ln(1 - \hat{\lambda}_{r+1}) \quad r = 0, 1, 2, \dots, n-2, n-1 \quad (2.14)$$

In this test, the null hypothesis of r cointegrating vectors is tested against the alternative hypothesis, $r+1$ cointegrating vectors. Thus, the hypothesis $r = 0$ is tested against the alternative that $r = 1$, $r = 1$ against alternative $r = 2$ and so forth.

This procedure is called a vector cointegration test technique. It has the advantage over the Engle-Granger two-step approach and the Phillips-Ouliaris methods in that it can estimate more than one cointegration relationship, if the data set contains two or more time series (Ssekuma, 2011).

3.5 ERROR CORRECTION MODEL

A common practice prior to performing cointegration test is to determine the degree of integration of series, $I(d)$. ADF and PP tests were then applied to all series to determine their order of integration, no presence of structural breaks is assumed by these tests. The subsequent step is to apply the Johansen multivariate cointegration technique to test whether there is a cointegrating vector(s) between the nonstationary series (Johansen & Juselius, 1990). The hypothesis imposed on the cointegration equations is a linear deterministic trend with an intercept in data. If the economic time series is found to be cointegrated, an econometric framework for an ECM representation can be stated. The ECM procedure can reconcile the long run equilibrium with disequilibrium behaviour in the short run, which allows testing for short term or dynamic causality.

The ECM specification can be written as follows:

$$\Delta L_REMUN_t = a_0 - a_1 ECT_{t-1} + \sum_{j=1}^p a_{2j} \Delta L_LABPROD_{t-j} + \sum_{j=1}^p a_{3j} \Delta L_REMUN_{t-j} + \varepsilon_t \quad (2.15)$$

$$\Delta L_LABPROD_t = b_0 - b_1 ECT_{t-1} + \sum_{j=1}^p b_{2j} \Delta L_LABPROD_{t-j} + \sum_{j=1}^p b_{3j} \Delta L_REMUN_{t-j} + \mu_t \quad (2.16)$$

where L_REMUN_t is logged total remuneration, $L_LABPROD_t$ is logged total labour productivity, Δ is the first-order differencing operator and ECT_{t-1} stands for the preceding period's error correlation term generated from a cointegrating equation using ordinary least squares (OLS) estimator. Given this study has only 42 observations, and to save degree of freedom, a maximum lag length of four can be imposed on the ECM (as a general rule, an optimal lag length of four quarters is adequate in an empirical study when annual data is being used).

3.6 DIAGNOSTIC TEST

A number of diagnostic tests are performed such as White's heteroscedasticity tests, Serial correlation tests and a test for normality using the Jarque-Bera test. The test for

heteroscedasticity is done to ensure that the variances are homoscedastic and the resulting estimators are best linear unbiased estimators.

3.6.1 Heteroscedasticity tests

The heteroscedasticity test concentrates on the Lagrange Multiplier (LM) test in order to test for the presence or absence of heteroscedasticity in the residuals. The LM test is applicable whether lagged dependent variables are included or not. The test procedure is as follows:

H_0 : There is no heteroscedasticity.

Versus

H_1 : There is heteroscedasticity.

The test statistic is:

$$LM_E = nR^2 \quad (2.17)$$

where n is the number of observations, and R^2 is the coefficient of determination of the augmented residual regression. The null hypothesis is rejected if the probability in the serial correlation test table is less than the critical probability value $p = 0.05$ and conclude that there is heteroscedasticity.

3.6.2 Serial correlation tests

The serial correlation test concentrates on the Breusch-Godfrey LM test in order to test for the presence or absence of serial correlation in the residuals. The Breusch-Godfrey test is applicable whether lagged dependent variables are included or not. The hypothesis to be tested is:

H_0 : There is no serial correlation.

Versus

H_1 : There is serial correlation.

The Breusch-Godfrey LM test allows examination of the relationship between $\hat{\mu}_t$ and the several of its lagged values at the same time. The test is a more general test for serial correlation up to the r^{th} order. The model for the errors under this test is as follows:

$$\mu_t = p_1\mu_{t-1} + p_2\mu_{t-2} + \dots + p_r\mu_{t-r} + v_t, \quad v \sim N(0, \delta_v^2) \quad (2.18)$$

The null hypothesis is rejected if the probability in the serial correlation test table is less than the critical probability value $p = 0.05$.

3.6.3 Normality test

The study uses the Jarque-Bera test to determine whether the ECM is normally distributed. This test measures the difference in kurtosis and skewness of a variable compared to those of the normal distribution (Jarque & Bera, 1980).

In the Jarque-Bera test, the null and alternative hypotheses are as follows:

H_0 : The variable is normally distributed.

Versus

H_1 : The variable is not normally distributed.

The test statistic is:

$$JB = \frac{N-K}{6} \left[S^2 + \frac{(K-3)^2}{4} \right] \quad (2.19)$$

where N is a number of observations, k is the number of estimated parameters, S is the skewness of a variable, and k is the kurtosis of a variable. The null hypothesis is rejected if the p -value $\leq$ level of significant.

If there is especially conditional heteroscedasticity literature suggests the use of generalised autoregressive conditional heteroscedastic (GARCH) or ARCH models. The model here is selected using the Akaike Information Criterion (AIC) or Bayesian Information Criterion (BIC) then the model is estimated in the E-Views package.

3.7 GRANGER CAUSALITY TESTS

The cointegration technique pioneered by Engle and Granger (1987), Granger (1986), and Hendry (1986) made a significant contribution towards testing Granger causality. Granger causality is a technique for determining whether one time series is useful in forecasting another. The Granger causality tests are performed to establish the direction or directions of short run dynamics among the variables. “Granger causality” is a statistical term, which is interpreted thus: “If A and B are two jointly covariance stationary processes, then A is said to Granger cause B if past B and past A better predicts current B than past B alone” (Alexander, 1993). Hence, the issue is theoretically one of likelihood involving lead–lag relationships rather than “causality” in the strict sense of an endogenous/exogenous relationship. There may be a unidirectional causal relationship between two variables, a bi-directional relationship, or independence. One of the practical issues faced when applying Granger causality tests is the choice of lag length. The generally recognised wisdom is to make a mistake on the side of including more lags rather than fewer, since omitted variable bias is more serious than inadequacy resulting from the inclusion of irrelevant variables. However, testing for suitable lag length in a VAR using various statistical information criteria assists in selecting an appropriate lag length. The ECM specification is then used for the causality tests as it ensures stationarity of the variables (Alexander, 1993 and Wakeford, 2004). The null hypothesis to be verified here is that there is no Granger causality between two variables. The Granger causality test is as follows:

$$X_t = \sum_{i=1}^n \alpha_{x,i} X_{t-i} + \sum_{i=1}^n \beta_{x,i} Y_{t-i} + \mu_{x,t} \quad (2.20)$$

$$Y_t = \sum_{i=1}^n \alpha_{y,i} Y_{t-i} + \sum_{i=1}^n \beta_{y,i} X_{t-i} + \mu_{y,t} \quad (2.21)$$

where X_t is the log of the first variable at time t and Y_t is the log of the second variable at time t . $\mu_{x,t}$ and $\mu_{y,t}$ are the white noise error terms at time t . $\alpha_{x,i}$ is the parameter of the past value of X , which tells us how much past value of X explains the current value of X and $\beta_{x,i}$ is the parameter of the past value of Y , which tells us how much past value of Y explains the current value of X . Similar explanations apply to $\alpha_{y,i}$ and $\beta_{y,i}$.

3.8 CONCLUSION

This chapter describes all the steps of econometric procedure that is planned to be followed when analysing the relationship between remuneration and labour productivity in South Africa. The dual approach (graphical plots and formal tests for testing any serial correlation) are used to check whether the data are stationary or not. ADF and PP are used to test the unit root. Johansen's (1991) cointegration test is used to determine whether the linear combination of the series possesses a long run equilibrium relationship. Finally, the Granger causality tests are performed to establish the direction or directions of short run relationships among the variables.

CHAPTER 4

DATA ANALYSIS AND INTERPRETATION OF THE RESULTS

4.1 INTRODUCTION

This chapter focuses on data analysis and the interpretation of the results for the study. A lot can be learned from a preliminary analysis of the data before econometric modelling is conducted. The following section therefore presents several graphs, correlation coefficients and tests for integration. These are preliminary to subsequent cointegration and Granger causality tests.

The rest of the chapter is organized as follows: section 4.2 preliminary data analysis, section 4.3 is the pairwise correlation, section 4.4 is the order of integration, section 4.5 is the structural stability test, section 4.6 is the unit root test, section 4.7 cointegration test, section 4.8 is error correction models, section 4.9 Granger causality test, section 4.10 the diagnostic test and section 4.11 is the summary.

4.2 PRELIMINARY DATA ANALYSIS

4.2.1 Univariate Data Analysis

A useful starting point of a time series analysis is a visual examination of time plots of remuneration (real wage), productivity and the unemployment rate, along with total employment. All variables used in this study were transformed in logarithmic form so that coefficients can be interpreted as elasticities and they are unit free. The data were transformed to try to linearise any exponential trends which may be present in the series. The following notations are used for the four variables: $L_REMUN = \log(\text{remuneration index})$; $L_LABPROD = \log(\text{productivity index})$; $L_UNEMP = \log(\text{total unemployment rate (percentage)})$ and $L_EMPLOY = \log(\text{employment index})$. The visual plots are displayed on the figures below.

Figure 4.1 Remuneration

Figure 4.1.1 L_REMUN at level

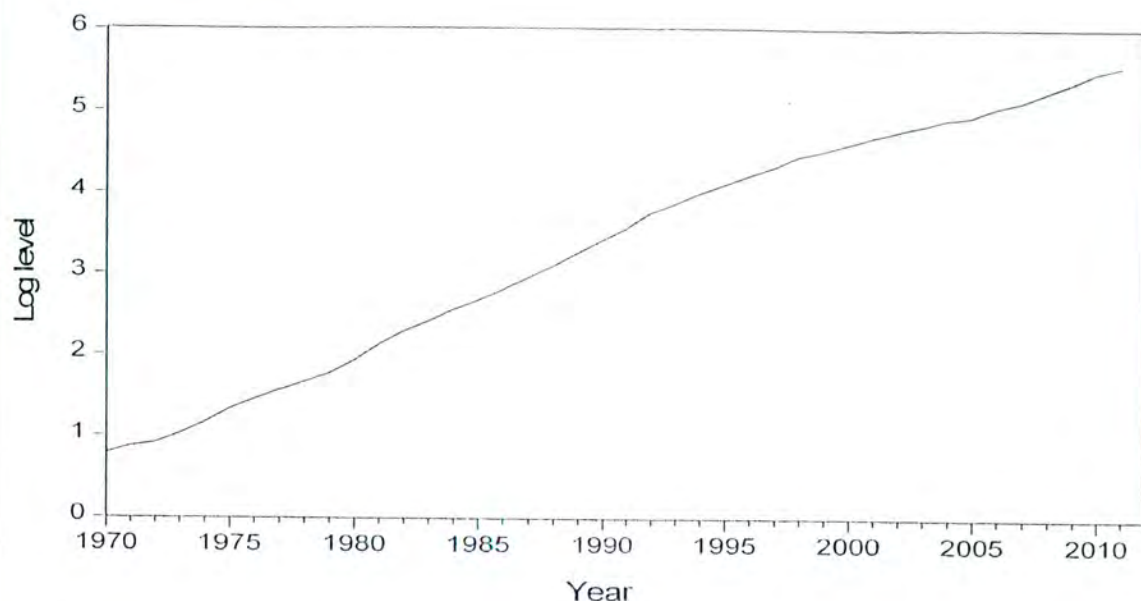


Figure 4.1.2 L_REMUN at first difference

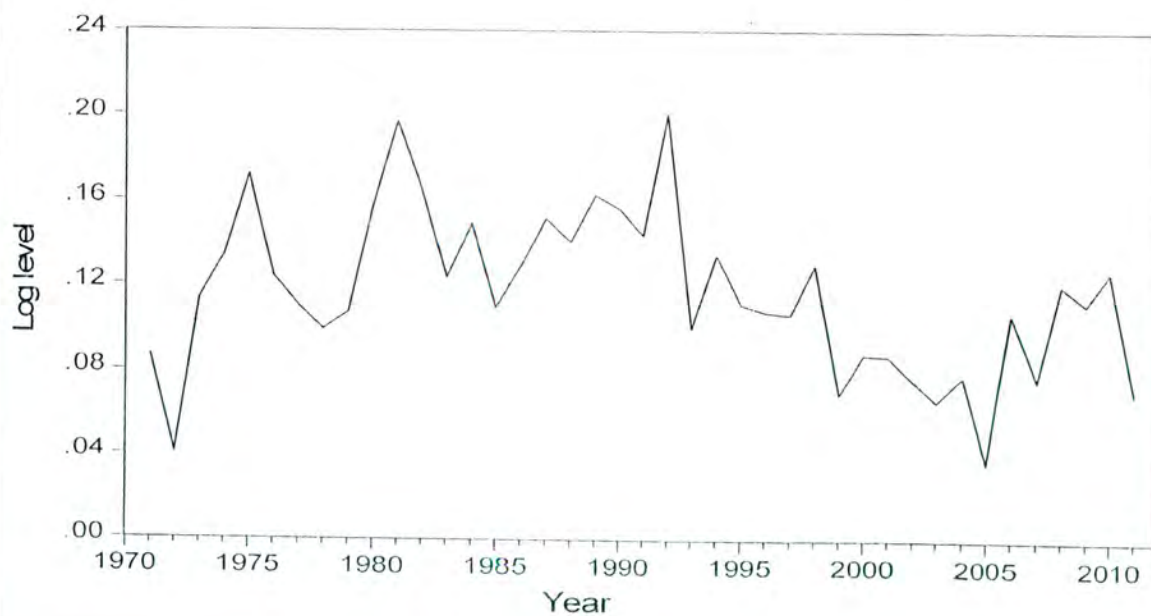


Figure 4.1.1 depicts the reality that remuneration fluctuated considerably around a horizontal upwards trend throughout. In other words, for the period 1970 – 1989, remuneration appears to have followed the business cycle quite closely. Since about 1990, however, the remuneration index has increased considerably, with fluctuations around a roughly linear trend. Figure 4.1.2 shows that the first differenced series might be stationary.

Figure 4.2 Labour productivity

Figure 4.2.1 L_LABPROD at level

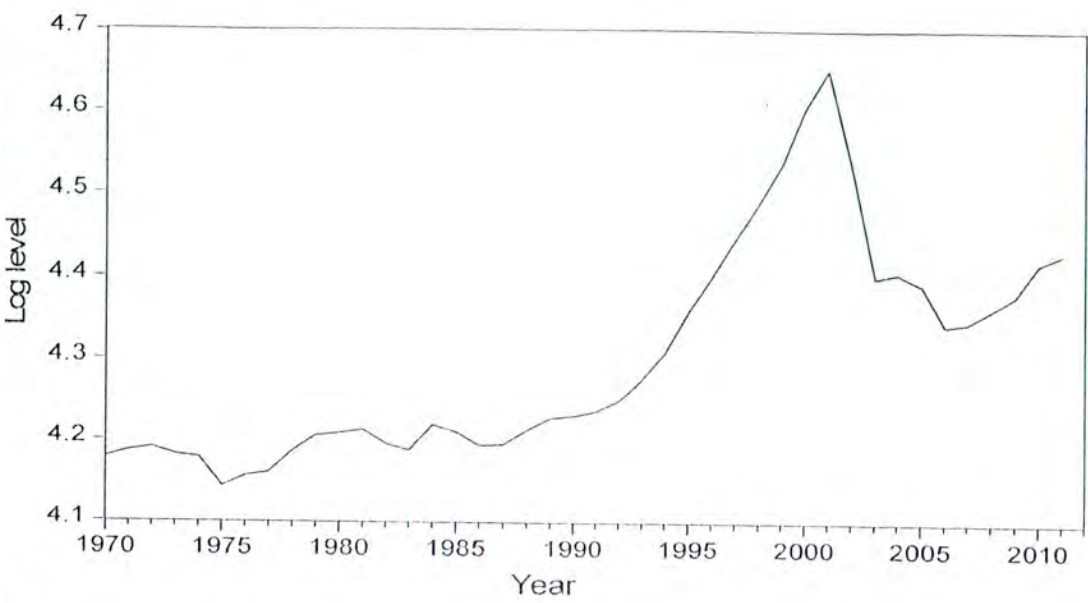


Figure 4.2.2 L_LABPROD at first difference

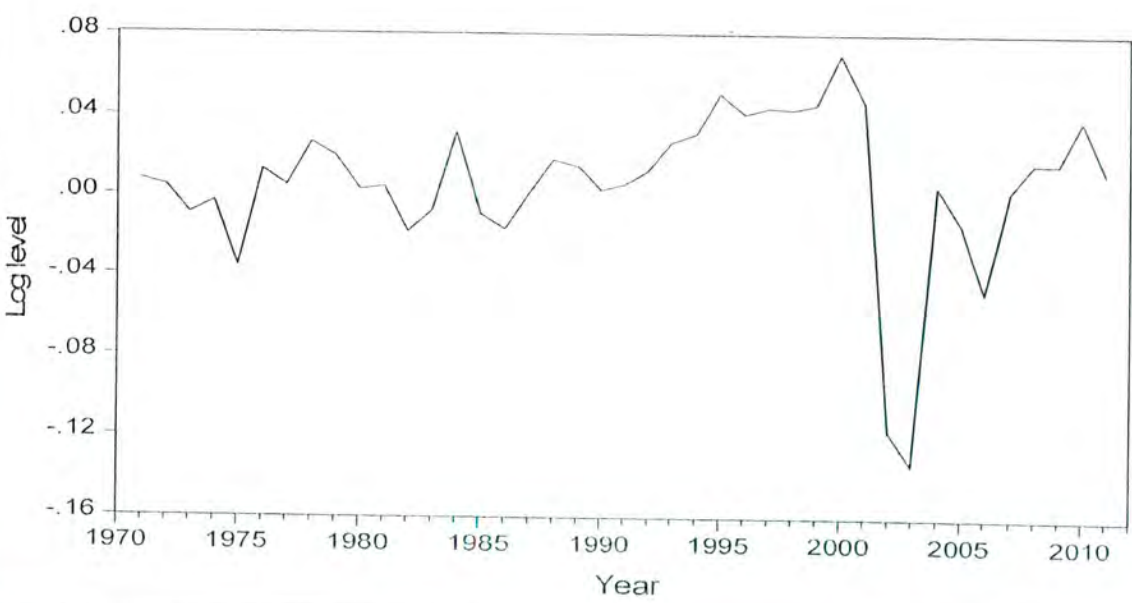


Figure 4.2.1 shows that the productivity series displays a pattern that is of a roughly similar pattern to that of remuneration, although it is not as smooth. During the 1970s and 1980s labour productivity showed a slight positive trend, interrupted by a number of shocks. From 1987 the labour productivity curve appeared to be exponential, rising somewhat more steeply than remuneration and there was a rapid drop around 2001. The labour productivity series started to increase again around year 2006. The visual inspection on the plot of the variable at

level suggests that the series is nonstationary. Figure 4.2.2 depicts the idea that the first differenced series is stationary, which means that the series' mean and variance are constant over time.

Figure 4.3 Unemployment

Figure 4.3.1 L_UNEMP at level

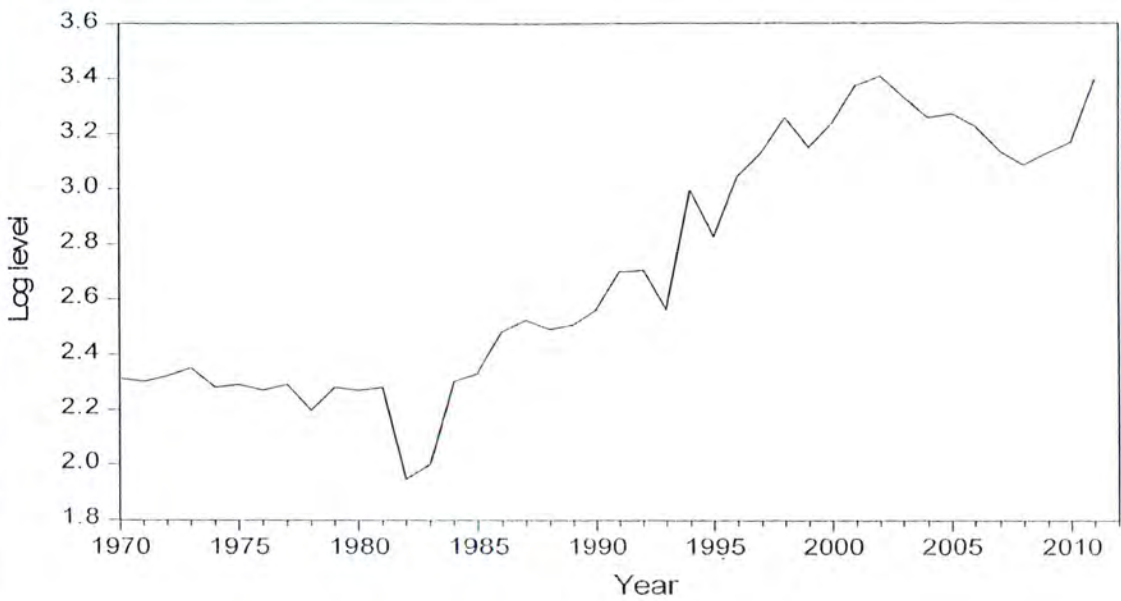


Figure 4.3.1 L_UNEMP at first difference

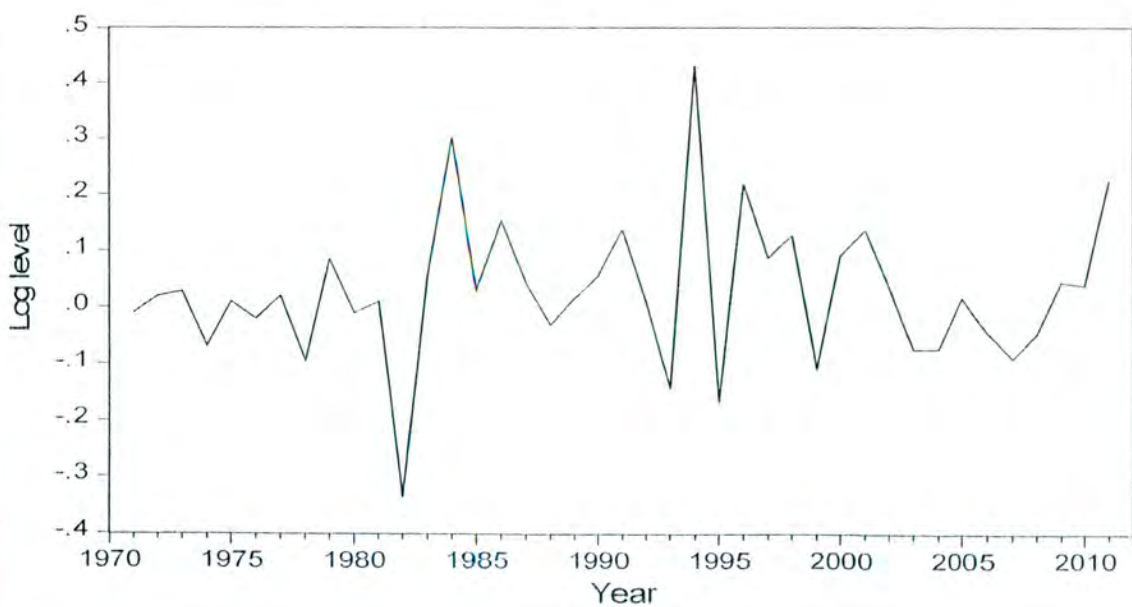


Figure 4.3.1 shows that the unemployment series consists of irregular fluctuations. This is evidenced by the upward trend in the unemployment series from 1983 to 2001 which,

however, declines from 2003 to 2009 but rises again after 2010 making this series nonstationary. Figure 4.3.2 shows that the first differenced series might be stationary, which means that the series' mean and variance are constant over time.

Figure 4.4 Employment

Figure 4.4.1 L_EMPLOY at level

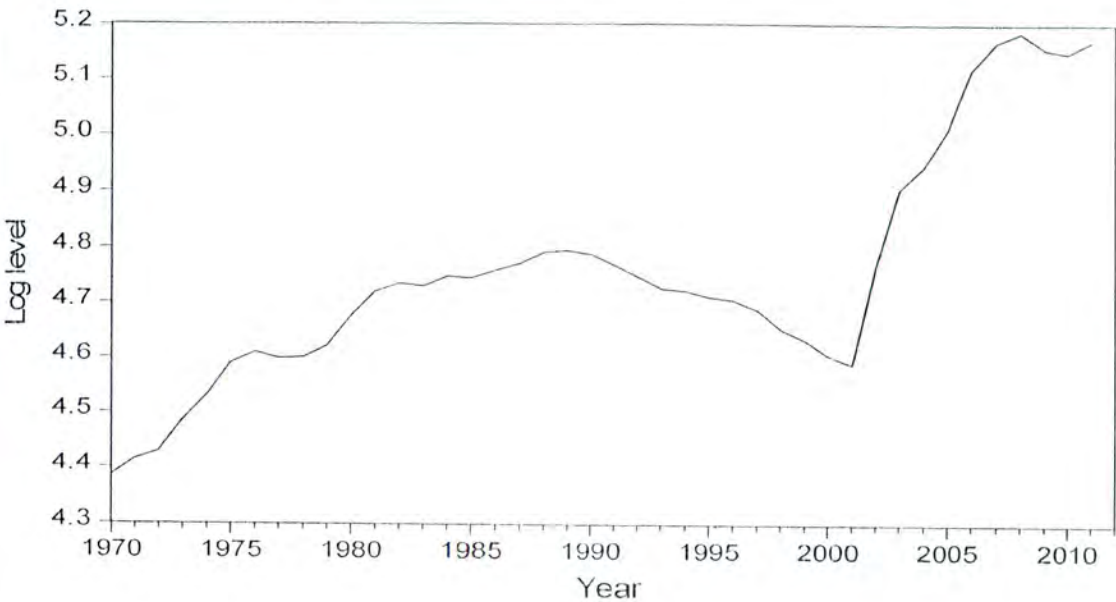


Figure 4.4.2 L_EMPLOY at first difference

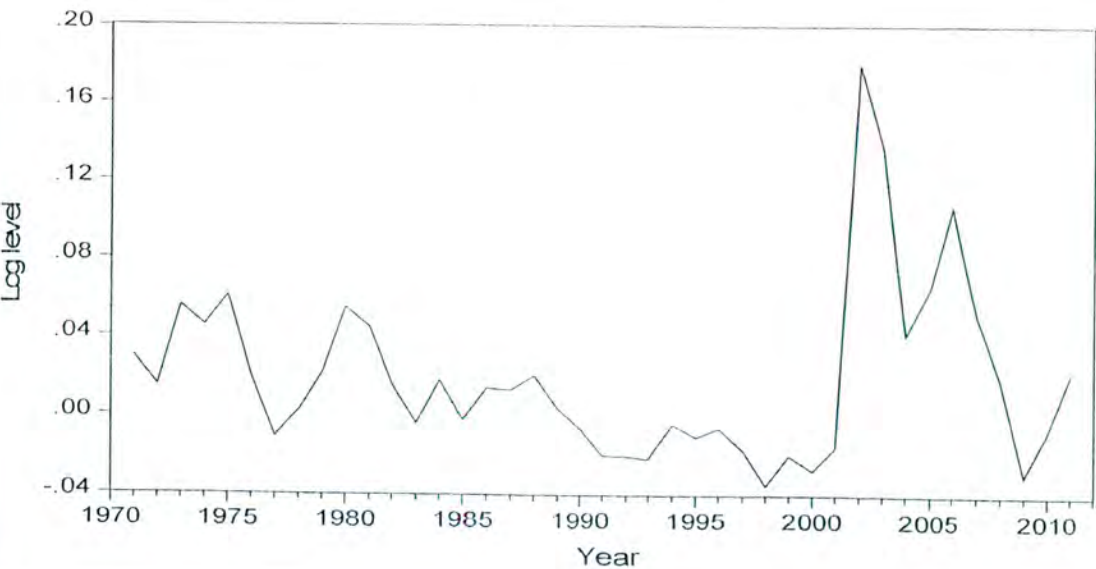


Figure 4.4.1 depicts the idea that the employment series rose consistently from 1970 to 1990 other than a drop from 1976 to 1977, after which it declines as from 1990 to 2001, with a

short term setback after the democratic election in 1994. The employment series then started to rise sharply from 2002 to 2008 with a slight drop afterwards making it nonstationary. Figure 4.4.2, its first difference, indicates that the series might be stationary. A more formal testing procedure is employed to examine each of the above-mentioned variables.

4.3 DETERMINATION OF THE INTEGRATION STATUS

Prior to examining the integration status or orders of integration of the variables, a visual examination of the data is performed. Visual inspection of the data suggests the following:

- L_REMUN reveals a clear upward trend, suggesting the existence of a linear time trend.
- L_LABPROD also shows an upward trend and a break suggesting the existence of a linear time trend and a structural break.
- L_UNEMPLOY also shows an upward trend and a break suggesting the existence of a linear time trend and a structural break.

The next step is to test whether or not a linear trend should be included in the model.

4.3.1 Inclusion of Linear Time in Remuneration

In order to include a linear trend term in L_REMUN, a regression of L_REMUN was run on time point, t , and the results are reported in Table 4.1.1 below:

Table 4.1.1 Regression of Remuneration

<i>Variable</i>	<i>Coefficient</i>	<i>Std. Error</i>	<i>t-Statistic</i>	<i>Prob.</i>
C	5.048902	0.357783	14.11165	0.0000
T	-45.66110	8.623969	-5.294673	0.0000
Constant= C Trend= T Sample:1970 – 2010 R-squared = 0.836230 Adjusted R-squared = 0.832031 S.E. of regression = 27.10660 Sum squared resid = 28655.95 Log likelihood = -192.4421 F-statistic = 199.1387 Prob(F-statistic) = 0.000000				

Since the probability value (0.000) is significant, therefore the unit root test for remuneration should include time trend.

4.3.2 Inclusion of Linear Time in Productivity

Table 4.1.2 Regression of labour productivity

<i>Variable</i>	<i>Coefficient</i>	<i>Std. Error</i>	<i>t-Statistic</i>	<i>Prob.</i>
C	0.658554	0.093305	7.058090	0.0000
T	60.37524	2.249015	26.84520	0.0000
Constant= C Trend= T Sample:1970 – 2010 R-squared = 0.560893 Adjusted R-squared = 0.549634 S.E. of regression = 7.069035 Sum squared resid = 1948.879 Log likelihood = -137.3359 F-statistic = 49.81664 Prob(F-statistic) = 0.000000				

Since the probability value (0.000) is significant, the unit root test for productivity should include a time trend.

4.3.3 Inclusion of Linear Time in Unemployment

Table 4.1.3 Regression of unemployment

<i>Variable</i>	<i>Coefficient</i>	<i>Std. Error</i>	<i>t-Statistic</i>	<i>Prob.</i>
C	0.531063	0.045715	11.61674	0.0000
T	5.191585	1.101919	4.711404	0.0000

Constant= C
 Trend= T
 Sample:1970 – 2010
 R-squared = 0.775796
 Adjusted R-squared = 0.770047
 S.E. of regression = 3.463519
 Sum squared resid = 467.8425
 Log likelihood = -108.0850
 F-statistic = 134.9486
 Prob(F-statistic) = 0.000000

Since the probability value (0.000) is significant, the unit root test for unemployment should include a time trend.

4.3.4 Pairwise Correlations

Table 4.2 Correlations

	<i>L_REMUN</i>	<i>L_LABPROD</i>	<i>L_UNEMP</i>
L_REMUN	1	0.661371546	0.846130966
L_LABPROD	0.661371546	1	0.890650781
L_UNEMP	0.846130966	0.890650781	1

The correlation coefficients presented in Table 4.2 above give a more precise summary of the relationships among remuneration, labour productivity and unemployment. The correlation coefficient ranges from 0.7 to 0.9. This means that the pairwise correlations are all strongly positive. It can be concluded that there is a strong positive correlation among all the variables. When productivity increases, employees' contribution to the firms' revenue also increases causing demand for workers to increase. As remunerations are determined by supply and demand, an increase in demand will lead to an increase in remunerations.

4.3.5 Structural stability test

H_0 : There is no break at a specified breakpoint

H_1 : There is a break at a specified breakpoint

Table 4.3 Test for structural break

<i>F-statistic</i>	2.570102	<i>Prob. F(3,36)</i>	0.0694
Log likelihood ratio	8.150727	Prob. Chi-Square(3)	0.0430
Wald Statistic	7.710305	Prob. Chi-Square(3)	0.0524
Chow Breakpoint Test: 1990			
Equation Sample: 1970 – 2011			

The Chow test shows that there is an evidence of a structural break on the year 1990. The probability value of Log likelihood ratio and Wald statistics is significant at the 5% level of significance. The break could be caused by the state of the economy around 1990.

4.3.6 Unit Root Test

Having gathered some very useful information from graphs, the next step is to turn to an analysis of the time series properties of the series. The visible evidence of upward trends suggests that all three series are nonstationary. This is tested formally by Augmented Dickey–Fuller (ADF) and Phillips and Perron (PP) tests for stationarity. The hypotheses for unit root are as follows:

$$H_0 : \delta_2 = 1$$

$$H_1 : \delta_2 < 1 \text{ for ADF and}$$

$$H_0 : \gamma = 1$$

$$H_1 : \gamma < 1 \text{ For PP.}$$

Table 4.4 Unit root test for Remuneration, Labour productivity and Unemployment

Variable	<i>ADF</i>		<i>PP</i>	
	Level	1 st Difference	Level	1 st Difference
L_REMUN	3.269	-3.223***	5.030	-3.295***
L_LABPROD	-3.048	-3.631**	-1.975	-3.601**
L_UNEMP	-2.259	-6.853*	-2.259	-6.853*

Note: *, **, and *** indicates the MacKinnon critical values for ADF and PP at 1%, 5% and 10% levels are -4.253, -3.548, and -3.207 respectively

The study uses both the ADF and PP tests for examining the order of integration of the variables. The results in Table 4.4 show that all the three variables are stationary at their first differences confirming that there is a presence of stochastic trends. As the variables follow the same order of integration, $I(1)$, now the study can turn to cointegration in which the long run equilibrium among the variables can be examined.

4.4 MULTIVARIATE DATA ANALYSIS

4.4.1 Testing for cointegration with a structural break in 1990

The next step is to apply the Johansen cointegration test to test for the existence of a long run (cointegrating) relationship between L_LABPROD, L_REMUN and L_UNEMP over the period for which data are available. After following the graphical indications that a structural break occurred in 1990, and the supporting discussion, allowance is made in the testing procedure for such a break. Maddala and Kim (1998) recommended a methodology which allows for structural breaks in the first instance. The methodology involves estimating a VAR and testing for lag order, determining the number of cointegrating vectors using the Johansen procedure, and then estimating error correction models if a cointegrating relation is found. Throughout this process, a dummy variable (D90) is used to test for the presence of a structural break in the year 1990. Dummy takes on values of zero up to 1989 and values of one thereafter.

4.4.2 Testing for lag order in the VAR

Table 4.5.1 Test statistic and choice criteria for selecting the order of the VAR model

<i>Lag</i>	<i>LogL</i>	<i>LR</i>	<i>FPE</i>	<i>AIC</i>	<i>SIC</i>	<i>HQ</i>
0	-402.9770	NA	800945.4	22.10686	22.36809	22.19896
1	-249.9351	264.7211	334.3452	14.32081	14.97389*	14.55105
2	-238.6098	17.75320	299.5537	14.19512	15.24004	14.56351
3	-229.0673	13.41108	301.1764	14.16580	15.60256	14.67232
4	-204.8671	30.08665*	141.0708*	13.34417*	15.17278	13.98884*
5	-196.7091	8.819519	163.8656	13.38968	15.61013	14.17249
Sample: 1970 – 2011 Exogenous variables: C D90 LR: sequential modified LR test statistic (each test at 5% level) FPE: Final prediction error AIC: Akaike information criterion SIC: Schwarz information criterion HQ: Hannan-Quinn information criterion						

Note: * indicates lag order selected by the criterion

A starting point of five lags is chosen. The results displayed in Table 4.5.1 clearly indicate that a VAR(4) is appropriate. The LR test, FPE, AIC and HQ all selected p equal to four. The tests indicate that one should reject the restriction that lags four should be excluded.

4.4.3 Cointegration test for L_REMUN, L_LABPROD and L_UNEMP, 1970 - 2011

With the VAR order having been established, Johansen's (1988) maximum likelihood test for cointegration can be applied.

Table 4.5.2.1 Unrestricted Cointegration Rank Test (Trace)

<i>Hypothesized No. of CE(s)</i>	<i>Eigenvalue</i>	<i>Trace Statistic</i>	<i>Prob. **</i>
None *	0.524870	52.61027	0.0000
At most 1 *	0.309539	25.07606	0.0013
At most 2 *	0.264596	11.37140	0.0007

Note: Trace test indicates 3 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Table 4.5.2.2 Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

<i>Hypothesized No. of CE(s)</i>	<i>Eigenvalue</i>	<i>Max-Eigen Statistic</i>	<i>Prob. **</i>
None *	0.524870	27.53421	0.0055
At most 1	0.309539	13.70466	0.0611
At most 2 *	0.264596	11.37140	0.0007

Note: Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Because of the possibility that L_REMUN has a deterministic trend, and the graphical evidence that the three series are trending together, the ‘unrestricted intercepts, no trends’ option is selected as being most appropriate in this instance. The results imply that the trace test and the eigenvalue test select cointegration vectors. The trace test in table 4.5.2.1 indicates that there are three cointegrating vectors while max-eigenvalue test in table 4.5.2.2 indicates one cointegration vector. According to Banerjee *et al.* (1993), in a case where there is a different value of the two tests, the results obtained from the Maximal Eigenvalue of the Stochastic Matrix are preferred (Banerjee *et al.*, 1993) implying that it is concluded that there is one cointegrating equation. This gives an allowance to estimate the long term relationship and ECMs.

Table 4.5.3 Cointegrating Vector for L_REMUN, L_LABPROD and L_UNEMP, 1970 - 2011

<i>1 Cointegrating Equation(s):</i>	<i>Log likelihood</i>	<i>-209.2471</i>
Normalized cointegrating coefficients (standard error in parentheses)		
L_REMUN	L_LABPROD	L_UNEMP
1.000000	2.470052	-1.257468
	(2.17334)	(3.20195)

The long term equilibrium vector is estimated to be $Z = L_REMUN + 2.47 L_LABPROD - 1.257 L_UNEMP$. The coefficient of $L_LABPROD$ has a standard error of 2.17 and it is therefore insignificant and the coefficient of L_UNEMP has a standard error of 3.2 and is clearly insignificant. It is therefore not possible to conclude that a long term relationship exists among these three series for this sample period.

4.4.4 Cointegration test for L_REMUN, L_LABPROD and L_UNEMP, 1990–2011

Table 4.6.1 Unrestricted Cointegration Rank Test (Trace and Maximum Eigenvalue)

<i>Hypothesized No. of CE(s)</i>	<i>Eigenvalue</i>	<i>Trace Statistic</i>	<i>Prob.**</i>	<i>Max-Eigen Statistic</i>	<i>Prob.**</i>
None *	0.740687	39.92489	0.0025	26.99441	0.0067
At most 1	0.346209	12.93048	0.1174	8.499350	0.3302
At most 2 *	0.198729	4.431130	0.0353	4.431130	0.0353

Note: Trace test indicates 1 cointegrating eqn(s) at the 0.05 level

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

In the ‘unrestricted intercepts, no trends’ case, the trace test and max-eigenvalue tests indicate that there is one cointegrating vector. The probability value of 0.33 for “at most one” is greater than five percent level of significance. The hypothesis relating to “at most one” cannot be rejected, which means that there is a single cointegrating vector.

Table 4.6.2 Cointegrating Vector for L_REMUN, L_LABPROD and L_UNEMP, 1990–2011

<i>I Cointegrating Equation(s):</i>	<i>Log likelihood</i>	<i>-144.3060</i>
Normalized cointegrating coefficients (standard error in parentheses)		
L_REMUN	L_LABPROD	L_UNEMP
1.000000	2.525119	-8.825643
	(0.54167)	(1.17973)

The long term equilibrium vector is estimated to be $Z = L_REMUN + 2.53 L_LABPROD - 8.83 L_UNEMP$. The coefficient of $L_LABPROD$ has a standard error of 0.54 and is therefore significant and the coefficient of L_UNEMP has a standard error of 1.18 and is also significant. The main interest of the study is to test the relationship between remuneration and labour productivity, therefore the next step is to test the relationship between the two variables.

4.4.5 Cointegration test for L_REMUN and L_LABPROD, 1990–2011

The last results (Cointegration test for L_REMUN , $L_LABPROD$ and L_UNEMP , 1990 – 2011) showed that there is a relationship between L_REMUN , $L_LABPROD$ and L_UNEMP . Cointegration tests were also conducted for the period 1970–2011 with a dummy variable for the year 1990. The results were qualitatively similar, in that a single cointegrating vector was found. The same methodology will be applied as before to test the relationship between L_REMUN and $L_LABPROD$.

Table 4.7.1 Test statistic and choice criteria for selecting the order of the VAR model

<i>Lag</i>	<i>LogL</i>	<i>LR</i>	<i>FPE</i>	<i>AIC</i>	<i>SIC</i>	<i>HQ</i>
0	-151.5577	NA	240417.0	18.06561	18.16364	18.07536
1	-96.01720	91.47848*	563.2574	12.00202	12.29610	12.03126
2	-91.46434	6.427563	542.9560	11.93698	12.42711	11.98570
3	-86.17626	6.221274	499.4796	11.78544	12.47162	11.85365
4	-78.94989	6.801285	391.4190*	11.40587	12.28810	11.49356
5	-72.81934	4.327452	392.3353	11.15522*	12.23349*	11.26240*

Sample: 1990 – 2011
Exogenous variables: C
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SIC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Note: * indicates lag order selected by the criterion

A starting point of five lags is chosen. The results displayed in Table 4.7.1 clearly indicate that a VAR(5) is appropriate. The AIC, SIC and HQ test selected p equal to five. The tests indicate that one should reject the restriction that lags five should be excluded.

Table 4.7.2 Unrestricted Cointegration Rank Test (Trace and Maximum Eigenvalue)

<i>Hypothesized No. of CE(s)</i>	<i>Eigenvalue</i>	<i>Trace Statistic</i>	<i>Prob.**</i>	<i>Max-Eigen Statistic</i>	<i>Prob.**</i>
None *	0.986606	69.87096	0.0000	69.00706	0.0000
At most 1	0.052562	0.863905	0.3526	0.863905	0.3526

Note: Trace test indicates 1 cointegrating eqn(s) at the 0.05 level

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

The Johansen cointegration test was applied in a VAR(5), again with unrestricted intercepts and no trends. The probability values for both the trace test and maximal eigenvalue test clearly indicate a single cointegrating vector at the 5 percent level of significance. The next step is to estimate the long term equilibrium vector.

Table 4.7.3 Cointegrating Vector for L_REMUN and L_LABPROD, 1990–2011

<i>I Cointegrating Equation(s):</i>	<i>Log likelihood</i>	<i>-144.3060</i>
Normalized cointegrating coefficients (standard error in parentheses)		
L_REMUN	L_LABPROD	
1.000000	-1.980844	
	(0.05506)	

The long term equilibrium vector is estimated to be $Z = L_REMUN - 1.98 L_LABPROD$. The coefficient of $L_LABPROD$ has a standard error of 0.06 and is therefore significant. This implies that for every 1 percent rise in productivity, real wages rise by 1.98 percent in the long term.

4.5 ERROR CORRECTION MODELS

As a cointegrating relationship was found between L_REMUN and $L_LABPROD$, it may be concluded that there is a long term causal relationship between the variables. It also means that ECMs may be estimated, which allow us to test for short term or dynamic causality. The table below gives the summary of the ECMs.

Table 4.8 Error correction models for L_REMUN and L_LABPROD, 1990–2011

<i>Regressor</i>	<i>Dependent Variable</i>	
	L_REMUN	L_LABPROD
Constant		17.32** (9.21)
ECM(-1)	-0.18* (0.08)	-0.58* (0.08)
L_LABPROD(-4)	-0.39 (0.29)	
DL_LABPROD(-5)	0.026 (0.27)	
L_REMUN(-1)		0.94* (0.34)
DL_REMUN(-2)	1.47* (0.1)	-0.41 (0.34)
R-squared	0.99	0.77
Adjusted R-squared	0.99	0.73
S.E. of regression	4.97	4.65

Note: *significant at 5 percent and **significant at 10 percent. Parentheses indicate standard errors

The table above shows the ECM results. The optimum lag length, which is 5, is selected by AIC, SIC and HQ tests. The ECM term is negative as expected, indicating that remuneration adjusts back towards equilibrium (with productivity) following a shock in the previous year. The magnitude of this coefficient suggest that approximately 0.18 and 0.58 of the disequilibrium is corrected for L_REMUN and L_LABPROD respectively. The coefficient of the error correction term in the L_LABPROD is large, indicating a rapid adjustment of labour productivity to equilibrium. For the L_REMUN model, none of the lagged labour productivity is significant which means that labour productivity has no impact on remuneration in the short term.

4.6 GRANGER CAUSALITY TEST

Table 4.9 Causality between Labour productivity and Remuneration

<i>Null Hypothesis:</i>	<i>Obs</i>	<i>F-Statistic</i>	<i>Prob.</i>
L_LABPROD does not Granger Cause L_REMUN	17	0.92822	0.5225
L_REMUN does not Granger Cause L_LABPROD		1.35422	0.3573

The probability 0.5225 is more than the critical probability $p\text{-value} = 0.05$ therefore the null hypothesis is not rejected. This implies that L_LABPROD does not Granger cause L_REMUN and the alternative hypothesis is also not rejected, meaning that L_REMUN does not Granger cause L_LABPROD.

4.7 DIAGNOSTIC TEST

4.7.1 Diagnostic test for equation 2.15: ΔL_REMUN_t

4.7.1.1 Test for Heteroscedasticity

H_o : There is no heteroscedasticity.

H_1 : There is heteroscedasticity.

Table 4.10.1 Test for Heteroscedasticity: ΔL_REMUN_t

F-statistic	0.669468	Prob. F(4,12)	0.6255
Obs*R-squared	3.101527	Prob. Chi-Square(4)	0.5410
Scaled explained SS	0.660076	Prob. Chi-Square(4)	0.9562

The LM test is applicable whether lagged dependent variables are included or not. The probability of 0.54 is greater than 0.05, therefore the null hypotheses is cannot be rejected. There is no conditional heteroscedasticity.

4.7.1.2 Test for serial correlation

H_0 : There is no serial correlation.

H_1 : There is serial correlation.

Table 4.10.2 Test for serial correlation: ΔL_REMUN_t

F-statistic	1.185694	Prob. F(5,8)	0.3945
Obs*R-squared	7.185226	Prob. Chi-Square(5)	0.2072

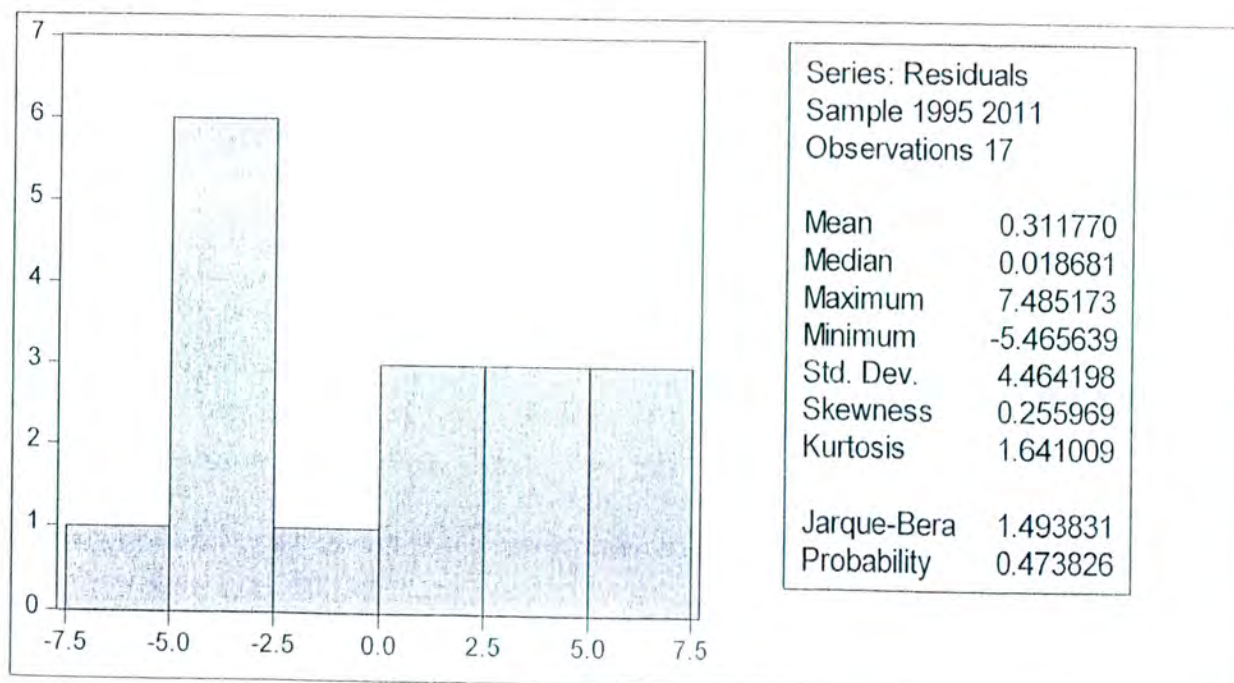
The Breusch-Godfrey LM test is used to test for the presence or absence of serial correlation in the residuals. The null hypothesis is rejected, since the p-value of 0.21 is greater than the 5 percent level of significance. Therefore it is concluded that there is no serial correlation.

4.7.1.3 Test for normality

H_0 : The residuals are normally distributed.

H_1 : The residuals are not normally distributed.

Figure 4.5 Test for normality: ΔL_REMUN_t



The test shows a histogram of the residuals and the Jarque-Bera statistic for testing the normality. The Jarque-Bera test statistic is used to determine whether variables are normally distributed in the model. The Jarque-Bera test statistic is 1.49 and the probability is 0.47. The normality test is used to test whether the probability value is greater than the critical probability value of 0.05, therefore probability of 0.47 is greater than the critical probability value of 0.05. Therefore, the null hypothesis is not rejected and it is concluded that the residuals are normally distributed.

4.7.2 Diagnostic test for equation 2.16: $\Delta L_LABPROD_t$

4.7.2.1 Test for Heteroscedasticity

H_0 : There is no heteroscedasticity.

H_1 : There is heteroscedasticity.

Table 4.10.3 Test for Heteroscedasticity: $\Delta L_LABPROD_t$

F-statistic	7.587977	Prob. F(9,10)	0.0020
Obs*R-squared	17.44545	Prob. Chi-Square(9)	0.0422
Scaled explained SS	15.79242	Prob. Chi-Square(9)	0.0713

The LM test is applicable whether lagged dependent variables are included or not. The probability of 0.04 is not greater than 0.05, therefore the null hypotheses is rejected. There is conditional heteroscedasticity. This means there is homoscedasticity.

4.7.2.2 Test for serial correlation

H_0 : There is no serial correlation.

H_1 : There is serial correlation.

Table 4.10.4 Test for serial correlation: $\Delta L_LABPROD_t$

F-statistic	1.553396	Prob. F(5,11)	0.2517
Obs*R-squared	8.277284	Prob. Chi-Square(5)	0.1416

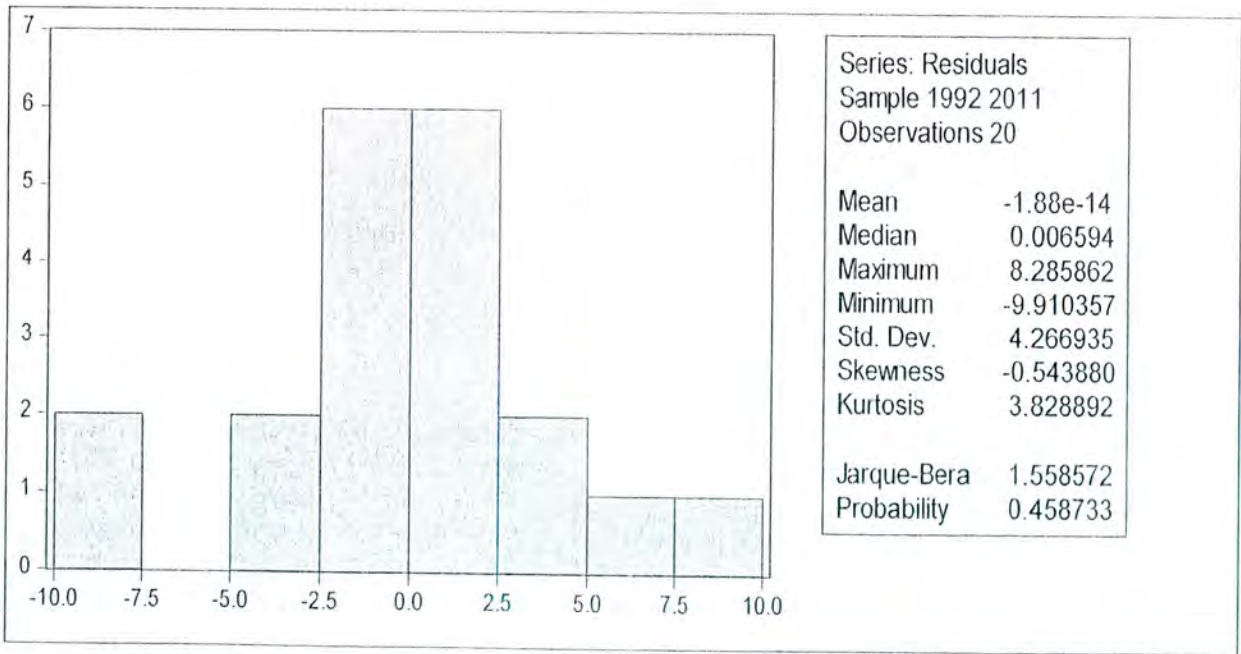
The serial correlation test concentrates on the Breusch-Godfrey LM test in order to test for the presence or absence of serial correlation in the residuals. The null hypothesis is not rejected, since the p-value of 0.14 is greater than 5 percent level of significance. Therefore there is no presence of serial correlation.

4.7.2.3 Test for normality

H_0 : The residuals are normally distributed.

H_1 : The residuals are not normally distributed.

Figure 4.6 Test for normality: $\Delta L_LABPROD_t$



The test shows a histogram of the residuals and the Jarque-Bera statistic for testing normality. The Jarque-Bera test statistic tests whether variables are normally distributed in the model. The Jarque-Bera is 1.56 and the probability is 0.46. The probability of 0.46 is greater than the

critical probability value of 0.05. Therefore the null hypothesis is not rejected and it is concluded that the residuals are normally distributed.

Since there is a presence of conditional heteroscedasticity, the next step is to use ARCH model to test again the presence of heteroscedasticity.

4.7.3 Diagnostic test for equation 2.16 using ARCH

4.7.3.1 Test for Heteroscedasticity

H_0 : There is no heteroscedasticity.

H_1 : There is heteroscedasticity.

Table 4.10.5 Test for Heteroscedasticity: $\Delta L_LABPROD_t$

F-statistic	0.174202	Prob. F(1,17)	0.6816
Obs*R-squared	0.192722	Prob. Chi-Square(1)	0.6607

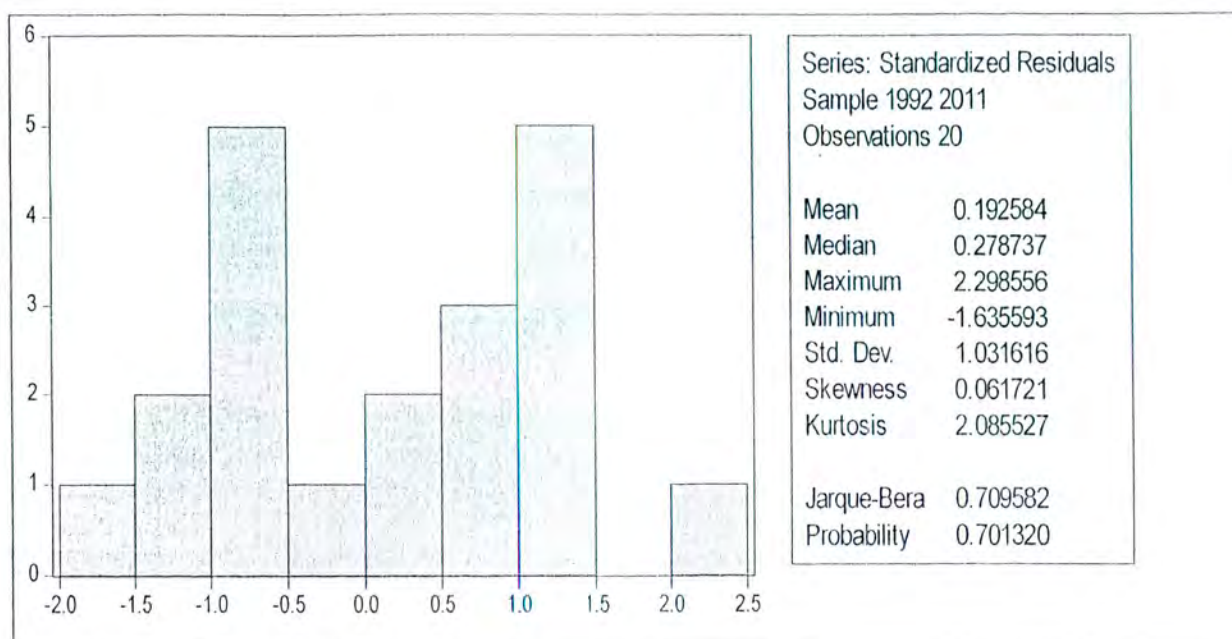
The ARCH LM test shows that there is no evidence of autoregressive conditional heteroscedasticity. The probability of 0.682 is greater than 0.05, therefore the null hypothesis cannot be rejected. The ARCH test results strongly suggest that there is no presence of ARCH in the residuals.

4.7.3.2 Test for normality

H_0 : The residuals are normally distributed.

H_1 : The residuals are not normally distributed.

Figure 4.7 Test for normality: $\Delta L_LABPROD_t$



The test shows a histogram of the residuals and the Jarque-Bera statistic for testing the normality. The Jarque-Bera test statistic tests whether variables are normally distributed in the model. Jarque-Bera is 0.71 and the probability value is 0.70. The probability value is greater than the critical probability value of 0.05. Therefore the null hypothesis is not rejected and it is concluded that the residuals are normally distributed.

4.8 CONCLUSION

This chapter focuses on the data analysis and interpretation of the results for the analysis of the relationship between remuneration and labour productivity in South African economy. The variables used in the study are remuneration, labour productivity unemployment and employment. The chapter helps to identify whether the series is significant or not. The null hypothesis is defined as $H_0: \rho=1$ (the data is non-stationary) whilst the alternative hypothesis is defined as $H_a: \rho \neq 1$ (the data is stationary). The original series is nonstationary but after differencing and running some formal test, it was concluded that the first differenced series are stationary. After applying Johansen cointegration technique, it was found that the data are cointegrated and significant. The series are significant as they passed most of the tests; it is also found that the equation 2.16 has heteroskedasticity. Furthermore, ARCH test results strongly suggest that there is no presence of ARCH in the residuals. A normality test was

conducted on the data and it was found that residuals are normally distributed since the probability is greater than 0.05. Cointegration on residuals was conducted and it was found that the residuals are significant, thus stationary.

The econometric evidence suggests that the study has the following dynamic causal system: remuneration impacts on labour productivity negatively but labour productivity has no effect on remuneration; labour productivity has a weak autoregressive pattern but real wages lack this altogether; and adjustment to equilibrium occurs through both remuneration and labour productivity negatively and positively respectively.

CHAPTER 5

DISCUSSIONS OF THE FINDINGS, CONCLUSIONS AND

RECOMMENDATIONS

5.1 INTRODUCTION

Chapter five presents and discusses findings from the study based on the results obtained in chapter four. Then the discussions, conclusions and recommendations are made and areas that need further research are also proposed.

5.2 KEY FINDINGS OF THE STUDY

A number of procedures were used in the study to investigate the long run (cointegrating) relationship between remuneration and labour productivity. This entailed visual inspection and the employment of formal testing procedure for unit root for each variable. Afterwards the study employed Johansen multivariate cointegration analysis and the Granger causality test to investigate the long run and short run relationship between remuneration and labour productivity in South Africa.

Since about 1990, the remuneration series has increased considerably, with fairly gentle variations around a roughly linear trend. However, the differenced series showed a more stationary shape. Prior to this period during the 1970s and 1980s, labour productivity has shown a slight positive trend, interrupted by a number of shocks. From 1987 the labour productivity curve appeared to be exponential, increasing somewhat more steeply than remuneration. The unemployment series depicted an upward fluctuation from 1983 to 2001 with a decline from 2003 to 2009.

There is significance evidence of a structural break in 1990, which seems to have affected the level of employment in the first instance, and fed through into other variables such as remuneration and labour productivity. This evidence is supported by various economic and policy factors as well as other empirical work. A long run equilibrium (cointegrating)

relationship exists between remuneration, labour productivity and unemployment for the period 1970 to 2011. The unemployment rate behaves in a way unpredictable with the theory proposed by Blanchflower and Oswald (1993, 1994, and 1995) who established a body of international wage curve literature in which a negative relationship between wages and unemployment is hypothesised and substantiated empirically.

There results also indicated that there is strong evidence of cointegration between remuneration and labour productivity in the period 1990 to 2011. In the long run, a one percent increase in labour productivity is associated with an approximately 1.98% increase in remuneration. The econometric results show that unemployment is not connected to the long run equilibrium between remuneration and labour productivity. More specifically, it is clear that in the South African labour market, the high unemployment rate has little or no effect in terms of stopping growth in remuneration. The study by Ho and Yap (2001) also found a significant relationship between wages and labour productivity for the Malaysian manufacturing industry where the rises in real wages exceeded the rises in labour productivity in the long run.

The ECM term is negative as expected, indicating that remuneration adjusts back towards long run equilibrium (with labour productivity) following a shock in the previous year. The magnitude of these coefficients suggests that approximately 0.18 and 0.58 of the disequilibrium is corrected for L_REMUN and L_LABPROD respectively. The coefficient of the error correction term in the L_LABPROD is large, indicating a rapid adjustment of labour productivity to equilibrium. For the L_REMUN model, none of the lagged labour productivity is significant which means that labour productivity has no impact on remuneration in the short run. The researcher therefore cannot conclude that remuneration Granger cause labour productivity in the long run. L_REMUN does not Granger cause L_LABPROD and vice versa.

Finally, given the economy's slow growth performance over the past years, the rapid increase in labour productivity and remuneration reflects to a large extent the sharp weakening in employment levels. South Africa's labour productivity performance should not therefore be

looked at in isolation of the employment trend, which indicates the job-shedding nature of economic development in this country over the previous years. The data are significant as they passed all the tests; the equation 2.16 has heteroskedasticity. Furthermore, ARCH test results strongly suggest that there is no presence of ARCH in the residuals. Normality and also serial correlation tests were conducted on the data and it was found that residuals are normally distributed and there was no evidence of serial correlation since the probability values were greater than 0.05.

5.3 CONCLUSIONS AND RECOMMENDATIONS

In conclusion, the study found that there was a cointegrating relationship between remuneration and labour productivity in the period 1990 to 2011. The results revealed that labour productivity has no impact on remuneration in the short run and remuneration does not Granger cause labour productivity in the long run and vice versa. The results also suggest that approximately 0.18 for remuneration and 0.58 of the disequilibrium is corrected for labour productivity.

Coming to the policy recommendations the manufacturing sector should improve the labour productivity development by improving remunerations and other benefits of the employees. The higher output will enhance the growth in the economy and improve the standard of living of the employees and could also reduce unemployment. The conclusion to the study implies that the upward movement of labour productivity may increase remuneration and could also create more employment opportunities. The productivity can increase only if employment and remuneration increase. Decision-makers should adopt the dual strategy of offering more competitive remunerations to encourage labour productivity, and also increase investment on education and training to enhance labour skills and productivity.

In addition, government should also improve on setting up minimum remuneration policies and other benefits to enable the low and middle classes wage labour forces to cope with the rising cost of living in South Africa. At least two possible avenues for further research from this study may be identified. Firstly, is to repeat the analysis and add as many variables as possible relating to remuneration and labour productivity (such as price, inflation, growth

rate, GDP, etc.). Secondly, the another potentially enlightening way forward would be to repeat the same study using different econometric techniques such as comparison using Engle and Granger, and Johansen cointegration technique. The study also recommends that there is still a need for the South African government to take urgent steps against the increasing unemployment rate, because unemployment is a major problem to social progress and results in waste of trained manpower.

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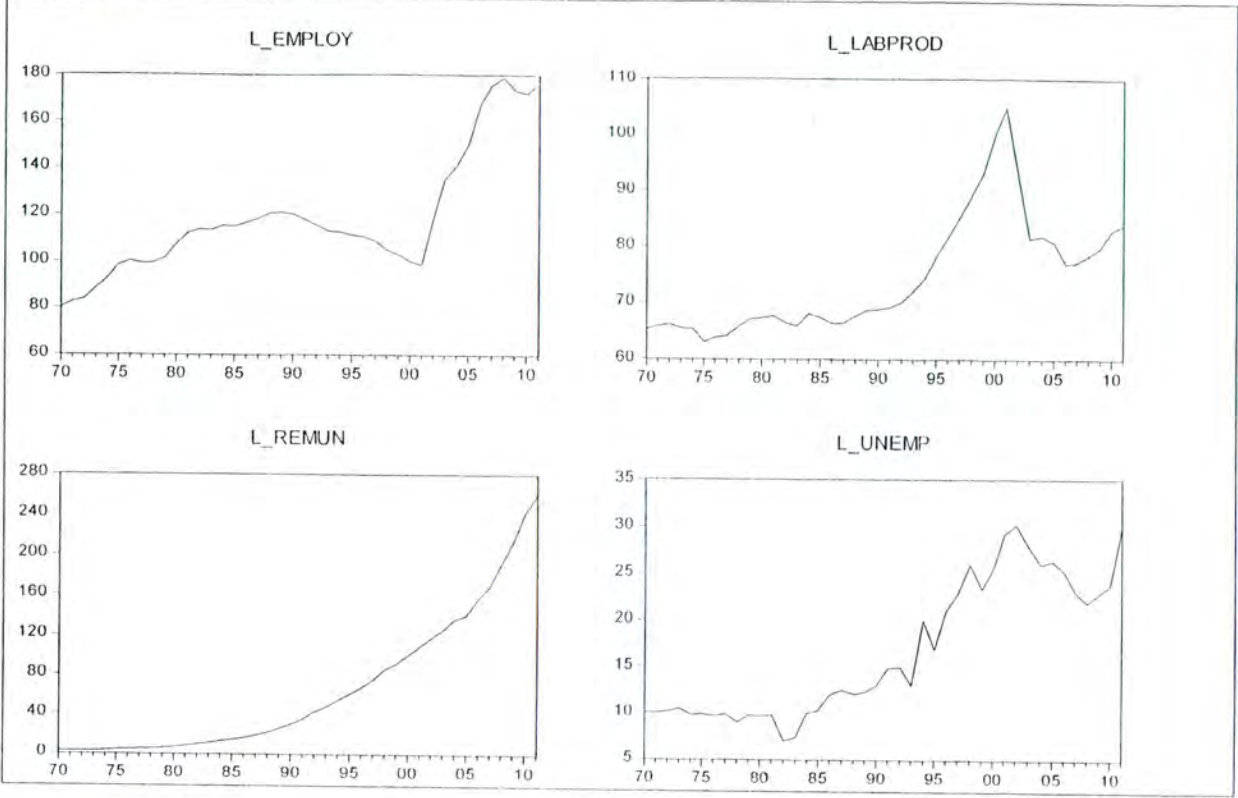
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APPENDIX

Appendix A



Appendix B

Dependent Variable: L_REMUN				
Method: Least Squares				
Date: 01/28/13 Time: 17:17				
Sample (adjusted): 1970 2010				
Included observations: 41 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
T	5.048902	0.357783	14.11165	0.0000
C	-45.66110	8.623969	-5.294673	0.0000
R-squared	0.836230	Mean dependent var		60.36585
Adjusted R-squared	0.832031	S.D. dependent var		66.13937
S.E. of regression	27.10660	Akaike info criterion		9.484982
Sum squared resid	28655.95	Schwarz criterion		9.568571
Log likelihood	-192.4421	Hannan-Quinn criter.		9.515421
F-statistic	199.1387	Durbin-Watson stat		0.060261
Prob(F-statistic)	0.000000			

Appendix C

Dependent Variable: L_LABPROD

Method: Least Squares

Date: 01/28/13 Time: 17:32

Sample (adjusted): 1970 2010

Included observations: 41 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
T	0.658554	0.093305	7.058090	0.0000
C	60.37524	2.249015	26.84520	0.0000
R-squared	0.560893	Mean dependent var		74.20488
Adjusted R-squared	0.549634	S.D. dependent var		10.53361
S.E. of regression	7.069035	Akaike info criterion		6.796876
Sum squared resid	1948.879	Schwarz criterion		6.880464
Log likelihood	-137.3359	Hannan-Quinn criter.		6.827314
F-statistic	49.81664	Durbin-Watson stat		0.239680
Prob(F-statistic)	0.000000			

Appendix D

Dependent Variable: L_UNEMP

Method: Least Squares

Date: 01/28/13 Time: 17:35

Sample (adjusted): 1970 2010

Included observations: 41 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
T	0.531063	0.045715	11.61674	0.0000
C	5.191585	1.101919	4.711404	0.0000
R-squared	0.775796	Mean dependent var		16.34390
Adjusted R-squared	0.770047	S.D. dependent var		7.222674
S.E. of regression	3.463519	Akaike info criterion		5.369998
Sum squared resid	467.8425	Schwarz criterion		5.453587
Log likelihood	-108.0850	Hannan-Quinn criter.		5.400436
F-statistic	134.9486	Durbin-Watson stat		0.339815
Prob(F-statistic)	0.000000			

Appendix E

Date: 01/28/13 Time: 17:56

Sample (adjusted): 1975 2011

Included observations: 37 after adjustments

Trend assumption: Linear deterministic trend

Series: L_REMUN L_LABPROD L_UNEMP

Exogenous series: D90

Warning: Critical values assume no exogenous series

Lags interval (in first differences): 1 to 4

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
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None *	0.524870	52.61027	29.79707	0.0000
At most 1 *	0.309539	25.07606	15.49471	0.0013
At most 2 *	0.264596	11.37140	3.841466	0.0007
Trace test indicates 3 cointegrating eqn(s) at the 0.05 level * denotes rejection of the hypothesis at the 0.05 level **MacKinnon-Haug-Michelis (1999) p-values				
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.524870	27.53421	21.13162	0.0055
At most 1	0.309539	13.70466	14.26460	0.0611
At most 2 *	0.264596	11.37140	3.841466	0.0007
Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level * denotes rejection of the hypothesis at the 0.05 level **MacKinnon-Haug-Michelis (1999) p-values				
Unrestricted Cointegrating Coefficients (normalized by b'S11*b=I):				
L_REMUN	L_LABPROD	L_UNEMP		
0.072961	0.180216	-0.091746		
-0.088523	-0.703774	1.462202		
-0.293436	0.290257	0.929160		
Unrestricted Adjustment Coefficients (alpha):				
D(L_REMUN)	0.667112	0.416856	-0.790503	
D(L_LABPROD)	-0.897411	0.904621	-0.329688	
D(L_UNEMP)	-0.589790	-0.646835	-0.282462	
1 Cointegrating Equation(s): Log likelihood -209.2471				
Normalized cointegrating coefficients (standard error in parentheses)				
L_REMUN	L_LABPROD	L_UNEMP		
1.000000	2.470052	-1.257468		
	(2.17334)	(3.20195)		
Adjustment coefficients (standard error in parentheses)				
D(L_REMUN)	0.048673			
	(0.02837)			
D(L_LABPROD)	-0.065476			
	(0.03026)			
D(L_UNEMP)	-0.043031			
	(0.02182)			
2 Cointegrating Equation(s): Log likelihood -202.3948				
Normalized cointegrating coefficients (standard error in parentheses)				
L_REMUN	L_LABPROD	L_UNEMP		
1.000000	0.000000	5.620795		
		(2.11577)		
0.000000	1.000000	-2.784663		
		(0.40378)		
Adjustment coefficients (standard error in parentheses)				

D(L_REMUN)	0.011771 (0.04342)	-0.173148 (0.27499)
D(L_LABPROD)	-0.145556 (0.04212)	-0.798377 (0.26671)
D(L_UNEMP)	0.014229 (0.03045)	0.348936 (0.19281)

Appendix F

Date: 01/28/13 Time: 17:58

Sample (adjusted): 1992 2011

Included observations: 20 after adjustments

Trend assumption: Linear deterministic trend

Series: L_REMUN L_LABPROD L_UNEMP

Lags interval (in first differences): 1 to 4

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.740687	39.92489	29.79707	0.0025
At most 1	0.346209	12.93048	15.49471	0.1174
At most 2 *	0.198729	4.431130	3.841466	0.0353

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.740687	26.99441	21.13162	0.0067
At most 1	0.346209	8.499350	14.26460	0.3302
At most 2 *	0.198729	4.431130	3.841466	0.0353

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b*S11*b=I):

L_REMUN	L_LABPROD	L_UNEMP
-0.064468	-0.162789	0.568970
-0.012585	0.200587	-0.347343
0.006143	-0.004084	-0.260009

Unrestricted Adjustment Coefficients (alpha):

D(L_REMUN)	-2.915326	-1.623301	0.238029
D(L_LABPROD)	1.239021	-0.750754	1.564094
D(L_UNEMP)	-0.826866	1.055341	0.349261

1 Cointegrating Equation(s): Log likelihood -144.3060

Normalized cointegrating coefficients (standard error in parentheses)

L_REMUN	L_LABPROD	L_UNEMP
1.000000	2.525119	-8.825643
	(0.54167)	(1.17973)
Adjustment coefficients (standard error in parentheses)		
D(L_REMUN)	0.187945	
	(0.05488)	
D(L_LABPROD)	-0.079877	
	(0.06333)	
D(L_UNEMP)	0.053306	
	(0.03358)	
2 Cointegrating Equation(s):		
	Log likelihood	-140.0563
Normalized cointegrating coefficients (standard error in parentheses)		
L_REMUN	L_LABPROD	L_UNEMP
1.000000	0.000000	-3.844062
		(1.05997)
0.000000	1.000000	-1.972810
		(0.37212)
Adjustment coefficients (standard error in parentheses)		
D(L_REMUN)	0.208374	0.148970
	(0.04867)	(0.19143)
D(L_LABPROD)	-0.070429	-0.352290
	(0.06326)	(0.24879)
D(L_UNEMP)	0.040025	0.346292
	(0.02916)	(0.11469)

Appendix G

Date: 01/25/13 Time: 23:16

Sample (adjusted): 1996 2011

Included observations: 16 after adjustments

Trend assumption: Linear deterministic trend

Series: L_REMUN L_LABPROD

Lags interval (in first differences): 1 to 5

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.986606	69.87096	15.49471	0.0000
At most 1	0.052562	0.863905	3.841466	0.3526

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.986606	69.00706	14.26460	0.0000
At most 1	0.052562	0.863905	3.841466	0.3526

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b*S11*b=I):

L_REMUN	L_LABPROD
0.314661	-0.623295
-0.174233	0.685036

Unrestricted Adjustment Coefficients (alpha):

D(L_REMUN)	1.872069	0.094838
D(L_LABPROD)	-1.684835	0.162923

1 Cointegrating Equation(s): Log likelihood -22.31773

Normalized cointegrating coefficients (standard error in parentheses)

L_REMUN	L_LABPROD
1.000000	-1.980844
	(0.05506)

Adjustment coefficients (standard error in parentheses)

D(L_REMUN)	0.589068
	(0.07358)
D(L_LABPROD)	-0.530153
	(0.11599)

Appendix II

Pairwise Granger Causality Tests

Date: 01/29/13 Time: 12:05

Sample: 1990 2011

Lags: 5

Null Hypothesis:	Obs	F-Statistic	Prob.
L_LABPROD does not Granger Cause L_REMUN	17	0.92822	0.5225
L_REMUN does not Granger Cause L_LABPROD		1.35422	0.3573

Appendix I

Dependent Variable: L_REMUN

Method: Least Squares

Date: 01/29/13 Time: 14:48

Sample (adjusted): 1995 2011

Included observations: 17 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DL_LABPROD(-5)	0.025702	0.265403	0.096840	0.9243
ECM(-1)	-0.179878	0.084962	-2.117156	0.0541
DL_REMUN(-2)	1.474310	0.105136	14.02284	0.0000
L_LABPROD(-4)	-0.386752	0.293829	-1.316249	0.2108
R-squared	0.994453	Mean dependent var		137.6000
Adjusted R-squared	0.993173	S.D. dependent var		60.09373
S.E. of regression	4.965399	Akaike info criterion		6.245189

Sum squared resid	320.5175	Schwarz criterion	6.441239
Log likelihood	-49.08410	Hannan-Quinn criter.	6.264677
Durbin-Watson stat	0.938707		

Appendix J

Dependent Variable: L_LABPROD
Method: Least Squares
Date: 01/29/13 Time: 15:20
Sample (adjusted): 1992 2011
Included observations: 20 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DL_REMUN(-2)	-0.410263	0.342811	-1.196760	0.2488
ECM(-1)	-0.577093	0.079279	-7.279232	0.0000
C	17.31841	9.208462	1.880706	0.0783
L_REMUN(-1)	0.936419	0.338633	2.765292	0.0138
R-squared	0.770840	Mean dependent var		83.25000
Adjusted R-squared	0.727873	S.D. dependent var		8.913473
S.E. of regression	4.649785	Akaike info criterion		6.088376
Sum squared resid	345.9280	Schwarz criterion		6.287522
Log likelihood	-56.88376	Hannan-Quinn criter.		6.127251
F-statistic	17.94010	Durbin-Watson stat		1.275504
Prob(F-statistic)	0.000023			

Appendix K

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	0.669468	Prob. F(4,12)	0.6255
Obs*R-squared	3.101527	Prob. Chi-Square(4)	0.5410
Scaled explained SS	0.660076	Prob. Chi-Square(4)	0.9562

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 01/29/13 Time: 17:46
Sample: 1995 2011
Included observations: 17

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	58.75614	46.65736	1.259311	0.2319
ECM(-1)	0.033911	0.386324	0.087779	0.9315
L_LABPROD(-4)	-0.825666	1.027124	-0.803861	0.4371
DL_LABPROD(-5)	0.276296	0.958848	0.288154	0.7781
DL_REMUN(-2)	0.048887	0.467800	0.104505	0.9185
R-squared	0.182443	Mean dependent var		18.85397
Adjusted R-squared	-0.090076	S.D. dependent var		16.58048
S.E. of regression	17.31113	Akaike info criterion		8.780505
Sum squared resid	3596.103	Schwarz criterion		9.025568
Log likelihood	-69.63429	Hannan-Quinn criter.		8.804865
F-statistic	0.669468	Durbin-Watson stat		1.992237
Prob(F-statistic)	0.625492			

Appendix L

Appendix 2

Breusch-Godfrey Serial Correlation LM Test:				
F-statistic	1.185694	Prob. F(5,8)	0.3945	
Obs*R-squared	7.185226	Prob. Chi-Square(5)	0.2072	
Test Equation:				
Dependent Variable: RESID				
Method: Least Squares				
Date: 01/29/13 Time: 17:47				
Sample: 1995 2011				
Included observations: 17				
Presample missing value lagged residuals set to zero.				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
ECM(-1)	-0.109706	0.212190	-0.517018	0.6191
L_LABPROD(-4)	-0.046976	0.335772	-0.139905	0.8922
DL_LABPROD(-5)	-0.083040	0.423689	-0.195994	0.8495
DL_REMUN(-2)	0.096359	0.227359	0.423821	0.6829
RESID(-1)	0.685590	0.470778	1.456292	0.1834
RESID(-2)	-0.422800	0.463803	-0.911594	0.3886
RESID(-3)	0.079844	0.621753	0.128418	0.9010
RESID(-4)	-0.893775	0.722860	-1.236443	0.2514
RESID(-5)	0.076969	0.702993	0.109487	0.9155
R-squared	0.422660	Mean dependent var	0.311770	
Adjusted R-squared	-0.154679	S.D. dependent var	4.464198	
S.E. of regression	4.797049	Akaike info criterion	6.278931	
Sum squared resid	184.0935	Schwarz criterion	6.720044	
Log likelihood	-44.37091	Hannan-Quinn criter.	6.322778	
Durbin-Watson stat	1.729656			

Appendix M

Appendix M

Heteroskedasticity Test: White				
F-statistic	7.587977	Prob. F(9,10)	0.0020	
Obs*R-squared	17.44545	Prob. Chi-Square(9)	0.0422	
Scaled explained SS	15.79242	Prob. Chi-Square(9)	0.0713	
Test Equation:				
Dependent Variable: RESID^2				
Method: Least Squares				
Date: 01/29/13 Time: 16:24				
Sample: 1992 2011				
Included observations: 20				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-325.9982	337.0813	-0.967121	0.3563
DL_REMUN(-2)^2	-0.507386	0.329005	-1.542185	0.1541
DL_REMUN(-2)*ECM(-1)	-0.613939	0.200846	-3.056766	0.0121
DL_REMUN(-2)*L_REMUN(-1)	1.552984	0.639076	2.430047	0.0354
DL_REMUN(-2)	-69.99523	23.26764	-3.008264	0.0132
ECM(-1)^2	-0.028126	0.026193	-1.073778	0.3081

ECM(-1)*L_REMUN(-1)	0.590241	0.204524	2.885929	0.0162
ECM(-1)	-6.221517	5.830831	-1.067003	0.3111
L_REMUN(-1)^2	-0.994916	0.344130	-2.891107	0.0161
L_REMUN(-1)	66.84254	24.50526	2.727682	0.0213
R-squared	0.872273	Mean dependent var	17.29640	
Adjusted R-squared	0.757318	S.D. dependent var	29.84710	
S.E. of regression	14.70350	Akaike info criterion	8.520902	
Sum squared resid	2161.930	Schwarz criterion	9.018768	
Log likelihood	-75.20902	Hannan-Quinn criter.	8.618090	
F-statistic	7.587977	Durbin-Watson stat	2.096033	
Prob(F-statistic)	0.001963			

Appendix N

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	1.553396	Prob. F(5,11)	0.2517
Obs*R-squared	8.277284	Prob. Chi-Square(5)	0.1416

Test Equation:

Dependent Variable: RESID

Method: Least Squares

Date: 01/29/13 Time: 16:25

Sample: 1992 2011

Included observations: 20

Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DL_REMUN(-2)	0.296585	0.517934	0.572632	0.5784
ECM(-1)	-0.013519	0.207320	-0.065210	0.9492
C	-1.185938	23.25104	-0.051006	0.9602
L_REMUN(-1)	-0.259758	0.630720	-0.411844	0.6884
RESID(-1)	0.655123	0.534618	1.225404	0.2460
RESID(-2)	-0.698439	0.405596	-1.722006	0.1130
RESID(-3)	0.280018	0.587674	0.476486	0.6431
RESID(-4)	-0.177557	0.382649	-0.464021	0.6517
RESID(-5)	-0.232768	0.370112	-0.628911	0.5422
R-squared	0.413864	Mean dependent var	-1.88E-14	
Adjusted R-squared	-0.012416	S.D. dependent var	4.266935	
S.E. of regression	4.293344	Akaike info criterion	6.054172	
Sum squared resid	202.7608	Schwarz criterion	6.502251	
Log likelihood	-51.54172	Hannan-Quinn criter.	6.141642	
F-statistic	0.970873	Durbin-Watson stat	1.797063	
Prob(F-statistic)	0.503474			

Appendix O

Dependent Variable: L_LABPROD

Method: ML - ARCH (Marquardt) - Normal distribution

Date: 01/10/13 Time: 23:55

Sample (adjusted): 1992 2011

Included observations: 20 after adjustments

Failure to improve Likelihood after 34 iterations

Presample variance: backcast (parameter = 0.7)

GARCH = C(5) + C(6)*RESID(-1)^2 + C(7)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
DL_REMUN(-2)	-0.364668	0.156891	-2.324344	0.0201
ECM(-1)	-0.613279	0.055763	-10.99791	0.0000
C	11.65502	6.113538	1.906428	0.0566
L_REMUN(-1)	0.941560	0.165119	5.702317	0.0000
Variance Equation				
C	2.134641	6.256814	0.341171	0.7330
RESID(-1)^2	0.949345	0.838525	1.132160	0.2576
GARCH(-1)	-0.032325	0.403311	-0.080148	0.9361
R-squared	0.760306	Mean dependent var		83.25000
Adjusted R-squared	0.715364	S.D. dependent var		8.913473
S.E. of regression	4.755454	Akaike info criterion		5.564706
Sum squared resid	361.8296	Schwarz criterion		5.913212
Log likelihood	-48.64706	Hannan-Quinn criter.		5.632738
Durbin-Watson stat	1.256745			

Appendix P

Heteroskedasticity Test: ARCH				
F-statistic	0.174202	Prob. F(1,17)		0.6816
Obs*R-squared	0.192722	Prob. Chi-Square(1)		0.6607
Test Equation:				
Dependent Variable: WGT_RESID^2				
Method: Least Squares				
Date: 01/10/13 Time: 23:55				
Sample (adjusted): 1993 2011				
Included observations: 19 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.198566	0.381998	3.137627	0.0060
WGT_RESID^2(-1)	-0.100328	0.240378	-0.417375	0.6816
R-squared	0.010143	Mean dependent var		1.089894
Adjusted R-squared	-0.048084	S.D. dependent var		1.190112
S.E. of regression	1.218389	Akaike info criterion		3.332236
Sum squared resid	25.23600	Schwarz criterion		3.431651
Log likelihood	-29.65624	Hannan-Quinn criter.		3.349061
F-statistic	0.174202	Durbin-Watson stat		1.948235
Prob(F-statistic)	0.681628			