

**MODELLING AND FORECASTING STUDENT ENROLMENT WITH BOX-  
JENKINS AND HOLT-WINTERS METHODOLOGIES:  
A CASE OF NORTH WEST UNIVERSITY,  
MAFIKENG CAMPUS**

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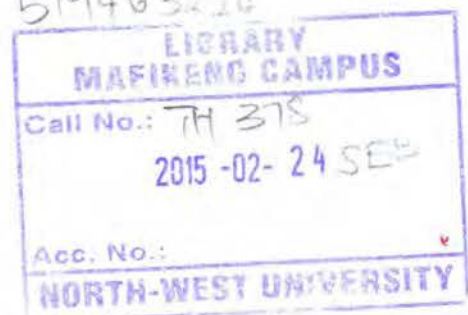
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**MINI-DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE  
REQUIREMENTS FOR THE DEGREE OF MASTERS IN STATISTICS IN THE  
FACULTY OF COMMERCE AND ADMINISTRATION AT  
THE NORTH WEST UNIVERSITY  
(MAFIKENG CAMPUS)**

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## DECLARATION

I declare that this work is a direct result of personal effort. It is **submitted in partial fulfillment** of the requirements for the Master's degree in Statistics at the North West University, Mafikeng Campus.



D.S. Sebolai

23 / 03 / 10  
Date

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## ABSTRACT

This study was aimed at modelling and forecasting student enrolment at the Mafikeng Campus of the North West University, by forecasting future values of student enrolment, using the best performing forecasting model between Box-Jenkins and Non-Seasonal Holt-Winters methodologies. Secondary data for undergraduate and postgraduate student enrolment were obtained from the Mafikeng Campus Registrar's office and Information Systems Department.

Box-Jenkins ARIMA models were chosen to compete with the Non-Seasonal Holts-Winters method in forecasting future figures of student enrolment. The log-transformed and first differenced AR(1,1),  $\Delta\hat{X}_t = \mu + \theta X_{t-1} + e_t$  was found to be the best model to forecast undergraduate future values by using the Ljung-Box Chi-square statistic, residual analysis and normality test on the residual. Similarly, the log-transformed and first differenced data for postgraduate students reflected AR (2,1) as the best forecasting model,  $\Delta\hat{X}_t = \mu + \theta X_{t-1} + \theta X_{t-2} + e_t + \phi e_{t-1}$ .

The Root Mean Square Error (RMSR)  $\frac{1}{n} \sum_{t=1}^n 100 * \frac{e_t}{y_t}$ , Mean Percentage Error  $\sqrt{\frac{1}{n} \sum_{t=1}^n e_t^2}$  and Adjusted R-Square  $R^2 = 1 - \frac{SS_E}{SS_T}$  were used to compare the Box-Jenkins method with the Non-Seasonal Holt-Winters method in forecasting future values of student enrolment.

Descriptive analysis indicated that the undergraduate student enrolment started to drop in the year 2005. The number of student enrolment decreased until 2006 and increased in 2007. According to the analysis of RMSE, MPE and R-Square, the Box-Jenkins methodology appeared to be a better technique to be used to forecast future values of student enrolment. In that regard, AR(1,1) was used to forecast future values for undergraduate

student enrolment, and AR(2,1) was used to forecast future values for postgraduate student enrolment up to 2011. The forecasts reflected that there would be a decrease in undergraduate student enrolment in the next two years. Forecasting values for postgraduate enrolment were not exceptional in this case.

The study concluded by providing recommendations to the university top management to devise mechanisms of recruiting and retaining students in the Mafikeng Campus of the North West University. Further, the campus management needs to consider some possible factors which may contribute to the increase in the student enrolment such as; increasing quality of programmes and ensuring student and staff participation during decision-makings. Finally, further research was also recommended on other possible factors which might be contributing to the decreasing numbers of student enrolment.

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## ABBREVIATIONS

The concepts/abbreviations that are used in the study are defined below:

BJ – Box-Jenkins

AR – Autocorrelation

MA – Moving average

ARMA – Autocorrelation moving average

ARIMA – Autocorrelation moving average with  $i$  representing differencing

HW – Holt-Winters method

TSA-Time Series Analysis

OLS - Ordinary Least Square

ACF – Autocorrelation function

PACF – Partial autocorrelation

NWU – North West University

## CHAPTER ONE

### ORIENTATION

#### 1.1 INTRODUCTION

The new dispensation brought with itself the compulsory requirement for certain institutions of higher learning in South Africa to be merged and ultimately become one institution. The merger requirements had with them a series of integration of some Historically Advantaged Institutions (HAIs) merge with Historically Disadvantaged (HDIs). These merged institutions were expected to lose their former identity and form integrated institution with the similar name, governed by the same policies, overseen by single council and similar qualification offered at different learning to be identical irrespective of learning site from which qualification has been obtained (Sedgwick, 2004).

Government Gazette (No. 1689. 14: 2003) states that the profile of state universities in South Africa and the realities before the mergers were that, the country had twenty-one universities and fifteen technikons making up the then institutional landscape that had very different resources, management capacity and institutional culture. All these elements had direct influence towards the institution's ability to attract new students, to retain staff, to contribute to national research outputs, to transform staff and students' profile and to compete at a national and international level (Government Gazette, No. 1689. 14: 2003).

On 1 January 2004 the former University of the North West (UNW) and the Potchefstroom University for Christian Higher Education (PU for CHE) were merged to form a new institution called the North-West University (NWU). In this merger the former Sebokeng Campus of the Vista University were incorporated. After this merger, North-West University (NWU) has been experiencing a number of problems as it continues to grow and become consolidated as a merged institution. These problems

have surfaced and are most prominently illustrated by several disruptions of academic activities that have occurred at the Mafikeng campus. This resulted in the closure of the Mafikeng campus on three occasions in 2008 alone. The Minister of Education appointed a Task Team on October 2008 to carry out an investigation with a view to finding a sustainable solution to the problems that have plagued the Mafikeng campus.

According to students (Task Team report: 2009), among other things, the campus closure was as a result of poor disciplinary measures on students, communication culture, insufficient accommodation for students, fee increment in the absence of sufficient resources and Student Representative Council (SRC) constitution.

On the other hand, campus management felt that the university's problems have been strongly influenced by external parties, in particular political parties, trade unions and business interests (Task Team report: 2009). Significantly, as per this report, management expressed a sense of desperation with these 'external' influences on the University, but seemed to have no plan or mechanism to deal with those problems.

However, the staff unions presented mostly a picture of a fractured relationship between management and themselves (Task Team report: 2009). They submitted a list of grievances and allegations they claimed was proof that there was a problem with both the campus management and the institutional management.

It is within this context that due to the controversies, tragedies, intimidation and destruction of properties which took place in the previous years, this campus might have caused students to be discouraged to continue their studies with this campus. This study is intended to come up with a forecasting model for student enrolment at Mafikeng Campus using the Box-Jenkins forecasting model and Holt-Winters' forecasting model.

## 1.2 STUDY BACKGROUND

According to Sedgwick (2004), South African government chose to merge institutions as the ultimate route for transformation strategy of the institutions of higher learning. Sedgwick (2004) indicated that the Department of Education promoted the educational policies of the government of South Africa and provided a national framework for their implementation. The government decided on which institutions should merge with which.

The Government Gazette (No 1689, November 2003) states that the Department of Education believes that the objective of the restructuring is to establish institutions that are better capable of meeting job market demands, equalizing access and sustain student growth.

### 1.2.1 MERGED INSTITUTIONS OF HIGHER LEARNING IN SOUTH AFRICA

The following are the newly formed institutions for higher learning in South Africa. According to Segwick (2004), the process was carried out in two phases where many institutions were incorporated with others with effect from the 1<sup>st</sup> January 2004 and the second phase was scheduled for January 2005.

**Table 1.1 South African Merged Universities**

<b>University of Technology</b>	
Durban Institute of Technology	M.L.Sultan Campus Steve Biko Campus
Tshwane University of Technology	Pretoria Technikon Campus Technikon North West Campus Technikon Northern Gauteng Campus
<b>Traditional University</b>	
North West University	Potchefstroom – Vaal Campus University of North West Potchefstroom University
University of Kwazulu Natal	Durban – Westville Campus Natal University-Durban Campus Natal University-Pietermaritzburg Campus
University of Limpopo	Medunsa Campus University of the North

<b>Comprehensive Universities</b>	
Nelson Mandela Metropolitan University	Port Elizabeth Technikon Campus Nelson Mandela Metropolitan University University of Port Elizabeth Campus
University of Johannesburg	Rand Afrikaans Campus Witwatersrand Technikon Campus
Walter Sisulu University for Technology & Science	Border Technikon Campus Eastern Cape Technikon Campus University of Transkei Campus

Some of these institutions which are historical universities and technikons, had satellite campuses, where some were at the areas closer to the main campuses. However, some of the institutions, especially those from historically disadvantaged institutions shut down their satellite campuses since the merger process had begun without necessarily justifying the decline or discontinued need of the type of service they were providing. The former experience is contrary to the later, where historically disadvantaged institutions did not only retain their satellite campuses. Those satellite campuses were instead strengthened and given all the support needed, yet all these institutions affected by the merger requirement were expected to come and merge as equal partners. Much of that change which had to take place can be described as radical change.

The Government Gazette (No. 1689. 14 November 2003) reports that, this merger was aimed at achieving the following strategic goals as per:

- overcoming the apartheid-induced divide between historically white and historically black institutions,
- promoting a more equitable staff and student body,
- enabling the development and provision of a wider and more comprehensive range of vocational, in particular technikon-type, professional and general programmes in line with regional and national needs,

- building administrative, management governance and academic capacity,
- consolidating the deployment and use of academic personnel,
- building research capacity; and
- enhancing sustainability through increased size.

In addition to the above, Sedgwick (2004) stated that the new South African government came to the conclusion of compelling these institutions of higher learning to merge. He indicated that, this was because the inherited disparity system of higher education, which was characterized by injustices, inequalities, imbalances, and privileged as a result of racial and gender-biased policies, structures and segregation practices. Essentially, the ultimate desire for the merger was to empower and strengthen the historically disadvantaged institutions.

### **1.3 STATEMENT OF THE PROBLEM**

According to Jansen (2003), any negative impact on students of high institutions of learning will impact negatively on the institutional recruitment rate. This is supported by Wan (2008:47-48), who argues that the long-term success of the newly merged institution is dependent on shared identity that is recruitment practice, admission criteria, cultural practices, racial climate and presence of an ethnic community.

Merged institutions in South Africa are experiencing campus disruptions to academic activities, violence, intimidation and destruction to properties. This practice seems to be increasing in many merged institutions in South Africa as is normally shown on the media coverages. North West University (Mafikeng Campus) is not exceptional. The decreasing number of student enrolment might be an indication that many people from the society might start losing hope and getting discouraged about the operations

after the merger at the Mafikeng Campus. The descending number of student enrolment on this campus is evidenced by the enrolment of this year 2009 (7,212), which is less than the presiding year of 2008, which was 8,385.

This study focuses on predicting student enrolment on Mafikeng Campus by identifying the accurate and performing forecasting method between Box-Jenkins method and Holt-Winters method.

#### **1.4 AIM OF THE STUDY**

The aim of this study was to model and forecast the future student enrolment at Mafikeng Campus of the North West University.

#### **1.5 RESEARCH OBJECTIVES**

The specify objectives of this study are;

- 1.5.1 to model student enrolment at the Mafikeng Campus of the North West University,
- 1.5.2 to forecast student enrolment at Mafikeng Campus of the North West University,
- 1.5.3 to select a better forecasting model between Box-Jenkins and Holts-Winters.

#### **1.6 RATIONALE OF THE STUDY**

The purpose of this study was to forecast the future student enrolment figures for Mafikeng Campus. The stakeholders of the University including authorities should know about the future enrolment figures, in order to make informed decisions and plan accordingly.

## **1.7 IMPORTANCE OF THE STUDY**

The research will contribute to the body of knowledge on the topic in various ways. This study might make the university authority aware of the problem dwindling of number of student enrolment which will help them to make informed managerial decisions for planning for the future.

## **1.8 SCOPE OF THE STUDY**

This study was done at the Mafikeng Campus of the North West University. The results therefore, cannot be generalized to student enrolment at all other campuses of the North West University and other universities of South Africa.

## **1.9 PLAN OF THE STUDY**

**Chapter 1** Orientation of the study which includes the background of the study, aim and objectives, importance, scope and plan of the study.

**Chapter 2** Literature Review

**Chapter 3** Box-Jenkins forecasting method and Holt-Winters' forecasting method

**Chapter 4** Presentations of results and analysis

**Chapter 5** Discussion, Concludes and recommendations

## **1.10 CONCLUSION**

This chapter provided the introduction of the study. It further included the statement of the problem, aim and objectives, importance of the study e.t.c. The next chapter focuses on the literature review.

## **CHAPTER TWO**

### **LITERATURE REVIEW**

#### **2.1 INTRODUCTION**

This chapter presents some literature review on the variable of interest. It further presents application of merger at corporate industry and examines its impact in institutions of higher learning. Benchmarking is then examined by looking at the challenges faced by students at institutions of higher learning, as well as challenges faced by the North West University (Mafikeng Campus) students and university's efforts for student's development and financial support. This study further motivated by the closure of former satellite campus of North West University called Mankwe Campus as a result of insufficient and constant decreasing number of student enrolment.

#### **2.2 STUDY CONTEXT**

While there is a small but growing literature on the merger of institutions of higher learning in South Africa, very little research has been focused on the impact of merger on internal and external forces. When referring to the highlight of the challenges facing pre-merger and post-merger operating performance, some researchers provided some ideas on the post-merger integration process. Eastman & Lang (2001) for example, indicate some of the outcomes of merger, such as; program integration, the achievements of phased development goals and the use efficiency of resources; conducting the effectiveness and efficiency analysis and the incentive, coordinative evaluation etc. When taking a panoramic view of these studies, it is found that very few studies focused on the area of the impact of merger on student enrolment in institutions of higher learning in South Africa. The purpose of this chapter is to investigate and to review the degree and pattern of student unrest, disruptions and tragedies and student enrolment in universities as a result of merger. This chapter mainly, tends to provide an overview, by way of benchmarking with the key topics,

arguments, findings on student governance, campuses unrest and student enrolment in universities as a result of merger.

### **2.3 LITERATURE REVIEW**

There is a small but substantial literature on the pre-merger planning, the post-merger integration process, and the outcomes of the merger. The planning and implementation of the merger is largely a top-down process and subject to political intervention. Most of the literature on mergers stresses that merger denotes radical institutional changes. Many have described these changes as drastic and dramatic. Not only are the governing systems of the institutions affected, but the 'souls' of the partners involved are also affected. Merger is by all means a complex process. The tensions in the dynamics of this process also center on factors associated with change in any organization. Although each merger can be seen as a unique arrangement between the institutions involved, there are some common issues and concerns that have emerged in all merger processes. Some major concerns identified in the literature include management and leadership, the reaction and resistance of staff, communication, the financial implications, concerns about institutional identity and reputation, and the difficulties in merging diverse cultures.

However, Jansen (2004: 7) states that "a merger can be deemed as successful if, among other things, it creates new institutions with new identities and cultures that transcend their past racial and ethnic institutional histories and contributes to their deracialisation". In the same light, Skodvin (1999) argues that merger outcomes could be interpreted as a product of the interaction between governmental macro politics (what government does) and institutional micro politics (how institutions respond) within specific institutional contexts. This suggest that it cannot be predicted that the outcomes of mergers are based on the existence of a common merger planning script, but the outcomes could be quite divergent depending on the kinds of politics resident in a particular merger context.

### **2.3.1 POST-MERGER INTEGRATION STRATEGIES**

Locke (2007) stated that communication, consultation, effective leadership and management are important after the merger. This view is supported by Kleiner (2003) who advanced that the solution to post-merger integration is dependent on directors been visible, not confined to their offices; setting direction for the new business, understanding the cultural, emotional and political issues pertaining to the change, providing clarity around roles and decision lines, continue to focus on customers and flexibility.

### **2.3.2 NORTH WEST UNIVERSITY AS A MERGED INSTITUTION**

The North West University consists of three campuses; Potchefstroom campus, Mafikeng campus and the Vaal Triangle campus, spread over a geographic distance of over 330 km. The three campuses differ not only in terms of their history, but also in other important dimensions such as the numbers of enrolled students, the diversity of academic programmes, their language policies and their institutional practices.

However, Mafikeng Campus has been experiencing problems which were most prominently illustrated by several disruptions of academic activities that occurred at the campus ever since the merger. This resulted in the closure of the campus on a frequent basis. The Minister of Education observed that the North-West University (NWU) had been experiencing a number of problems as it continued to grow and become consolidated as a merged institution. The campus unrest was normally caused by Student Representative Bodies. The minister eventually appointed a Task Team to carry out an investigation with a view to finding a sustainable solution to the problems that have plagued the Mafikeng campus in particular, but critically with a view to locating these problems within a holistic institutional context. According to the Task Team report (2009), the other main purpose of the Task Team was to identify the cause of the ongoing problems at Mafikeng campus, to propose solutions thereto and to

evaluate the extent to which the North West University had achieved the intended objectives of the merger and the processes it had followed towards this end.

The Task Team report (2009) revealed that The Mafikeng campus in 2007 had a student population of 8,702, comprising 7,891 undergraduate, 662 master's, and 149 doctoral students. The overall enrolment figure included 1,400 students who were enrolled in distance programmes. The campus has five faculties: Agriculture, Science and Technology; Human and Social Sciences; Education; Commerce and Administration and Law (Task Team report, 2009).

The report further indicated that in 2007 the campus conferred a total of 1,176 certificates and diplomas, 926 bachelor's degrees, 208 honours degrees, 62 master's degrees and 5 doctorates. The highest proportion (1,275) of the graduates was from the Faculty of Education, followed by the Faculty of Commerce and Administration (462). The Mafikeng campus has the lowest research productivity of the three campuses. In 2007 it generated a total of 10.08 research article equivalents, compared to 13.03 in 2006, with more than 50% of these outputs being from the Faculty of Agriculture, Science and Technology (Task Team report, 2009).

### **2.3.2.1 STUDENT ADMISSION AND SUPPORT (MAFIKENG CAMPUS)**

#### **i. Admission into the programmes**

Mafikeng Campus offers a number of undergraduate and graduate programmes in a mixed-mode format for working people within five faculties. The minimum requirements for admission as a new student are;

- students with matriculation exemption but without a sufficiently satisfactory pass for admission to degree programmes. This are students who would wish to study science, engineering or medicine but do not have satisfactory passes in Mathematics and Science,

- students with a senior certificate but without matriculation exemption and who show potential to succeed in higher education – these are students who are generally be placed in one-year foundation or access programmes which would lead to access to degree programmes,
- adult learners without senior certificates – These are people who did not had the opportunity to complete their schooling but demonstrate a satisfactory level of numeracy and literacy.

## **ii. Student support**

The Mafikeng campus Student Representative Council (SRC) is also present at all levels of student governance to represent the students. The campus has also been seen to encourage integration in sports in general. There is a campus residence which was officially opened in 1984, with house committees and student residential committees responsible for students' needs.

## **iii. Student development**

There is a student development office located in the Division of Student Services who is responsible for the conceptualization, implementation and quality assurance of all student development programmes offered by the division. These include Student Counselling and Careers, Campus Health Clinics, Residences, Student Leadership Development, Sport, Administration, Student Governance, Clubs and Societies, Student Academics Affairs and Financial Aid. There is a huge effort in attempting to support students in this regard. Student Development is aimed to address development needs for all students at the university through professional services of the division. The task of student service providers in the various sections is to set up structures that will provide opportunities for life skills learning in curricular and co-curricular activities.

#### **iv. Financial support**

The establishment of the NSFAS by the new democratic government is one of the most important initiatives that underpin the transformation of educational access in South Africa. The government's visionary thinking regarding the NSFAS and continued support of these endeavours should be applauded. The appearance of the delegation from the committee charged with consultation with all stakeholders indicates the dedication to the cause of educational justice for all in the new democratic South.

Incentives to encourage institutional success in improving the progression and graduation of students from disadvantaged backgrounds are provided on a performance basis through earmarked funding. This approach is consistent with the maintenance of a simple and transparent funding system. Implementation of the National Student Financial Aid Scheme (NSFAS), to ensure that access by the poorest of the poor to higher education is maintained and improved. The committee concerned has regular meetings to focus on the implementation of the criteria developed for allocation of funds and the assessment of appeals from student applications on matters related to the allocations of NSFAS funds. Students are always engaged and are therefore involved in all committees in the institution and participate fully in them.

Key elements in the selection of students are academic ability or potential for financial need. These elements are guided by an NSFAS policy document. According to the NSFAS guidelines, students are expected to pass at least 50% of their courses in order to qualify for funds. Students are also allowed to stay one year longer than the prescribed minimum duration to qualify. Financial need is broadly based on the income of the household and the number of dependants. Students or their families are generally expected to contribute towards their study costs, with the poorest making the smallest or no contribution at all. During the registration process, a student must pay a certain minimum amount upfront, and only registered students are allocated funds from the scheme (Kiran: 2000), "from Unibo to Uniwest: a critical overview of transformation at the University of the Northwest," Academic Worker.

Mafikeng Campus has always been involved with the needs of poor students. Prior to the early days of transformation from 1994, the bursaries and scholarship office administered a means test to award the few bursaries from various sources at its disposal (e.g. bequests, deceased estates). According to the University annual report (2001), in 1988 bursaries and scholarship office received 5 000 applications a year from needy students. The university responded by allocating funds from its limited budget (about R13 million in 2001) to the annual budget of the newly constituted Financial Aid Service. This was supplemented during the early 1990s by organisations such as Kagiso Trust, the IDT (Independent Development Trust), the South African Institute of Race Relations (SAIRR) and the Kellogg's Foundation. By 1996 they had to limit the intake of needy entrants to 500 per year in order to manage the budgetary requirements responsibly. The number of active financial aid applications settled at about 3 500 per year. They are currently funding about 2 000 undergraduates. About 13% of the student body is deemed sufficiently financially disadvantaged to receive benefits from the NSFAS. Therefore, there is immense pressure on the university to increase funding for needy entrants.

However, according to Task Team report (2009), the university management indicated that the students at Mafikeng campus receive more tuition than their counterparts at Potchefstroom, as these students generally need much more academic support on account of their background. The University claims to have improved its management of financial aid, including most importantly the NSFAS funds.

#### **2.4 CHALLENGES FACED BY NORTH-WEST UNIVERSITY (MAFIKENG CAMPUS)**

Ever since the implementation of the merger in 2004, Mafikeng Campus has encountered unrest episodes. Recently, last year they barricaded the entrance, burning tires and throwing stones to any stakeholder attempting to enter into the university premises. The police were called in and some of the security officers and students were

injured. In totality, this presented a historical outline of student unrest at this campus over a period of nearly four years.

#### **2.4.1 DISRUPTIONS AND TRAGEDY**

Ojo (1995: 250) stated that in response to violent student protests, a university management or government often chooses to call police to interfere; a response that often results in bloodshed and the loss of student lives. Yet, the violent repression of student activism is often a factor in "increasing both the size and the militancy" of activist movements (Ojo, 1995).

At the midst of the tragedy and disruption at Mafikeng Campus in the year 2008, the campus management, rather than listening to the grievances of the students, invited the police to disperse the protesting students. The arrival of the police aggravated the crisis in the ensuing battle, where some students were harmed through police gunshot and tear-gas. The students barricaded the university main gate, chanting their songs and condemning the university management. The chain of protests led to the closure of the University for almost a month. The armed force (police) invaded the campus to drive out students from their residences. The police lack adequate understanding of the significance of protests in crisis management. The confrontations between students and police force caused great damage of university property and a large number of students were wounded and raped. To the students, protest is an inalienable right. It is a way of expressing their grievances to the appropriate authorities.

Be that as it may, it is pertinent to observe that the condition under which an average policeman reacts during a student crisis is a contributory factor to their high handedness during students' demonstration. However, Sampson (1999) observed that students who are seen as an enlightened group and being objects of oppression perceive the police as a visible instrument of oppression.

#### **2.4.2 STUDENTS CRISES AFTER MERGER**

Contrary to experiences in China, regular teaching and studies were often, more or less dramatically, disrupted and universities were from time to time closed for weeks, months and even years. Student unrest has been endemic. The continuous unrest was due to students' dissatisfaction with newly introduced educational policies after the merger. Before the merger, only mature students were admitted into the few existing tertiary institutions. Although, they paid minimal fees, their clothes, including beddings were laundered at government expense.

When reference is made to student participation in university governance, it is hardly ever done so under the rubric of student politics. More often than not, the notions of student politics, student activism and student protest are conflated. According to the Task Team report (2009), Mafikeng Campus Students Representative Council indicated that the disruption was because of communication culture, lack of accommodation for students, higher tuition than their counterparts at Potchefstroom (fee increments), poor service delivery, lack of consultation during decision-making and application of disciplinary procedure. Besides the mentioned complaints from students, there were many types of frustrations and undercurrents of unease which influenced student propensity to disrupt university teaching such as victimisation and nepotism by the campus management as reflected in the Task Team report (2009).

maintenance and provision of new ones as well as communication gap over the ban on students unions are also causes of student's unrest. Emphasizing further on psychological factor as a cause of students' crises, Tamuno (2001) stated that the three key factors of leadership, time and circumstances may explain the differences in the cause and consequences of student actorism. Like Akinboye (2000), he categorized students into more mature group as well as active and passive groups. He reasoned that this classification helps in knowing the students' leaders and followers.

However, Altbauch and Lauter (1999) shed some light on identifying factors of students' crises as the degeneracy of the educational system and infrastructural facilities. Adegoke (2003) asserted that student unrest is related to lack of academic freedom, nonparticipation of students in institution's administration and the political situation of the country. He opined that most of the crises are sparked off by unpleasant government policies and procedures, as well as the high handedness of the administrators.

But unlike the other authors, Adegoke (2003) concluded by stating that academic freedom and racial discrimination are sources of student unrest in institutions of higher learning's, while political economic factors are sources of student unrest especially in Africa. Still on the political causes of students' crises, Donald (2001) stated that African students are more sensitive to political and economic matters in their countries. He stressed further that because of their contribution to political development through agitation and military force, government had to make certain political decisions in their respective countries. This view is equally shared by Adegoke (2003), who stated that African students have helped in reshaping the political pattern of their countries. Explaining further on this, Sampson (1999) stated that students have exercised considerable influence on political decisions.

While Babatope agrees with Nwala (2002) those students' who are revolutionary exploits are a necessity for a radical change and a resolve of political and economic problems, whilst Brender (2003) holds a different view and condemns students' militancy as unnecessary and counter-productive. It is clear from the comments and findings of these aforementioned authors that a multiplicity of factors can be said to account for student's unrest, irrespective of merger.

However, Nora (2001) in conjunction with Honnold (2004) identified the interacting influences on student enrolment being tuition fees, financial aid policies and students' socio-economic status. Brender (2003) stated that students who are more economically advantaged possess "tuition elasticity close to unity", meaning "a 1% increase in tuition will lead to about a 1% decrease in enrolment yield." Likewise, Honnold (2004) examine tuition, income, financial aids and unemployment as factors which may affect enrolment. These researchers further found that tuition and accommodation costs have a greater negative effect on enrolment for more economically disadvantaged students, while grants and loans have a stronger positive effect too. In the private university they studied, enrolment increased despite increases to tuition.

Also, Stater (2004) observed that student debt deters enrolment of poorer student's more than advantaged students. However, Chaikind (2003) asserted that "students with debts are significantly less likely to apply to graduate or first professional schools than their peers who did not have educational debts". This suggests that students who can most afford university education do not seem to make enrolment decisions based on tuition costs. In addition to this idea, Honnold (2004) stated that tuition fee, room and board cost show a greater negative effect on enrolment for more economically disadvantaged students, while grants and loans have a stronger positive effects. Likewise, Chaikind (2003) examined tuition, income, financial aid and unemployment as factors which may affect enrolment.

During the year 2008, the Mafikeng Campus Management claimed to have negotiated tuition fees for 2008 with the SRC in the latter half of 2007 as according to the Task Team report (2009). In spite of this agreement, the report indicated that some students approached management in early 2008 seeking to renegotiate the same fees. When management did not grant the request, these students initiated a class boycott which was accompanied by some acts of violence and damage to university property. Following these events, some students were charged for breaching the university code of conduct. The outcome of the disciplinary hearings was that some students were suspended while others were expelled from the university (Task Team report, 2009). This outcome in turn sparked a new round of student protests. In turn, the management and the SRC had previously already had to seek the intervention of a court of law to settle a dispute about the validity of the SRC constitution. Although according to the Task Team report (2009), the management felt that the university's problems have been strongly influenced by external politics, trade unions and business interests.

These differences between the students and campus management drew attention of the public, government and private sector through news papers, radios and televisions. This might have painted an ugly picture to the society and discouraged many parents within the society, not to register their children for higher education in Mafikeng Campus, of the North West University.

Although in principle, there might be other contributory factors leading to the decreasing numbers of student enrolment in Mafikeng Campus, not necessarily as a result of merger, factors such as; lack of facilities (laboratories, lectures, lecture halls), limited number of faculties (no faculty of engineering and medication), no variety of bursaries/sponsorship, academic standard and socio-economic status might also be causing the decline.

Be that as it may, the Mafikeng Campus has ever since its inception in 1980, been a predominantly black institution. This campus has not been successful in attracting white students, despite statewide implementation of the merger process. Even after institutions of higher learning had been merged, enrolment at historically black institutions continues to drop as black students have greater access to other educational institutions settings. The merger seems not to be addressing this problem at all.

## **2.5 CONCLUSION**

It is very clear from the literature that issues, which have over the years resulted in student unrest in institutions of higher learning including Mafikeng Campus as a result of merger implications, might have had clear consistence overtime. For example, students' life issues such as, student's involvement in the decision-making process especially in matters affecting students, poor communication and the impact of discipline system of students. Other issues have been police force during boycott actions, absence of welfare amenities, such as, residential facilities for a sizeable number of students, academic fees, etc; have constantly been issues that have largely dominated student protest actions.

The next chapter focuses on the time series forecasting methods, Box-Jenkins method and Holt-Winters method.

## CHAPTER THREE

### BOX-JENKINS FORECASTING AND HOLT-WINTERS FORECASTING METHODOLOGIES

#### 3.1 INTRODUCTION

This chapter discusses Box-Jenkins forecasting models and Holt-Winters forecasting model as some of time series forecasting methods. In this study, performance of the Box-Jenkins method is compared with that of Holt-Winters method in forecasting time series data of students' enrolment of North West University (Mafikeng Campus).

The Box-Jenkins method is one of the most widely used time series forecasting methods in practice (Makridakins *et al*, 1998). It is also one of the most popular models in traditional time series forecasting. It is often used as a benchmark model for comparison with other forecasting method.

This comparative approach is carried out to investigate the forecasting accuracy of Box-Jenkins methodology and Holt-Winters methodology, which are among those forecasting models most successfully applied in practice.

#### 3.2 BOX-JENKINS MODELS

##### Introduction

According to Makridakins *et al* (1998), Box-Jenkins methodology is based on statistical concepts and principles. The methodology can be used to model a wide spectrum of time series behavior. It has a large class of models to choose from and a systematic approach for identifying the correct model form. There are statistical tests for verifying model validity and statistical measures of forecast uncertainty. A preliminary Box-Jenkins analysis with a plot of the initial data should be run as the starting point in determining an appropriate model. The input data must be adjusted to form a

stationary series, that is, one whose values vary more or less uniformly about a fixed level over time (Makridakins *et al*, 1998). Apparent trends can be adjusted by applying a technique of "regular differencing," a process of computing the difference between every two successive values and computing a differenced series which has overall trend behavior removed. If a single differencing does not achieve stationarity, it may be repeated, although rarely, if ever, are more than two regular differencing required. Where irregularities in the differenced series continue to be displayed, log or inverse functions can be employed to stabilize the series, such that the remaining residual plot displays values approaching zero and without any pattern.

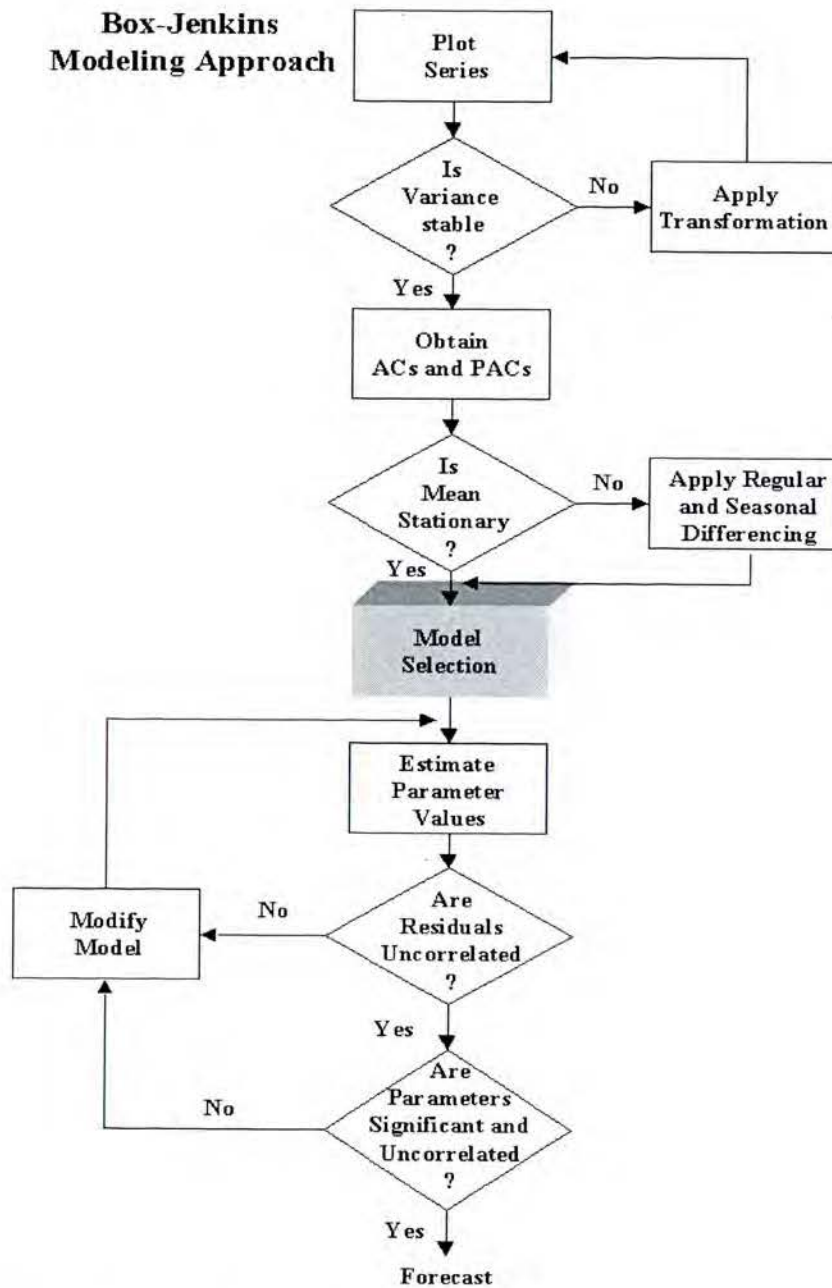
The Box-Jenkins methodology as stated by Brockwell & Davis (2002) is divided into four headings, namely;

- Model identification
- Estimation of parameters
- Diagnostic checking
- Forecasting

The start of any time series forecasting analysis is to graph sequence plots of the time series point to be forecasted (see figure 3.1). A sequence plot is a graph of the data series values, usually on the vertical axis, against time usually on the horizontal axis. The purpose of the sequence plot is to give the analyst a visual impression of the nature of the time series (Brockwell & Davis, 2002). This visual impression should suggest to the analyst whether there are certain behavioural "components" present within the time series.



Figure 3.1 Box-Jenkins Modeling Approach



Source: Brockwell & Davis: 2002

### 3.2.2 Model identification

Model identification involves transformations and differencing. Logarithmic transformation of the data can help to stabilize the variance in a series where the variation changes with the level (Brockwell & Davis: 2002). Then the data are differenced until there are no obvious patterns such as trend or seasonality left in the data. Stationarity can be assessed from a run sequence plot indicated in the Box Jenkins model approach. The sequence plot should show constant location and scale.

Brockwell & Davis (2002) mentioned that the variance of the errors of the underlying model must be invariant, i.e., constant. This means that the variance for each subgroup of data should be the same and must not depend on the level or the point in time. If this is violated then one can remedy this by stabilizing the variance.

#### *Logarithmic Transformation*

This transformation is appropriate if the variance of the original series is proportional to the mean, so that the *percent* fluctuations are constant through time. The new series,  $w_t$ , which is the first differences of the natural logarithms of the original series are of the form:

$$w_t = (1 - B)(\ln z_t) \dots\dots\dots 3.1$$

Then the series  $w_t$  can be modeled using the standard Box-Jenkins method. However Jenkins (1979) states that, the real interest may be in forecasting the original series  $z_t$ , not the natural logarithms of  $z_t$  by merely finding the antilogarithms of forecasts of the logged series.

It is a belief of Brockwell & Davis (2002) that, there should be no level or step shifts; also, no seasonal pulses should be present. The reason for this is that if they do exist, then the sample autocorrelation and partial autocorrelation will seem to imply ARIMA

structure. Also, the presence of these kinds of model components can obfuscate or hide the underlying structure, for example, a single outlier or pulse can create an effect where the structure is masked by the outlier.

Naylor *et al* (1983) asserted that stationarity can also be detected from an autocorrelation plot. Specifically, non-stationarity is often indicated by an autocorrelation plot with very slow decay. Seasonality (or periodicity) can usually be assessed from an autocorrelation plot, a seasonal subseries plot, or a spectral plot. Box-Jenkins models can be extended to include seasonal autoregressive and seasonal moving average terms (Naylor *et al*, 1983).

**i. The AR( $p$ ) process**

Naylor *et al* (1983) stated that most time series consist of elements that are serially dependent, such that one can estimate a coefficient or a set of coefficients that describe consecutive elements of the series from specific, time-lagged elements. This can be summarized as follows:

A  $p$ th-order difference equation is an AR( $p$ ) process:

$$X_t = \alpha_0 + \sum_{i=1}^p \alpha_i X_{t-i} + e_t \dots\dots\dots 3.2$$

Specifically, for an AR( $p$ ) process, the sample autocorrelation function should have an exponentially decreasing appearance. However, Pankratz (1983) observed that higher-orders of AR processes are often a mixture of exponentially decreasing and damped sinusoidal components. In this case, the partial autocorrelation of an AR( $p$ ) process becomes zero at lag  $p + 1$  and greater.

$$(1 - \phi_1 B - \phi_2 B^2 - \dots - \phi_p B^p) X_t = e_t \dots\dots\dots 3.3$$

$$X_t - \phi_1 X_{t-1} - \phi_2 X_{t-2} - \dots - \phi_p X_{t-p} = e_t$$

$$F_t = \sum_{i=1}^p \phi_i X_{t-i} \dots\dots\dots 3.4$$

where  $X_t$  is a stationary time series,  $e_t$  is a white noise error component, and  $F_t$  is the forecasting function.

For example, by letting  $p = 1$ ,

*The AR(1) process will be defined as;*

$$(1 - \phi_1 B)X_t = e_t$$

$$X_t - \phi_1 X_{t-1} = e_t$$

$$X_t - e_t = \phi_1 X_{t-1}$$

$$F_t = \phi_1 X_{t-1} \dots\dots\dots 3.5$$

When  $\rho_k = \phi_1^k$ , for  $k \geq 1$  dies down in a damped exponential fashion

By letting  $p = 2$ , then

*The AR(2) process*

$$(1 - \phi_1 B - \phi_2 B^2)X_t = e_t$$

$$X_t - \phi_1 X_{t-1} - \phi_2 X_{t-2} = e_t$$

$$X_t - e_t = \phi_1 X_{t-1} + \phi_2 X_{t-2}$$

$$F_t = \phi_1 X_{t-1} + \phi_2 X_{t-2} \dots\dots\dots 3.6$$

$$\rho_1 = \frac{\phi_1}{1 - \phi_2}$$

$$\rho_2 = \frac{\phi_1^2}{1 - \phi_2} + \phi_2$$

⋮

$$\rho_k = \phi_1 \rho_{k-1} + \phi_2 \rho_{k-2} \quad \text{for } k \geq 3 \text{ dies down according to a mixture of damped exponentials}$$

## ii. The MA (q) Process

The autocorrelation function of a MA(q) process becomes zero at lag  $q + 1$  and greater. Beran (1994) states that independent from the autoregressive process, each element in the series can also be affected by the past error (or random shock) that cannot be accounted for by the autoregressive component, that is:

The MA (q) process is defined by:

$$X_t = (1 - \theta_1 B - \theta_2 B^2 - \dots - \theta_q B^q) e_t$$

$$X_t - e_t = -\theta_1 e_{t-1} - \theta_2 e_{t-2} - \dots - \theta_q e_{t-q}$$

$$F_t = -\sum_{i=1}^q \theta_i e_{t-i} \dots \dots \dots 3.7$$

where  $X_t$  is a stationary time series,  $e_t$  is a white noise error component, and  $F_t$  is the forecasting function.

By letting  $q = 1$ ,

The MA(1) process is defined by

$$X_t = e_t - \theta_1 e_{t-1} \dots \dots \dots 3.8$$

$$X_t = (1 - \theta_1 B)e_t$$

$$X_t - e_t = -\theta_1 e_{t-1}$$

$$F_t = -\theta_1 e_{t-1} \dots \dots \dots 3.9$$

dies down in a fashion dominated by damped exponential decay

$$\rho_1 = \frac{-\theta_1}{1 + \theta_1^2}$$

⋮

$$\rho_k = 0 \quad \text{for } k > 1, \text{ cutting off after lag } 1$$

Then, by letting  $q = 2$

The MA(2) process will be defined as;

$$X_t = e_t - \theta_1 e_{t-1} - \theta_2 e_{t-2}$$

$$X_t = (1 - \theta_1 B - \theta_2 B^2)e_t$$

$$X_t - e_t = -\theta_1 e_{t-1} - \theta_2 e_{t-2}$$

$$F_t = -\sum_{i=1}^2 \theta_i e_{t-i} \dots \dots \dots 3.10$$

dies down according to a nature of damped exponential or damped sine wave.

$$\rho_1 = \frac{-\theta_1(1 - \theta_1)}{1 + \theta_1^2 + \theta_2^2}$$

$$\rho_2 = \frac{-\theta_2}{1 + \theta_1^2 + \theta_2^2}$$

⋮

$$\rho_k = 0 \quad \text{for } k > 2$$

### iii. The mixed model of ARMA (p, q) process

The Box-Jenkins ARMA model is a combination of the AR(p) and MA(q) models

$$X_t = \phi_1 X_{t-1} + \phi_2 X_{t-2} + \dots + \phi_p X_{t-p} + \varepsilon_t - \theta_1 \varepsilon_{t-1} - \theta_2 \varepsilon_{t-2} - \dots - \theta_q \varepsilon_{t-q}$$

$$(1 - \phi_1 B - \phi_2 B^2 - \dots - \phi_p B^p) X_t = (1 - \theta_1 B - \theta_2 B^2 - \dots - \theta_q B^q) \varepsilon_t$$

$$\phi_p(B) X_t = \theta_q(B) \varepsilon_t \dots \dots \dots 3.11$$

where the terms in the equation have the same meaning as given for the AR and MA model. Combining a moving average process with a linear difference equation generates an autoregressive-moving average model (Pankratz, 1983). This is referred to as the ARMA (p, q) model.

The ARMA (p, q) model is then;

$$X_t = \alpha_0 + \sum_{i=1}^p \alpha_i X_{t-i} + \sum_{i=0}^q \beta_i \varepsilon_{t-i} \dots \dots \dots 3.12$$

The objective of Box-Jenkins analysis is to determine the order of p and q, estimate the model and use the estimated model to forecast the series.

The equation of ARMA (p, q) model for  $X_t$  can be summarized as;

$$\left(1 - \sum_{i=1}^p \alpha_i L^i\right) X_t = \alpha_0 + \sum_{i=0}^q \beta_i \varepsilon_{t-i} \dots\dots\dots 3.13$$

$$X_t = \frac{\alpha_0 + \sum_{i=0}^q \beta_i \varepsilon_{t-i}}{\left(1 - \sum_{i=1}^p \alpha_i L^i\right)} \dots\dots\dots 3.14$$

This is the moving-average representation of  $X$  as indicated by Wiley & Son (1983).

By letting  $p$  and  $q = 1$

By assigning  $p$  and  $q$  to 1: ARMA (1, 1) becomes:

$$X_t = \phi_1 X_{t-1} + \varepsilon_t - \theta_1 \varepsilon_{t-1} \dots\dots\dots 3.15$$

$$X_t(1 - \phi_1 B) = \varepsilon_t(1 - \theta_1 B)$$

$$\rho_1 = \frac{(1 - \phi_1 \theta_1)(\phi_1 - \theta_1)}{(1 + \theta_1 - 2\theta_1 \phi_1)}$$

⋮

$$\rho_k = \phi_1 \rho^{k-1} \quad \text{for } k > 2 \dots\dots\dots 3.16$$

#### iv. ARIMA Process

The process is characterized by the values of  $p$ ,  $d$ , and  $q$ , it is called the integrated an Autoregressive Integrated Moving Average (ARIMA ( $p,d,q$ )) process (Pankratz, 1983).

For example ARIMA (2, 0, 0) process will simply be AR(2). An ARIMA (0, 0, 2) process will be an MA (2) and ARIMA (1, 0, 1) will be an ARMA (1, 1).

**v. Trend-stationary time series**

Box-Jenkins recommended the differencing approach to achieve stationarity as illustrated in Box-Jenkins model approach above. However, Dickey & Pantula (1987) argued that fitting a curve and subtracting the fitted values from the original data can also be used in the context of Box-Jenkins models. According to Dickey & Pantula

(1987), estimators of the unknown parameters are derived or defined and evaluated with respect to their means and variances. The variance of an estimator is a measure of its precision.

consider model;

$$Z_t = \mu_t + X_t \quad \text{with} \quad E(X_t) = 0 \dots\dots\dots 3.17$$

Examples – are :

1.  $\mu_t = \mu$
2.  $\mu_t = \beta_0 + \beta_1 t$
3.  $\mu_t = \beta_0 + \beta_1 t + \beta_2 t^2$
4.  $\mu_t = e^{\beta t}$
5.  $\mu_t = \begin{cases} \beta_1, & t = 1, 13, 25, \dots \\ \beta_2, & t = 2, 14, 26, \dots \\ \vdots \\ \beta_{12}, & t = 12, 24, 36, \dots \end{cases} \dots\dots\dots 3.18$
6.  $\mu_t = \beta \cos(2\pi ft + \phi) \dots\dots\dots 3.19$

Assumptions are:

$$E(X_t) = 0 \quad \text{for all } t$$

$\mu_t$  does not depend on the random variable

$E(Z_t) = E(\mu_t + X_t) = \mu_t$ .....	3.20
$Cov(Z_t, Z_s) = Cov(X_t, X_s)$ .....	3.21
$Var(Z_t) = Var(X_t)$ .....	3.22

## vi. Tests of stationarities

### Unit Root Tests

Phillips and Perron (1988) mentions three widely used tests of unit root tests: the Dickey-Fuller (DF), augmented Dickey-Fuller (ADF) and the Phillips-Perron (PP) test.

### The Augmented Dickey-Fuller (ADF) Test

To illustrate the use of Dickey-Fuller tests, consider first an AR(1) process.

$X_t = \rho X_{t-1} + e_t$ ,  $\{X_t\}$  is stationary if  $-1 < \rho < 1$ . If  $\rho = 1$ ,  $\{X_t\}$  is a non-stationary series (a random walk). If the process started at some point, the variance of  $\{X_t\}$  increases steadily with time and goes to infinity. If  $|\rho| > 1$ , the series is explosive (Brockwell & Davis, 2002). Therefore, the hypothesis of a stationary series can be evaluated by testing whether  $|\rho| > 1$ . The null hypothesis for both the DF and the PP tests is

$H_0 : \rho = 1$  against the alternative  $H_1 : \rho < 1$ . According to Brockwell & Davis (2002), the alternative  $\rho > 1$  does not make much economic sense and is not tested.

The test is carried out by estimating an equation with  $\{X_{t-1}\}$  subtracted from both sides of the equation:

$$X_t - X_{t-1} = \rho X_{t-1} - X_{t-1} + e_t$$

$$\Delta X_t = (\rho - 1)X_{t-1} + e_t$$

The null and alternative hypotheses are  $H_0 : \rho - 1 = 0$  and  $H_1 : \rho - 1 < 0$

The test statistic is given by

$\tau = \frac{\hat{\rho} - 1}{\sigma_{\hat{\rho}}}$  where  $\hat{\rho} - 1$  is the Ordinary Least Square (OLS) estimate of the coefficient of  $\tau$  and  $\sigma_{\hat{\rho}}$  is the standard error.

### Stationary condition

An autoregressive process is only stable if the parameters are within a certain range; for *example*, if there are only two autoregressive parameters then it must fall within the interval of  $-1 < \phi_2 < 1$ ,  $\phi_2 - \phi_1 < 1$ , and  $\phi_2 + \phi_1 < 1$ .

All pure AR processes are invertible, and no further checks are required. For an MA (1) or ARMA (p, 1) process, invertibility requires that the absolute value of  $\theta_1$  be less than one:  $|\theta_1| < 1$ .

**Table 3.1 Invertible conditions for ARMA**

Model Type	Invertibility Condition
AR (p, 0)	Always invertible
MA (1) or ARMA (p, 1)	$ \theta_1  < 1$
MA (2) or ARMA (p, 2)	$ \theta_2  < 1$ $\theta_2 + \theta_1 < 1$ $\theta_2 - \theta_1 < 1$

If  $q > 2$ , one can check this necessary (but not sufficient) condition for invertibility;

$$\theta_1 + \theta_2 + \dots + \theta_q < 1.$$

### 3.2.3 Model selection

Model selection is the process which tests whether the estimated model conforms to the specifications of a stationary univariate process. As stated by Jenkins (1979), for a stationary the series residuals should be independent of each other and constant in mean and variance over time. Plotting the mean and variance of residuals over time and performing a plotting of the autocorrelation and partial autocorrelation of the residual is helpful to identify misspecification. Pankratz (1983) mentions that, if the estimation is inadequate, we have to return to step one and attempt to build a better model. The tools are called an estimated autocorrelation function (ACF) and an estimated partial autocorrelation function (PACF). According to Jenkins (1979), an estimated autocorrelation coefficient ( $r_k$ ) is not fundamentally different from any other sample correlation coefficient. It measures the direction and strength of the statistical relationship between ordered pairs of observations on two random variables. It is a dimensionless number that can take on values only between -1 and +1 (Jenkins, 1979). A value of -1 means perfect negative correlation and a value of +1 means perfect positive correlation (Jenkins, 1979). If  $r_k = 0$  then  $z_{t+k}$  and  $z_t$  are not correlated at all in the available data. Jenkins (1979) mentions that sampling error could cause a  $r_k$  value to be nonzero even though the corresponding parameter  $\rho_k$  is zero

The standard formula for calculating autocorrelation coefficients is:

$$r_k = \frac{\sum_{t=1}^{n-k} (z_t - \bar{z})(z_{t+k} - \bar{z})}{\sum_{t=1}^n (z_t - \bar{z})^2} \dots\dots\dots 3.23$$

Equation (3.23) can be written more compactly since  $\bar{z}_t$  is defined as  $z_t - \bar{z}$ .

$$r_k = \frac{\sum_{t=1}^{n-k} \tilde{z}_t \tilde{z}_{t+k}}{\sum_{t=1}^n (\tilde{z}_t)^2} \dots\dots\dots 3.24$$

There is a slightly less accurate though computationally easier way to estimate the  $\phi_{kk}$  coefficients. It involves using the previously calculated autocorrelation coefficients ( $r_k$ ). As long as a data series is stationary the following set of recursive equations gives fairly good estimates of the partial autocorrelations:

$$\hat{\phi}_{11} = r_1$$

$$\hat{\phi}_{kk} = \frac{r_k - \sum_{j=1}^{k-1} \hat{\phi}_{k-1,j} r_{k-j}}{1 - \sum_{j=1}^{k-1} \hat{\phi}_{k-1,j} r_j} \quad (k = 2,3,\dots) \dots\dots\dots 3.25$$

where

$$\hat{\phi}_{kj} = \hat{\phi}_{k-1,j} - \hat{\phi}_{kk} \hat{\phi}_{k-1,k-j} \quad (k = 3,4,\dots; j = 1,2,\dots,k-1)$$

*Akaike's information Criterion*

Another method of model selection is called Akaike's information Criterion. Several models can be fitted to the series with the method of maximum likelihood. The model for which  $AIC = -2\text{Log}L + 2k$  ( $L$  is the likelihood function value and  $k$  the number of unknown parameters in the model) is a minimum, is selected. The term  $2k$  ensures that models of lower order (small  $k$ ) can also be selected, since  $\text{Log}L$  increases automatically if more parameters are estimated.

### 3.2.4 Estimation of parameters

Estimation of a parameter is a branch of statistics that deals with estimating the values of parameters based on measures or empirical data. The parameters describe an underlying physical sample setting in such a way that the value of the parameter affects the distribution of the measured data (Pankratz, 1983). An estimator attempts to approximate the unknown population parameter using the sample measurements.

Methods of estimation:

- Least squares estimation
- Maximum likelihood

#### *Least Squares Estimation*

The sum of squared error terms is given by  $S = \sum_{t=1}^n \varepsilon_t^2$ , where S is a function of the unknown parameters. Ordinary least squares estimates are the estimated parameter values for which S is a minimum (Pankratz, 1983).

For AR(1) Model:

$$\begin{aligned} Z_t - \mu &= \phi(Z_{t-1} - \mu) + \varepsilon_t \\ \therefore \varepsilon_t &= Z_t - \mu - \phi(Z_{t-1} - \mu) \dots \dots \dots 3.26 \end{aligned}$$

where  $\varepsilon_t$  is the error term.  $E(\varepsilon_t) = 0$

Let

$$\begin{aligned} S(\mu, \phi) &= \sum_{t=2}^n \varepsilon_t^2 \\ &= \sum_{t=2}^n [(Z_t - \mu) - \phi(Z_{t-1} - \mu)]^2 \end{aligned}$$



Where  $S^*$  is called the conditional sum of squared errors. It should be noted that the summation starts at  $n = 2$  for an AR(1) model.  $Z_1$  is used as a starting point and its value is assumed fixed. The estimators are derived by the minimization of the sum of squared error terms from time point 2 onwards. They are called conditional least squares estimators, since they are conditional on the value of  $Z_1$ . For a long time series there is practically no difference between the conditional least squares and ordinary least squares estimators.

Then for ARMA(1, 1);

$$\begin{aligned} X_t &= \phi X_{t-1} + \varepsilon_t - \theta \varepsilon_{t-1} \\ \varepsilon_t &= X_t - \phi X_{t-1} + \theta \varepsilon_{t-1} \\ \varepsilon_1 &= X_1 - \phi X_0 + \theta \varepsilon_0 \end{aligned}$$

Take  $X_0 = 0$  or  $X_0 = \bar{X}$  (if  $\mu \neq 0$ ), and  $\varepsilon_0 = 0$

Alternatively

$$S^*(\phi, \theta) = \sum_{t=2}^n \varepsilon_t^2 \dots\dots\dots 3.27$$

where  $S^*$  is the conditional sum of squares. The estimation is strongly influenced by the assumptions on  $\varepsilon_0, \varepsilon_1, \dots$ . The conditional least squares estimators might therefore be inaccurate.

### 3.2.5 Diagnostic checking

*White noise*

A white noise process is a sequence of uncorrelated variables with mean zero and fixed variance, say  $\sigma_\varepsilon^2$ . If  $\{\varepsilon_t\}_{-\infty}^{\infty}$  is a white noise process with variance  $\sigma_\varepsilon^2$ ,

$$\begin{aligned}
E(\varepsilon_t) &= 0 \\
E(\varepsilon_t^2) &= \sigma^2 \text{ - and} \\
E(\varepsilon_t \varepsilon_\tau) &= 0 \text{ - for } t \neq \tau \dots\dots\dots 3.28
\end{aligned}$$

If the  $\varepsilon_t$ 's are independent, the series is called an independent white noise process. If  $\varepsilon_t \sim N(0, \sigma^2)$ , then the process is called Gaussian white noise. The error terms of the model are defined to be a white noise process. The model that fits well should not have significant autocorrelations in its residual terms. As stated by Dickey & Pantula (1987), the fitted model should account for all autocorrelation that might be present in the series. It is not possible to fit any model to a white noise time series. White noise cannot be predicted from previous knowledge, since it is completely random (Dickey & Pantula, 1987).

A white noise series is stationary if all autocovariances (and autocorrelations) from lag 1 onwards are zero. For example, consider;

$$\begin{aligned}
\gamma_k &= Cov(\varepsilon_t, \varepsilon_{t-k}) \\
&= E(\varepsilon_t \varepsilon_{t-k}) = E(\varepsilon_t)E(\varepsilon_{t-k}) \dots\dots\dots 3.29 \\
&= 0 \text{ for } k \neq 0
\end{aligned}$$

*Test for white noise*

The Ljung-Box is used to test the hypothesis

if

$H_0 : \rho_1 = \dots = \rho_k = 0$  the Ljung-Box Q-statistic is given by

$$Q = n(n+2) \sum_{j=1}^k \frac{r_j^2}{n-j} \sim \chi^2(k) \text{ asymptotically under } H_0.$$

The test can also be applied to the *residuals* from ARIMA estimation. In that case the appropriate degrees of freedom of the  $\chi^2$ -distribution should be adjusted to represent the number of autocorrelations,  $k$ , less the number of AR and MA terms in the estimated model (Ljung & Box: 1978).

For example,

For a MA (q) Process

$$X_t = \varepsilon_t - \theta_1 \varepsilon_{t-1} - \theta_2 \varepsilon_{t-2} - \dots - \theta_q \varepsilon_{t-q}$$

$$E(X_t) = E(\varepsilon_t - \theta_1 \varepsilon_{t-1} - \theta_2 \varepsilon_{t-2} - \dots - \theta_q \varepsilon_{t-q}) = 0 \dots \dots \dots 3.30$$

*Auto covariances :*

$$\begin{aligned} \gamma_0 &= \text{Var}(X_t) \\ &= \text{Var}(\varepsilon_t - \theta_1 \varepsilon_{t-1} - \theta_2 \varepsilon_{t-2} - \dots - \theta_q \varepsilon_{t-q}) \\ &= (1 + \theta_1^2 + \dots + \theta_q^2) \sigma_\varepsilon^2 \dots \dots \dots 3.31 \end{aligned}$$

$$\begin{aligned} \gamma_1 &= \text{Cov}(X_t, X_{t-1}) \\ &= \text{Cov}(\varepsilon_t - \theta_1 \varepsilon_{t-1} - \theta_2 \varepsilon_{t-2} - \dots - \theta_q \varepsilon_{t-q}, \varepsilon_{t-1} - \theta_1 \varepsilon_{t-2} - \theta_2 \varepsilon_{t-3} - \dots - \theta_q \varepsilon_{t-1-q}) \\ &= \sigma_\varepsilon^2 (\theta_1 + \theta_2 \theta_1 + \dots + \theta_q \theta_{q-1}) \dots \dots \dots 3.32 \end{aligned}$$

$$\begin{aligned} \gamma_k &= \text{Cov}(X_t, X_{t-k}) \\ &= \text{Cov}(\varepsilon_t - \theta_1 \varepsilon_{t-1} - \theta_2 \varepsilon_{t-2} - \dots - \theta_q \varepsilon_{t-q}, \varepsilon_{t-k} - \theta_1 \varepsilon_{t-k-1} - \theta_2 \varepsilon_{t-k-2} - \dots - \theta_q \varepsilon_{t-k-q}) \\ &= \sigma_\varepsilon^2 (\theta_k + \theta_{k+1} \theta_1 + \dots + \theta_q \theta_{q-k}) \quad \text{for } k \leq q \end{aligned}$$

$$\gamma_k = \text{Cov}(X_t, X_{t-k}) = 0 \quad \text{if } k > q \dots \dots \dots 3.33$$

The autocorrelation function is

$$\rho_k = \frac{\gamma_k}{\gamma_0}$$

$$= \begin{cases} \frac{-\theta_k + \theta_{k+1}\theta_1 + \dots + \theta_q\theta_{q-k}}{1 + \theta_1^2 + \dots + \theta_k^2} & \text{for } k = 1, 2, \dots, q \\ 0 & \text{for } k > q \end{cases}$$

The autocorrelation function of a MA (q) process is 0 after q lags. The MA (q) process is invertible if the roots of the characteristics equation,

$\theta(L) = 1 - \theta_1 L - \theta_2 L^2 - \dots - \theta_q L^q = 0$  are greater than 1 in absolute value (Ljung & Box, 1978).

### 3.2.6 Forecasting

Consider model,

$$X_t = \alpha + \beta t + \varepsilon_t, \quad t = 1, 2, 3, 4, 5$$

$\alpha$  and  $\beta$  are constants,  $t$  is time

In which;

variable,  $\varepsilon_t$  and  $X_t$  are random variables

#### Criteria for selecting a forecasting method

In this study the performance of each model was be measured by computing the root mean square error (RMSE) and Mean Percentage Error (MPE). The model which has the lowest RMSE was then be considered as the best model and used to forecast the student enrolment for 2010 and 2011. Another way of doing was to leave some data observations of the series at the end for testing purposes, drawing the graphs one for the original time series data and the other for the fitted value and see how they compare.

### 3.3 HOLT-WINTERS METHODS

The Holt-Winters model is an effective forecasting technique that has less emphasis on the construction of a model for the time series (Cipra *et al*, 1995). The Holt-Winters model builds upon the simplest form of smoothing and takes into account the possibility of a time series exhibiting some form of trend or seasonality, both of which are updated by simple exponential smoothing. According to Cipra *et al* (1995), exponential smoothing assigns exponentially decreasing weights as the observation gets older. In other words, recent observations are given relatively more weight in forecasting than the older observations.

#### 3.3.1 Single exponential smoothing

The simplest form of exponential smoothing is single exponential smoothing, and can only be used for data without any systematic trend or seasonal components. Given such a time series, a logical approach is to take a weighted average of past values. It was observed by Cipra *et al* (1995) that, simple smoothing is used for short-range forecasting, usually just one month into the future. The model assumes that the data fluctuates around a reasonably stable mean (no trend or consistent pattern of growth).

The single exponential smoothing is defined as,

$$\bar{y}_t = w_0 y_{t-1} + w_1 y_{t-2} + w_2 y_{t-3} + \dots, \dots\dots\dots 3.34$$

$$= \sum_{i=0}^{\text{inf } \theta} w_i y_{t-i+1} \dots\dots\dots 3.35$$

where  $w_i$  are the weights given to the past values of the series. Since the observations of the series are also the most relevant, it is logical that these observations should be

given more weight than the observations further in the past. This is done by giving declining weights to the series. These decrease by a constant ratio and are of the form:

$$w_0 = \alpha(1 - \alpha)^i$$

where  $i = 0, 1, 2, \dots$ , and  $\alpha$  is the smoothing constant in the range  $0 < \alpha < 1$ . For example, if  $\alpha$  is set to 0.5, the weights will be:

$$w_0 = 0.5,$$

$$w_1 = 0.25,$$

$$w_2 = 0.125,$$

.

.

.

The equation for the estimate of  $y_t$  now becomes,

$$\bar{y}_t = \alpha y_{t-1} + \alpha(1 - \alpha)y_{t-2} + \alpha(1 - \alpha)^2 y_{t-3} + \dots, \dots\dots\dots 3.36$$

since

$$\bar{y}_t = \alpha y_{t-1} + (1 - \alpha)(\alpha y_{t-2} + \alpha(1 - \alpha) y_{t-3} + \dots,) \dots\dots\dots 3.37$$

it can be seen that,

$$\bar{y}_t = \alpha y_{t-1} + (1 - \alpha)\bar{y}_{t-2} \dots\dots\dots 3.38$$

### 3.3.2 Holt's linear model

Holt's linear model is an extension of single exponential smoothing. Holt designed this method to allow forecasting of data with trends. The method is as follows; For a time series  $y_1, y_2, \dots, y_{t-1}$ , the estimate of the value of  $y_{t-u}$ , is given by the next formula;

$$\bar{y}_{t+u} = m_t + ub_t \quad u=1,2,\dots, \dots\dots\dots 3.39$$

where  $m_t$  denotes an estimate of the level of the series at time  $t$ , where  $b_t$  denotes an estimate of the slope of the series at time  $t$ . The one step ahead formula is equal to,

$$\bar{y}_{t+u} = m_{t-1} + b_{t-1} \dots\dots\dots 3.40$$

with the updating equations  $m_t$  and  $b_t$  as;

$$m_t = \alpha_0 y_t + (1 - \alpha_0)(m_{t-1} + b_{t-1})$$

$$b_t = \alpha_1 (m_t - m_{t-1}) + (1 - \alpha_1)b_{t-1} \quad \text{with } 0 < \alpha_0 < 1 \text{ and } 0 < \alpha_1 < 1 \dots\dots\dots 3.41$$

**3.3.3 Holt-winters' trend and seasonality model**

The exponential smoothing methods examined thus far can deal with almost any type of data as long as they are non-seasonal. Nevertheless, in the case of seasonality these methods are not very useful. Holt-winters' trend and seasonality model can actually manage seasonality. The Holt-Winter's method is based on three smoothing equations: one for the level, one for the trend, and one for seasonality. It is similar to Holt's model; the only difference is that an equation is added to deal with seasonality. There are two different Holt-Winters' methods, depending on whether seasonality is modeled in an additive or multiplicative way. The choice of which to use depends on the characteristics of the specific time series. The following formula gives the Holt-Winter's multiplicative model;

$$\bar{y}_{t+u} = (m_t + ub)c_{t-s+u} \dots\dots\dots 3.43$$

where  $m_t$  denotes the level of the time series at time  $t$  and  $b_t$  represents the trend at time  $t$ . In this equation, the seasonal component is given by  $c_{t-s-u}$ , with  $s$  as the length of the seasonal period, and  $\hat{y}_{t+u}$  the forecast for  $u$  periods ahead.

$$\bar{y}_{t+1} = (m_t + b_t)c_{t-u} \dots\dots\dots 3.43$$

Because there are three components to exponential smoothing, three separate smoothing constants are required. The first two constants are:  $\alpha_0$  for the level,  $\alpha_1$  for the slope. Now a third constant  $\alpha_2$  is added for the seasonal component. The updating equations of  $m_t$ ,  $b_t$  and  $c_t$  are respectively;

$$m_t = \alpha_0 \frac{y_t}{c_{t-s}} + (1 - \alpha_0)(m_{t-1} + b_{t-1}), \dots\dots\dots 3.44$$

$$b_t = \alpha_1(m_t - m_{t-1}) + (1 - \alpha_1)b_{t-1}, \dots\dots\dots 3.45$$

$$c_t = \alpha_2 \frac{y_t}{m_t} (1 - \alpha_2)c_{t-s}, \dots\dots\dots 3.46$$

*Additive model*

The additive model is slightly different. Instead of multiplying the Holt model by the seasonal component, the seasonal factor is added. The formula will then be given by;

$$\bar{y}_{t+1} = m_t + ub_t + c_{t-s+u} \dots\dots\dots 3.47$$

Besides the difference mentioned before, the smoothing equations of  $m_t$  and  $c_t$  also differ from those used in the multiplicative model. For perfection all the update equations are shown beneath.

$$m_t = \alpha_0(y_t - c_{t-s}) + (1 - \alpha_0)(m_{t-1} + b_{t-1}), \dots\dots\dots 3.48$$

$$b_t = \alpha_1(m_t - m_{t-1}) + (1 - \alpha_1)b_{t-1}, \dots\dots\dots 3.49$$

$$c_t = \alpha_2(y_t - m_t) + (1 - \alpha_2)c_{t-s}, \dots\dots\dots 3.50$$

The parameters  $\alpha_0$ ,  $\alpha_1$  and  $\alpha_2$  should lie in the interval (0, 1).

### 3.3.4 Non-seasonal Holt-winter's model

This study employed the Non-Seasonal Holt-Winters model due to the nature of the students' enrolment data, which was arranged annually. The Non-Seasonal Holt-Winters model is another commonly used smoothing model and it has been applied to detect aberrant behavior. In the non-seasonal Holt-Winters model, there is a separate smoothing component  $m_t$  and a trend component  $b_t$ . There are two parameters  $\alpha_0$  [0; 1] and  $\alpha_1$  [0; 1]. The researcher developed and evaluated the accuracy of the Non-Seasonal Holt-Winters time series model for Student enrolment at the North West University, Mafikeng Campus (1980-2009). Additionally, the researcher compared the accuracy of the Non-Seasonal Holt-Winters time series model with the Box-Jenkins forecasting method.

In mathematical terms, the Non-Seasonal Holt-Winters model equation is:

$$m_t = \alpha_0(y_t - c_{t-s}) + (1 - \alpha_0)(m_{t-1} + b_{t-1}), \dots\dots\dots 3.51$$

$$b_t = \alpha_1(m_t - m_{t-1}) + (1 - \alpha_1)b_{t-1}, \dots\dots\dots 3.52$$

where  $m_t$  is the smoothed value,  $\alpha_0$  and  $\alpha_1$  are smoothing constants,  $b_t$  is the trend, and  $y_t$  is the actual value of the time series. The speed at which the older responses are dampened is a function of  $\alpha_0$  and  $\alpha_1$ . When  $\alpha_0$  and  $\alpha_1$  are close to 1, the dampening effect is quick; when  $\alpha_0$  and  $\alpha_1$  are close to 0, the dampening effect is slow. For this study,  $\alpha_0$  and  $\alpha_1$  were determined by minimizing the squared prediction error and the starting values for  $m$  and  $b$  were:

$$m_3 = y_2 \dots\dots\dots 3.53$$

$$b_3 = y_2 - y_1 \dots\dots\dots 3.54$$

The forecast is then,

$$b_f = m_3 + b_3 \dots \dots \dots 3.55$$

### 3.3.5 The best model for forecasting

The best performing model was considered by observing the Root Mean Squared Error (RMSE) and Mean Percentage Error (MPE) of each model. In this study, the model which has the lowest Root Mean Squared Error (RMSE) was then be used for forecasting. A model was considered as good, if the Mean Percentage Error (MPE) value was close to zero and the Root Mean Squared Error (RMSE) measures was small.

### 3.3.6 Measurements of forecasting accuracy

Before the forecasting results can be given, some measurements of forecasting accuracy must be determined. This section captures the equations of the most widely applied measurement methods. In this study, the following three methods were utilized for assessing the accuracy of forecasts;

Adjusted  $R$ -square ( $R^2$ ) is a modification of  $R$ -square that adjusts for the number of terms in a model.  $R$ -square always increases when a new term is added to a model, but adjusted  $R$ -square increases only if the new term improves the model more than would be expected by chance.

A general version, based on comparing the variability of the estimation errors with the variability of the original values, is

$$R^2 = 1 - \frac{SS_E}{SS_T} \dots \dots \dots 3.56$$

where  $SS_T$  and  $SS_E$  are ,

$$SS_T = \sum_i (y_i - \bar{y})^2 \dots\dots\dots 3.57$$

$$SS_E = \sum_i (y_i - \hat{y}_i)^2 \dots\dots\dots 3.58$$

then  $y_i$  and  $\hat{y}_i$  are the original data values and modeled values respectively. Then,  $SS_T$  is the total sum of squares and  $SS_E$  is the sum of squared errors.

When the Adjusted R-Square value is close to one (1), it will signifies that the model is good.

Other evaluation measures for a forecasting model are;

- Mean Percentage Error (MPE) =  $1/n \sum_{i=1}^n 100 * e_i / y_i \dots\dots\dots 3.59$

- Root Mean Squared Error (RMSE) =  $\sqrt{1/n \sum_{i=1}^n e_i^2} \dots\dots\dots 3.60$

A forecast is a good forecast if the MPE value is close to zero and the RMSE measures are small. The Smaller the RMSE values are, the better the forecasts.

### 3.4 CONCLUSION

This chapter outlined the specific processes of the Box-Jenkins and Non-Seasonal Holt-Winters' forecasting approaches, were employed for modeling and forecasting of student enrolment for the next two years in the study. The next chapter presents the results. SPSS and E-Views were used to analyse the data.

## CHAPTER FOUR

### DATA ANALYSIS AND RESULTS

#### 4.1 INTRODUCTION

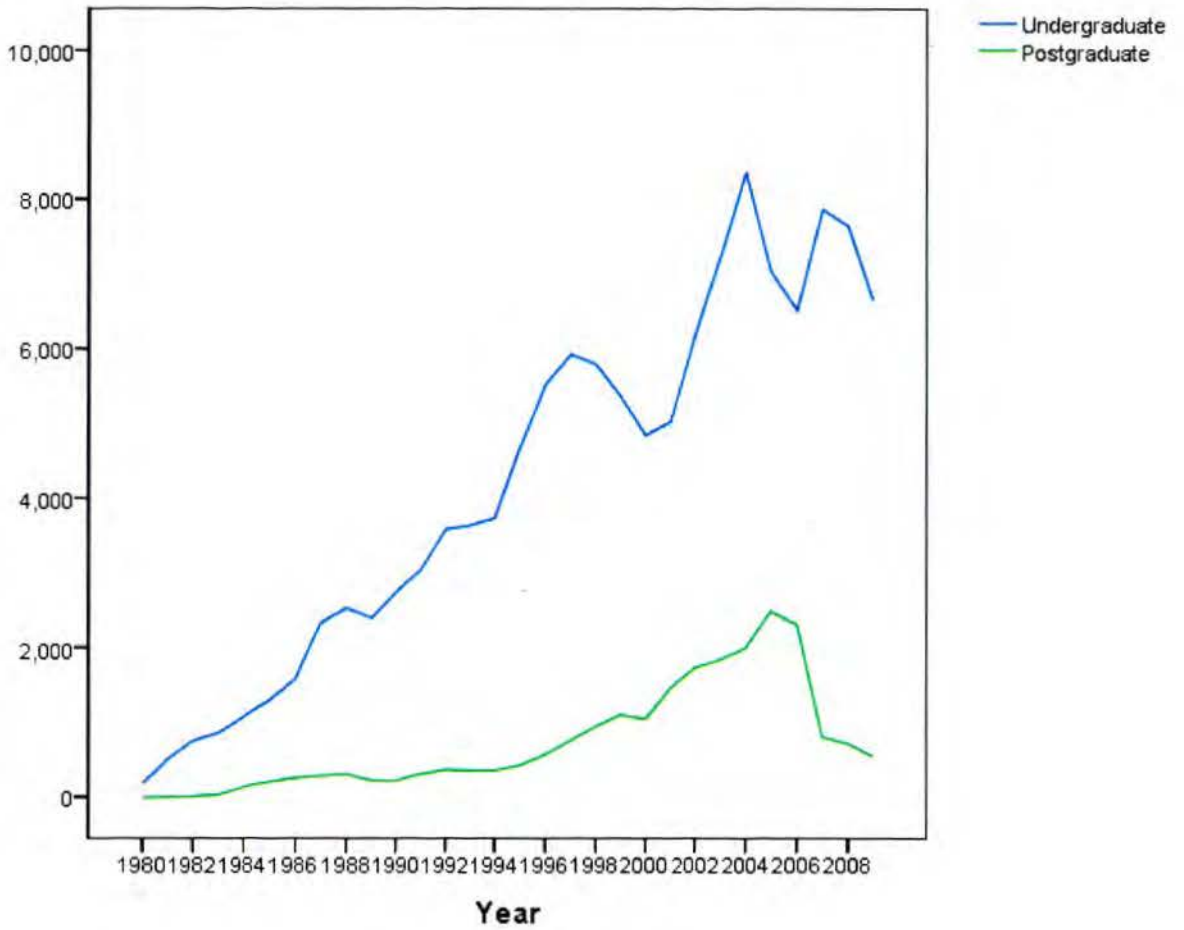
Chapter four presents the results of the study. It provides an assessment of behavioural patterns in form of the graphical presentation and processes of maintaining stationarity for both undergraduate and postgraduate series at the Mafikeng Campus of the North West University. The chapter further identifies the forecasting model through the plotting of Autocorrelation (ACF) and Partial Autocorrelations (PACF) and also verifying the adequacy of the each model. Moreover, the selection of the best model is performed through AIC and SBC assessment. Further the performances of the Box-Jenkins and Non-Seasonal Holts-Winters methodologies are compared using Root Mean Square Error, Mean Percentage Error and *R*-Square values. Finally, the best methodology is used to forecast the future values of student enrolment at the campus.

#### 4.2 THE NATURE OF THE TIME SERIES

Figure 4.1 illustrates the behavioural pattern of students' enrolment since the inception of the North West University at the Mafikeng campus (i.e.1980 to 2009). The figure shows a rising trend for both undergraduate and postgraduate student's enrolments over the period of time. Notably, the figure demonstrates that there was a slight decrease of student enrolment around the years 2004 and 2007. The figure shows a decrease in students' enrolment, for 2005, 2008 and 2009 for the undergraduates and a constant declining trend for postgraduate students after 2005 up to 2009.

The behavioural pattern of undergraduate and postgraduate student enrolment, demonstrates non-stationarity. In order to make the time series data stationary, which is necessary for the Box-Jenkins methodology, one can consider differencing the data as follows.

**Figure 4.1 Series plot for undergraduate and postgraduate**

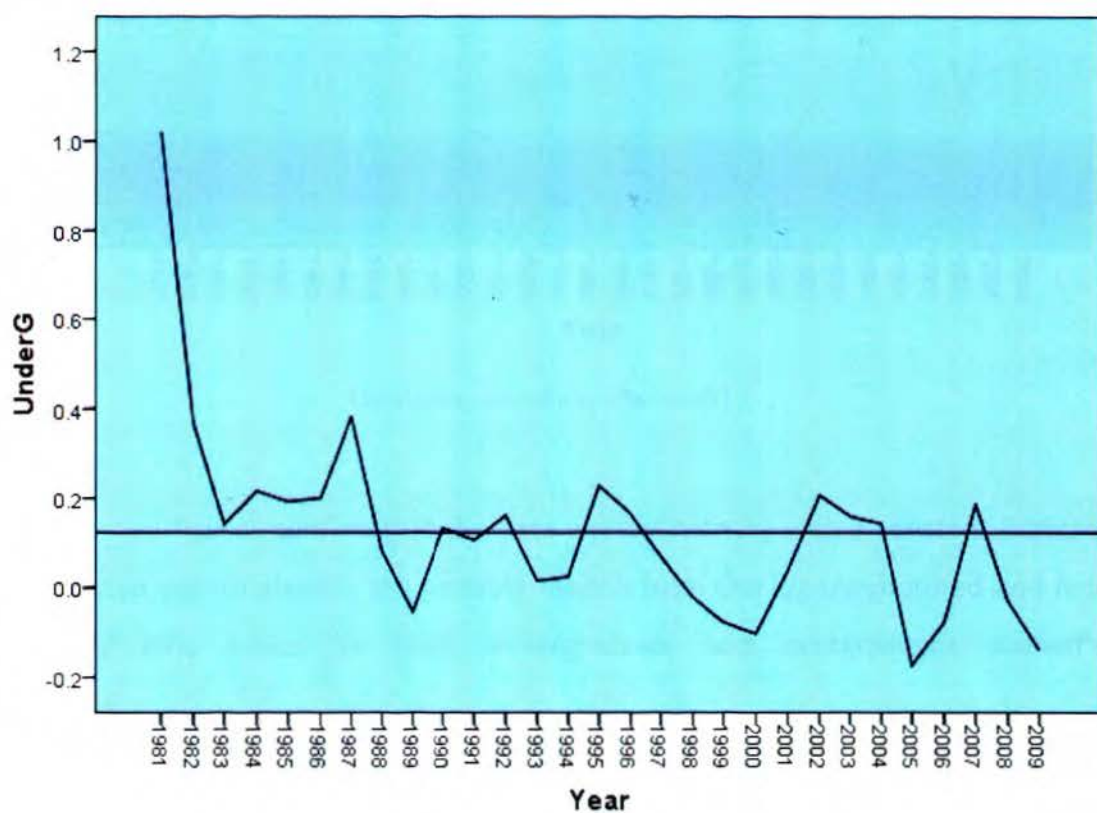


### 4.3 Differencing

The process of differencing the series of undergraduate and postgraduate data was done through the usage of SPSS. This involved computing and examining the differenced data for both undergraduate and postgraduate series. The series contained a significant trend component requiring non-seasonal differencing to induce stationarity.

It is evidenced from figure 4.2 that after introducing the log-transformation and first differencing, there seemed to be a fluctuation around a constant mean, which confirmed that the differenced data was first-order stationary.

**Figure 4.2 Log-Transformed and first differenced data for undergraduate students**

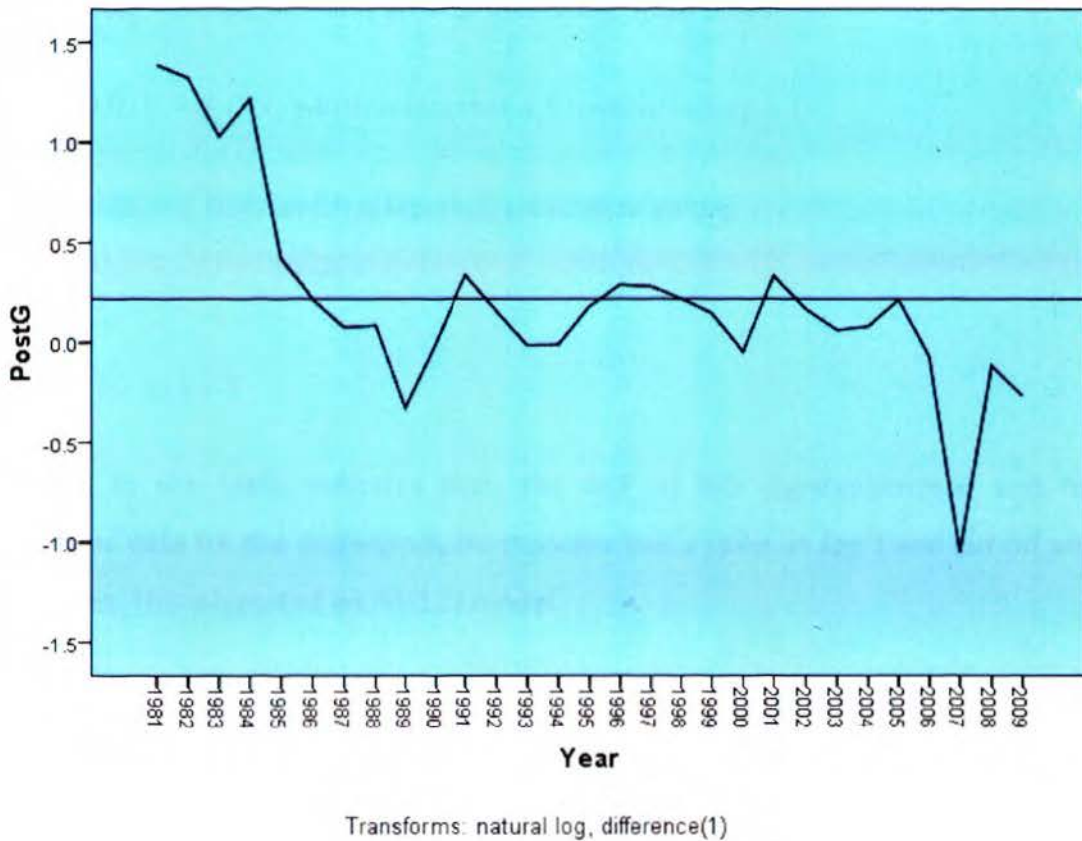


Transforms: natural log, difference(1)

Similarly, the run sequence plot of the log-transformed and first differenced data for postgraduate students' enrolment showed the revolving around a constant mean (+/-

1), though there is a tendency of some outliers with the differenced data, but less autocorrelated than the original data.

**Figure 4.3 Log-Transformed and first differenced data for postgraduate students**



The above two figures confirm that the data were stationary with a constant pattern. The next step was to identify the possible models from the log-transformed and first differenced data series for both undergraduate and postgraduate student's enrolments.

#### **4.4 Model identification**

One can identify the orders  $p$  and  $q$  of the ARIMA( $p,d,q$ ) processes by matching the patterns of the sample ACF and PACF with the theoretical patterns of known models. For this study, various potential models were investigated by using the ACF and PACF.

Table 4.1 below shows a dying down of autocorrelations in a damped sine-wave fashion. It is shown from the table that;

$$|T_{r,1}| = |3,402| = 3,402, \text{ which is greater than } 1,6 \text{ (critical value)}$$

$$|T_{r,2}| = |-0,021| = 0,021, \text{ which is less than } 1,6 \text{ (critical value)}$$

$$|T_{r,3}| = |0,038| = 0,038, \text{ which is less than } 1,6 \text{ (critical value),}$$

and

$$|T_{r,k}| < 1,6 \text{ for all } k > 3$$

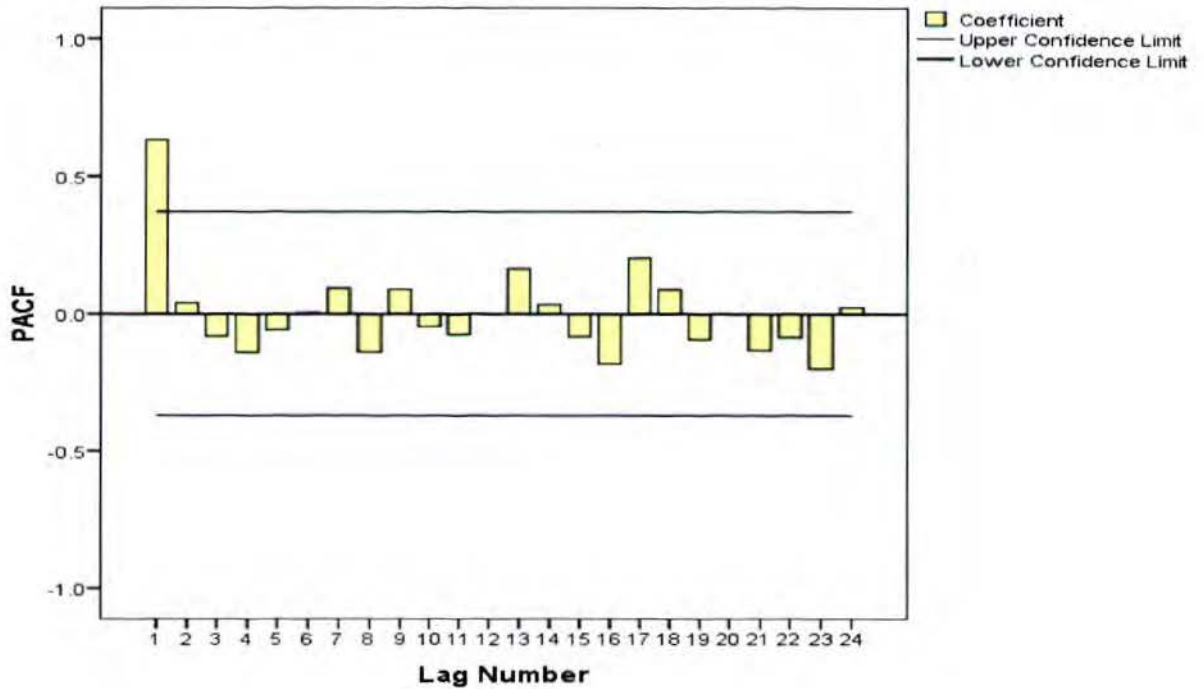
The data in the table indicates that, the ACF of the log-transformed and first differenced data for the undergraduate students had a spike at *lag 1* and cut off after *lag 1* series. This suggested an AR(1,1) model.

**Table 4.1 ACF of log-transformed and first differenced data for undergraduate**

Autocorrelation		AC	Q-Stat	T-Value
.  .  *****	1	0.148	0.7016	3.402
****  .	2	-0.459	7.7244	-0.021
. *  .	3	-0.141	8.4150	0.038
.  .	4	-0.036	8.4605	0.076
.  .	5	0.006	8.4617	0.133
.  .	6	0.039	8.5204	0.202
.  .	7	0.002	8.5207	0.289
.  .	8	0.054	8.6452	0.373
.  .	9	0.038	8.7113	0.464
.  .	10	-0.008	8.7147	0.559
.  *  .	11	0.094	9.1575	0.607
.  .	12	0.065	9.3827	0.670
. ***  .	13	-0.205	11.736	-1.549
. *  .	14	-0.146	13.017	0.525
.  .	15	0.054	13.204	-0.587
.  *  .	16	0.110	14.040	0.596
.  .	17	0.053	14.251	-0.649
. *  .	18	-0.125	15.537	-0.625
. **  .	19	-0.063	15.894	-0.664
.  *  .	20	0.079	16.524	-0.684
.  .	21	-0.009	16.534	0.739
.  .	22	-0.034	16.682	0.781
.  .	23	0.006	16.688	0.824
.  .	24	-0.027	16.821	0.856
.  .	25	0.000	16.821	0.888
.  .	26	0.023	16.979	0.910
.  .	27	-0.005	16.992	0.931

The partial autocorrelation (PACF) plot of the differenced data for the undergraduate students illustrated alternating positive and negative signs of partial autocorrelation coefficients slowly damped out to zero and it showed significance at *lag 1*. The observation suggests that the undergraduate students series could be described using a stationary AR(1,1) model.

Figure 4.4 PACF for log- differenced data with a 95% confidence band: Undergraduate



#### 4.5 Parameter Estimate: AR(1,1) model (undergraduate students)

Table 4.2 indicates the *lag* at which the parameter appeared in the model. The autoregressive parameter is labeled AR. The  $|sig|$  values provide significance tests for the parameter estimates and indicate whether some terms in the model may be unnecessary. In case, the significant value for the autoregressive parameter is greater than the critical value, this term is significant.

The t-critical value of 1,96 at 5% was used as a measure of significance. The AR(1,1) consisted of *lag 1* with coefficient value of -0,911, and a significant of 2,700 which is greater than the t-critical value. This implied that this model was significant. This is supported by the Ljung Box Chi-square value which was less than the significant value ( $0.6381 < 0.837$ ). Therefore, we cannot reject the hypothesis that the residuals were uncorrelated.

**Table 4.2 Parameter Estimate for AR(1,1): Undergraduate students**

Parameter Estimate		Estimate	SE	T	Sig.
constant		.148	.081	1.842	.077
AR	Lag 1	-0.911	.773	-1.477	2,700
	difference	1			
<b>Ljung-Box Q</b>					
Stationary R-squared	Statistics	DF	Sig	Chi-Sq (X <sup>2</sup> )	
.077	9.722	15	.837	6.38	

Table 4.3 shows parameter estimates for AR(2,1) model for undergraduate students. The AR(2,1) model is not significant because the significant values for lag 1 and 2 are both less than the critical value, that is,  $-1,282 < 1,96$  and  $-0,9264 < 1,96$  respectively. Therefore, it is concluded that AR(2,1) model was not suitable to fit the undergraduate students series of data. The Ljung-Box Q value is greater than the significance value, that is,  $3,042 > 1,934$ . This indicates that this model was not adequate.

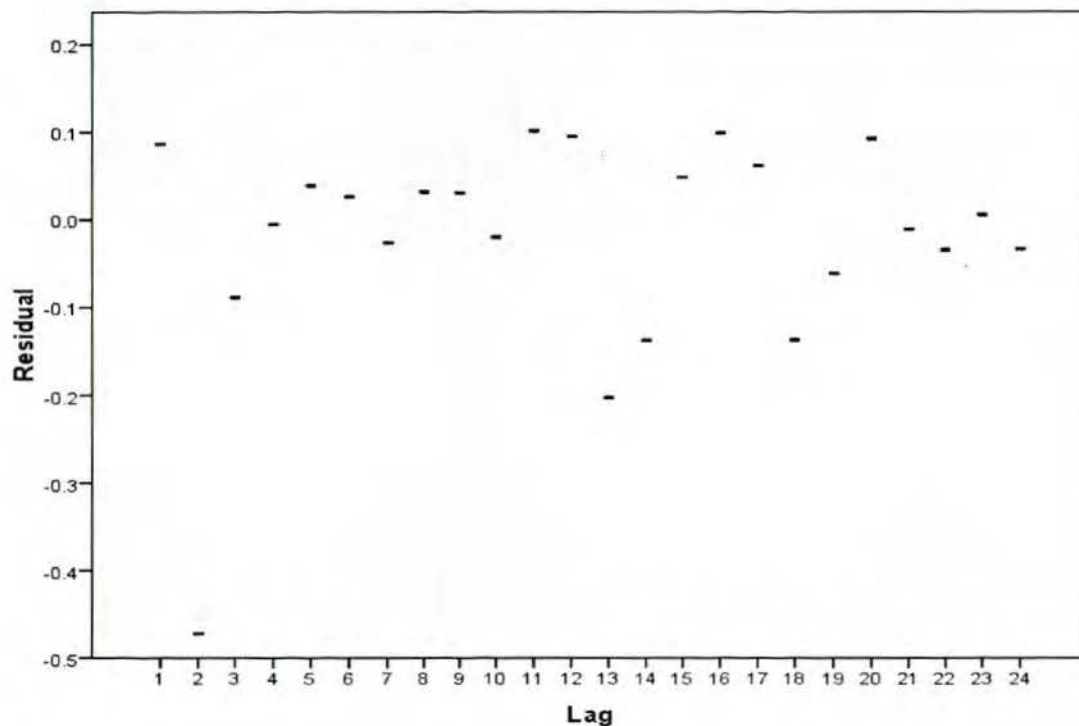
**Table 4.3 Parameter Estimate for AR(2,1) model: Undergraduate students**

Parameter Estimate		Estimate	SE	T	Sig.
constant		.172	.105	1.921	.7143
AR	Lag 1	-.0323	.3132	2.314	-1.282
	Lag 2	-.5238	1.261	-.2543	-.9264
	difference	1			
<b>Ljung-Box Q</b>					
Stationary R-squared	Statistics	DF	Sig	Chi-Sq (X <sup>2</sup> )	
.0165	9.291	14	1.934	3.042	

#### 4.6 Diagnostic check for AR(1,1)- Residual analysis

If a time series model is good, the researcher expects the residuals to be random and close to zero. According to figure 4.5, the residuals for AR(1,1) model alternate around zero. The residual plot indicates that the residuals remain relatively constant throughout and the variation is also constant.

**Figure 4.5 Residual plot for undergraduate students – AR(1,1) model**



#### 4.6.1 Testing for normality

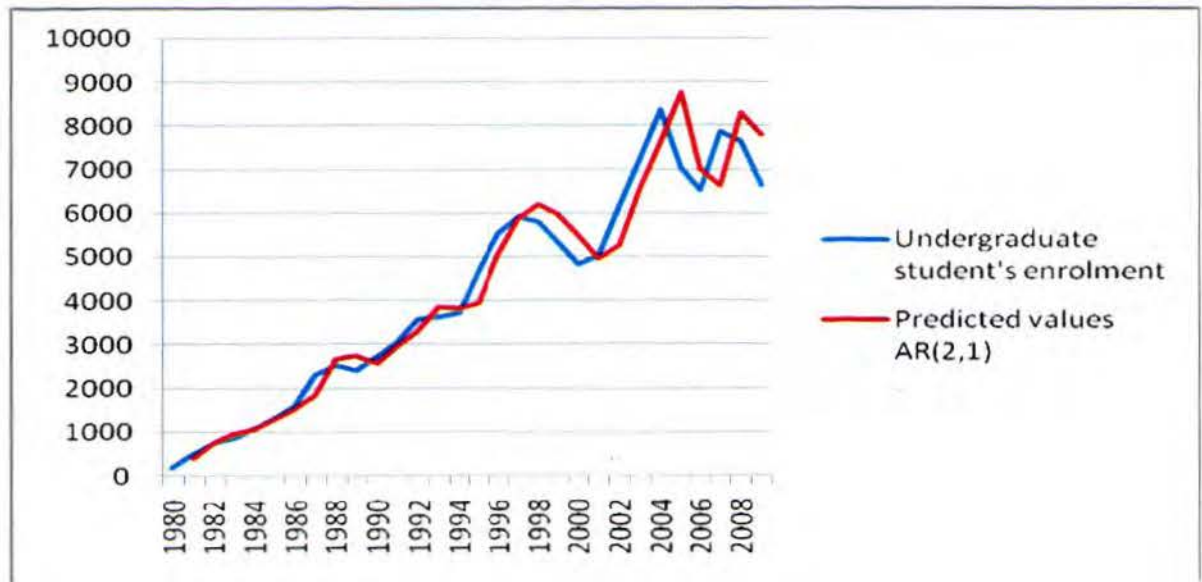
Table 4.4 shows the degree of AR(1,1) model for undergraduate data's normality. The normality is indicated by the skewness of 0.0512, which is very close to zero. The kurtosis value of 4.7382 is near the expected value of five (5) for the normal distribution. This suggested a good normality for the AR(1,1) model on undergraduate students.

**Table 4.4 Normality test**

<i>AR (1,1) Model</i>			
<i>Postgraduate</i>	<i>Natural Log</i>	<i>skewness</i>	<i>0.0512</i>
		<i>kurtosis</i>	<i>4.7382.</i>

Figure 4.6 below compares the original time series data and the predicted values for undergraduate students enrolment using AR(1,1) model. The AR(1,1) model resembles a smooth pattern around the original series, which suggest that the AR(1,1) model can forecast the future values of the undergraduate students enrolment at the Mafikeng Campus of the North West University reasonably well.

**Figure 4.6 Predicted values vs original data series for undergraduate**



#### 4.6.2 Akaike's Information Criterion and Schwarz's Bayesian Criterion

Table 4.5 showed the results of the Akaike's Information Criterion (AIC) and Schwarz's Bayesian Criterion (SBC or BIC). The undergraduate data compares AR(1,1) and AR(2,1) models. It is reflected from table 4.10 that, AR(1,1) is the best model by smallest numbers of AIC and BIC. This model therefore, is best to be used to forecast the future values for undergraduate data.



**Table 4.5 AIC/SBC for undergraduate competing models**

	<b>AR (1,1)</b>	<b>AR (2,1)</b>
Constant Estimate	0.1730	0.2000
Variance Estimate	1.13462	1.0572
Std Error Estimate	0.1240	0.1856
AIC	145.5324	205.2942
ABC	153.7535	232.5433

#### **4.7 Model identification for postgraduate student enrolment**

The autocorrelation in table 4.6 shows a dying down of autocorrelation in a damped exponential - oscillation. The data in the table shows that;

$$|T_{r1}| = |2,233| = 2, 233, \text{ which is greater than } 1,6 \text{ (critical value)}$$

$$|T_{r2}| = |-0,011| = 0, 011, \text{ which is less than } 1,6 \text{ (critical value)}$$

$$|T_{r3}| = |0,002| = 0, 002, \text{ which is less than } 1,6 \text{ (critical value)}$$

$$|T_{rk}| < 1,6 \text{ for all } k > 3$$

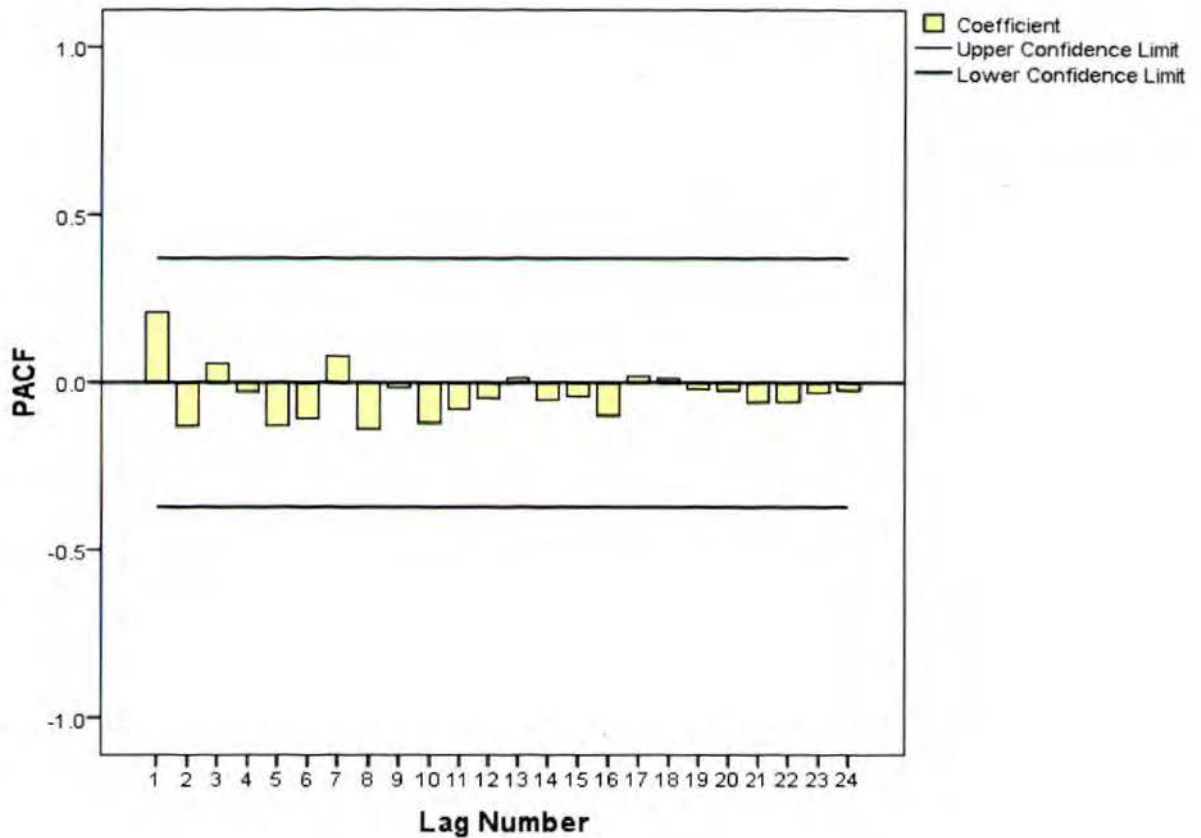
The ACF of the log-transformed and first differenced data for postgraduate series had a spike at *lag 1* and cut off quickly after *lag 1*. It was therefore concluded that, the autocorrelation suggested AR(1,1) model.

**Table 4.6 ACF log-transformed and differenced data for postgraduates**

Autocorrelation		AC	Q-Stat	T-Value
.   .   *****	1	0.879	25.589	2.233
.   *****   **	2	0.717	43.215	0.011
.   ***	3	0.572	54.839	0.002
.   ***	4	0.442	62.043	0.801
.   **	5	0.316	65.870	0.804
.   **	6	0.212	67.670	0.771
.   *	7	0.139	68.480	0.849
.   .	8	0.056	68.616	0.000
.   .	9	-0.016	68.628	0.000
.   *	10	-0.082	68.948	0.933
.   *	11	-0.130	69.802	0.949
.   *	12	-0.161	71.189	0.967
.   *	13	-0.183	73.087	0.981
.   **	14	-0.211	75.760	-0.989
.   **	15	-0.246	79.618	-0.994
.   **	16	-0.273	84.735	-0.996
.   **	17	-0.285	90.725	-0.998
.   **	18	-0.293	97.583	-0.998
.   **	19	-0.304	105.65	-0.999
.   **	20	-0.311	114.92	-1.000
.   *	21	-0.322	125.98	-1.000
.   **	22	-0.309	137.41	0.003
.   **	23	-0.274	147.72	0.020
.   **	24	-0.223	155.68	0.010
.   *	25	-0.161	160.65	1.000
.   *	26	-0.073	161.93	1.000
.   .	27	0.005	161.94	0.000
.   .	28	0.009	161.98	0.233

The partial autocorrelation plot showed that all the PACF lags fell within the lower and upper limits. This did not suggest any potential model at even ( $p = 1$ ) for postgraduate series.

**Figure 4.7 PACF for log-transformed and first differenced data with 95% confidence band: Postgraduate student**



#### 4.8 Parameter Estimate for postgraduate data – AR(1,1)

The postgraduate students model in table 4.6 indicated that the coefficient of AR(1,1) was significant. This was supported by the significant value (2,04), which was greater than the t-critical value (1,96). The Ljung-Box Chi-square value is less than the significant value (0,4016 < 0,923), which suggested that this model was adequate.

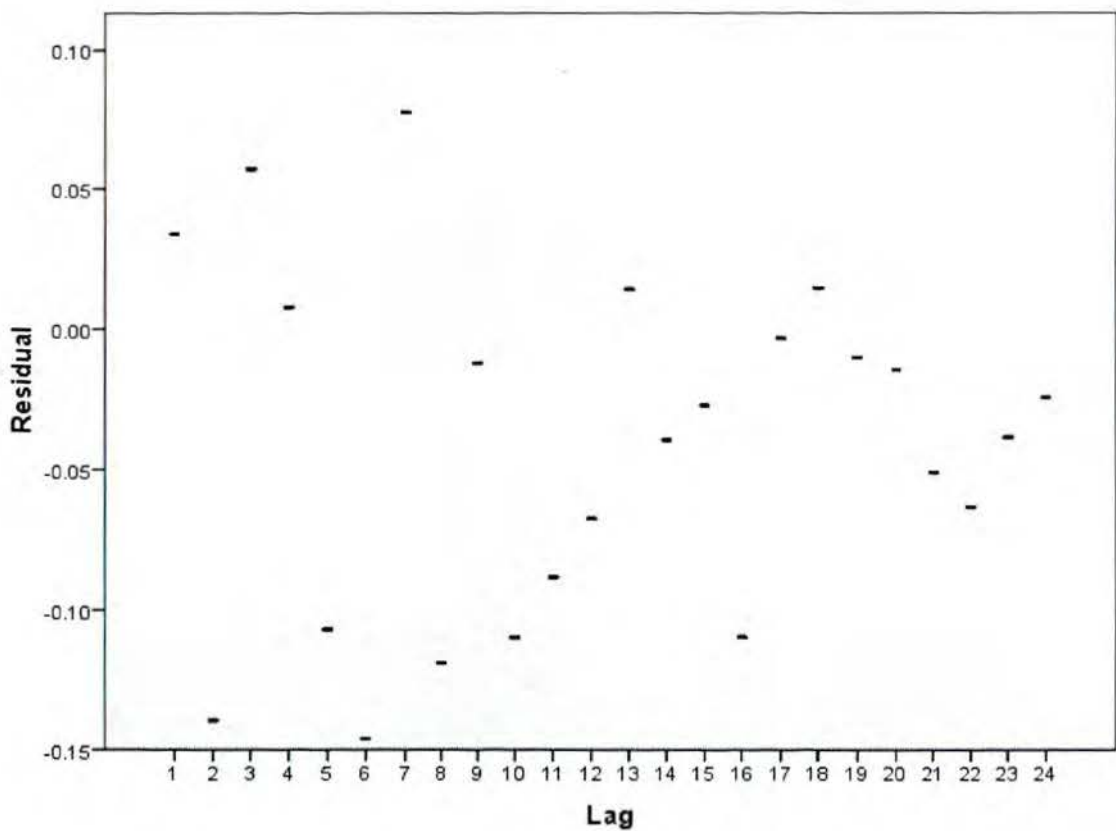
**Table 4.7 Parameter Estimate for AR(1,1) model**

Parameter Estimate		Estimate	SE	T	Sig.
constant		.216	.121	1.793	.084
AR	Lag 1	-.603	.193	-3.130	2.04
	difference	1			
<b>Ljung-Box Q</b>					
Stationary R-squared Statistics		DF	Sig	Chi-Sq ( $X^2$ )	
.292	9.518	17	.923	.4016	

#### 4.8.1 Diagnostic check for AR(1,1) - Residual Analysis

The residual analysis illustration in figure 4.8 shows a scattered and random behaviour for AR(1,1) model with decreasing variability. This did not fulfill the necessary requirement for the best model to be fitted.

**Figure 4.8 Residual plot for postgraduate – AR(1,1) model**



#### 4.8.2 Test for normality

Table 4.8 showed that the distribution of the residual was indicated by the skewness of 1.8512, which indicated that the distribution was positively skewed. The kurtosis value of 4.7382 was near the expected value of five (5). This did not suggested a good normality for the AR(1,1) model for the postgraduate students.

**Table 4.8 Normality test**

<i>AR (1,1) Model</i>			
<i>Postgraduate</i>	<i>Natural Log</i>	<i>skewness</i>	<i>1.8512</i>
		<i>kurtosis</i>	<i>10.249</i>

#### 4.9 Further models for postgraduate students' enrolment

The autocorrelation in table 4.9 showed a dying down in a damped exponential - oscillation. The table shows that;

$$|T_{r1}| = |2,752| = 2,752, \text{ which is greater than } 1,6 \text{ (critical value)}$$

$$|T_{r2}| = |-1,957| = 1,957, \text{ which is greater than } 1,6 \text{ (critical value)}$$

$$|T_{r3}| = |0,432| = 0,432, \text{ which is less that } 1,6 \text{ (critical value)}$$

$$|T_{rk}| < 1,6 \text{ for all } k > 3$$

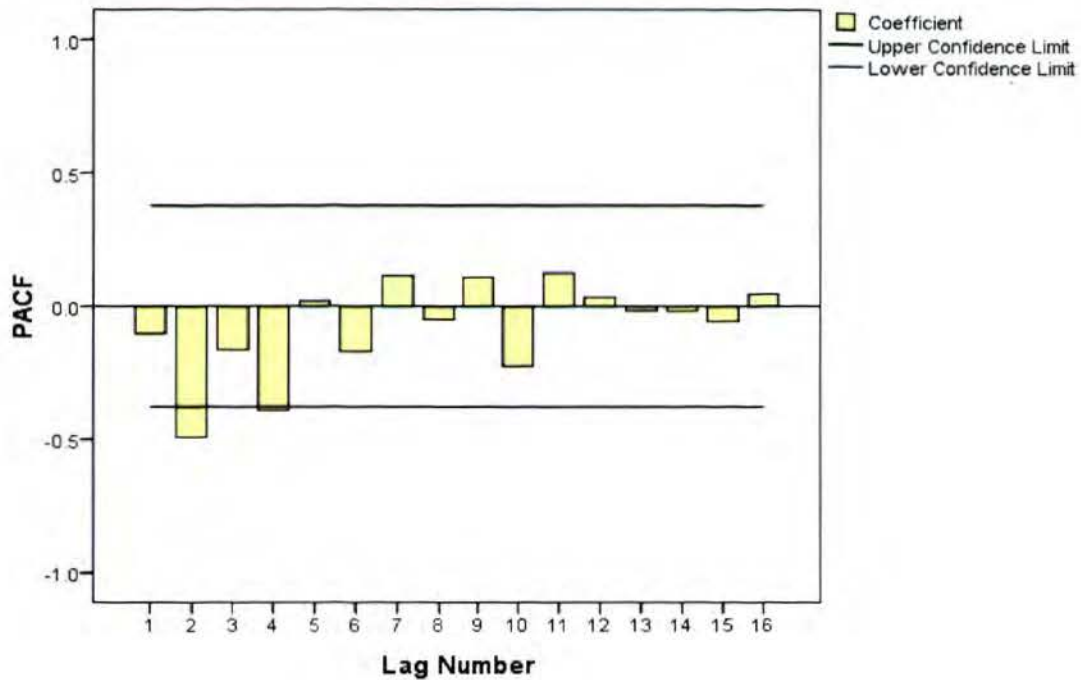
The ACF of the log-transformed and first differenced of postgraduate students had a spike at *lag 1* and at *lag 2* and cut off after *lag 1 and lag 2*. The table therefore suggested an AR(2,1) model.

**Table 4.9 ACF of the log-transformed and first differenced data for postgraduate students**

Autocorrelation	AC	Q-Stat	T-Value
. .  *****	1 0.543	0.545	2.752
. .  *****	2 -0.356	6.245	-1.957
.* .	3 -0.346	6.4654	0.434
. .	4 -0.0573	7.4243	0.4435
. .	5 0.0573	7.4253	0.264
. .	6 0.0246	7.643	0.643
. .	7 0.0653	7.5245	0.134
. .	8 0.0764	7.421	0.264
. .	9 0.0357	7.643	0.482
. .	10 -0.00574	7.6342	0.752
. .	11 0.073	8.2354	0.475
. .	12 0.0635	8.356	0.135
.*** .	13 -0.753	10.245	-1.536
.* .	14 -0.246	11.244	0.275
. .	15 0.074	11.654	-0.275
.* .	16 0.264	12.235	0.525
. .	17 0.0456	13.642	-0.265
.* .	18 -0.264	11.236	-0.256
.** .	19 -0.0543	13.653	-0.573
.* .	20 0.0654	15.765	-0.246
. .	21 -0.0024	15.387	0.275
. .	22 -0.0743	15.365	0.376
. .	23 0.0255	15.764	0.626
. .	24 -0.0643	15.346	0.742
. .	25 0.0243	15.765	0.375
. .	26 0.054	15.767	0.853
. .	27 -0.053	15.877	0.946

Figure 4.9 illustrates alternating positive and negative sign of partial autocorrelation coefficient decaying to zero with a clear statistical significance at *lags 2* and *lag 4*. The figure for PACF also suggest AR(2,1) model.

**Figure 4.9 PACF for the log-transformed and differenced data with 95% confidence band: Postgraduate students**



#### 4.9.1 Parameter Estimates for AR(2,1) model

The autoregressive parameters according to table 4.10 for postgraduate series have significant values compared to the critical value of 1,96. The AR(2) for lag 1 significant value is 2,682 and for lag 2 significant it is 2,535 both of them are greater that the critical value of 1,96. Thus, it was concluded that the AR(2,1) model was adequate for the change in the postgraduate series.

The check for white noise residuals was also showed on the table below. The Ljung-Box Chi-square value tests showed that we cannot reject the hypothesis that the residuals were uncorrelated. Thus, it was therefore conclude that the AR(2,1) model was adequate for the change of the postgraduate series.

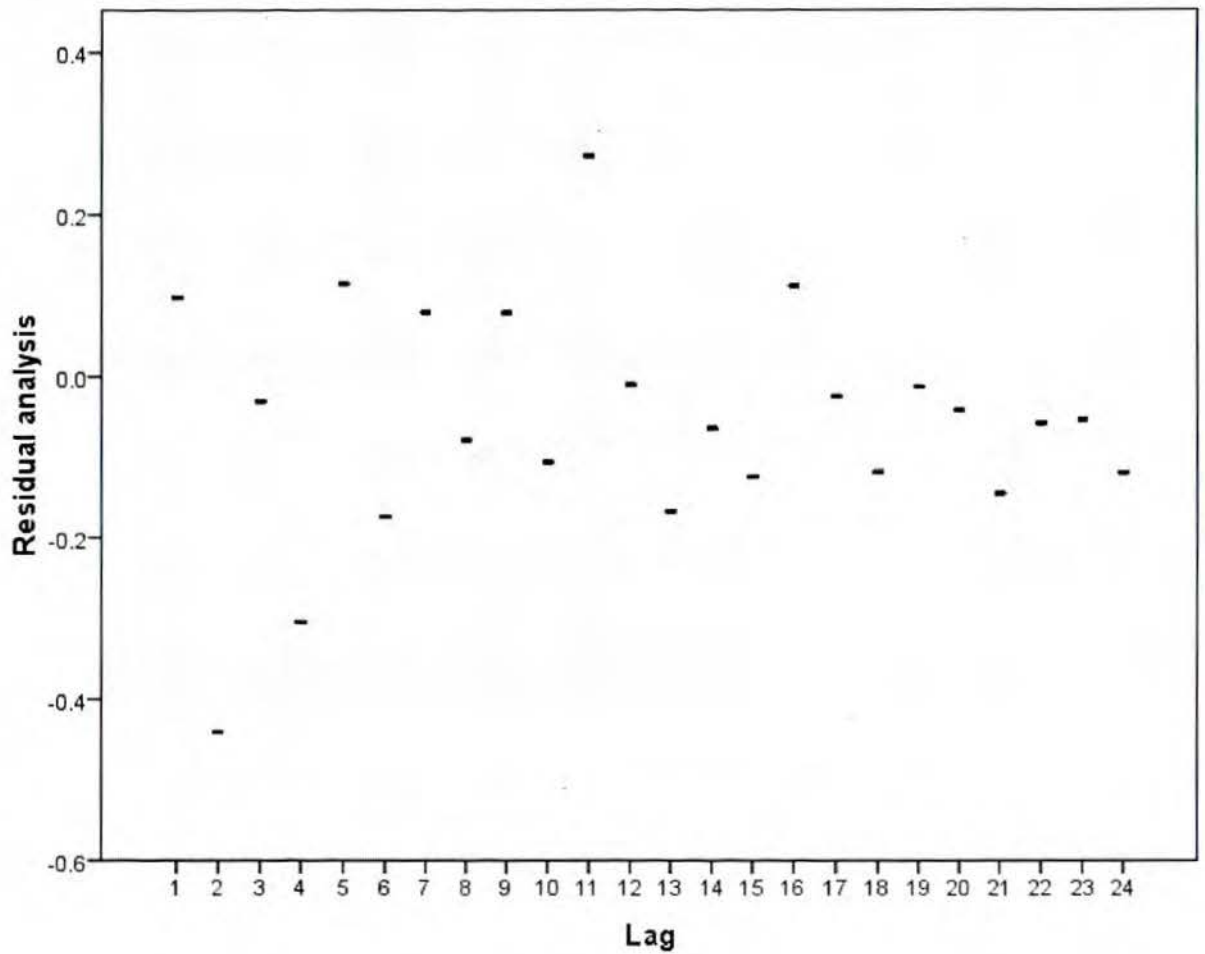
**Table 4.10 Parameter Estimate for AR(2,1) model**

Parameter Estimate		Estimate	SE	T	Sig.
constant		.200	.1856	1.035	.2783
AR	Lag 1	-.857	.183	4.534	-2.682
	Lag 2	-.237	1.703	-.136	-2.535
	difference	1			
<b>Ljung-Box Q</b>					
Stationary R-squared Statistics		DF	Sig	Chi-Sq ( $X^2$ )	
10.462		14	.724	.684	

#### 4.9.2 Residual analysis

The residual in figure 4.10 illustrates a constant behaviour of residual for AR(1,1) model. This suggests that this model is best to be fitted.

Figure 4.10 Residual plot for postgraduate – AR(2,1) model



#### 4.9.3 Test for normality – AR(2,1)

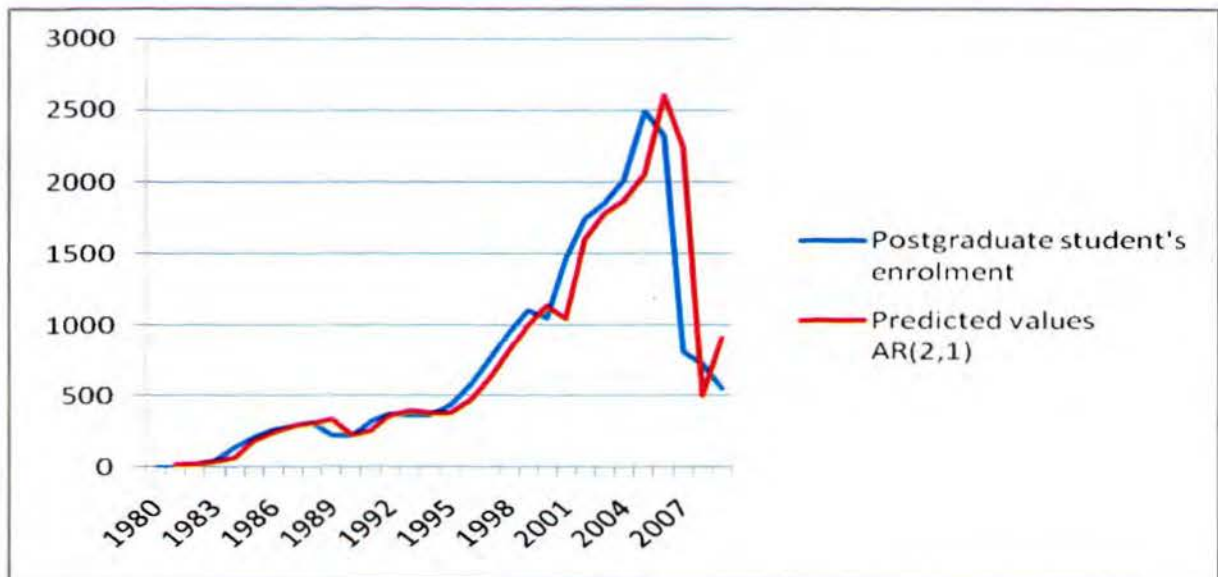
Table 4.11 shows the degree of the AR(1,1) model for postgraduate data's normality. The normality is indicated by the skewness of 1.8912, which indicates that the model was positively skewed. The kurtosis value of 4.7382 is near the expected value of five (5). This suggested a good normality of AR(1,1) model for postgraduate students.

**Table 4.11 Normality Test**

<i>AR (1,1) Model</i>			
<i>Postgraduate</i>	<i>Natural Log</i>	<i>skewness</i>	1.8912
		<i>kurtosis</i>	4.7382

Figure 4.11 below depicted the comparison between the original data series for postgraduate series and the best selected model, AR(2,1).

**Figure 4.11 AR(2,1) Predicted values vs the original data series**



#### 4.10 Akaike's Information Criterion and Schwarz's Bayesian Criterion

Table 4.12 indicates the AIC and BIC for postgraduate competing models. The AR(2,1) has smallest values for both AIC and BIC. It is therefore concluded that the AR(2,1) model fits the data better without overparameterizing for postgraduate series.

**Table 4.12 AIC/SBC for postgraduate competing models**

	<b>AR (1,1)</b>	<b>AR (2,1)</b>
Constant Estimate	0.4902	0.3280
Variance Estimate	1.5324	1.14264
Std Error Estimate	0.5335	0.3830
AIC	245.3934	121.4332
ABC	253.8134	292.56435

#### 4.11 Non-Seasonal Holt-Winter methodology

The results for the Non-Seasonal Holts Winters model for undergraduate students are shown in table 4.13. All the estimated values are between 0.1 and 0.5. These parameters do not affect the estimates of the trend for subsequent forecasts, that is, how quickly the trend will be "damped" or increased. The Mean Percentage Error which is close to two (i.e. 1.9804) and the Root Mean Square Error were compared to the values of Box-Jenkins models to choose a better forecasting model.

**Table 4.13 Exponential Smoothing Model Parameters- Non-Seasonality Holt Winters for undergraduate data**

Sample: 1980 2009		
Included observations: 30		
Method: Holt-Winters No Seasonal		
Original Series: UNDERGRADUATE		
Forecast Series: UNDERGSM		
Parameters:	Alpha	0.1000
	Beta	0.4000
Mean Percentage Error (MPE)		1.9804
Root Mean Squared Error (RMSE)		642.4008
End of Period Levels:	Trend	0.9269

Table 4.14 indicated the parameter estimates for the non-seasonal components. The values of alpha and beta parameters are close to zero, which means that the trend component is constant across all the values of the time series. The values for the Mean Percentage Error and the Root Mean Square Error were 1,9804 and 642,4008 respectively. These were also compared to the Box-Jenkins models.

**Table 4.14 Exponential Smoothing Model Parameters- Non-Seasonality Holt Winters for postgraduate data**

Sample: 1980 2009		
Included observations: 30		
Method: Holt-Winters No Seasonal		
Original Series: POSTGRADUATE		
Forecast Series: POSTGRSM		
Parameters:	Alpha	0.1000
	Beta	0.4000
Mean Percentage Error (MPE)		0.9621
Root Mean Squared Error (RMSE)		594.1371
End of Period Levels:	Trend	0.263624

Table 4.15 indicated that the RMSE values for both undergraduate and postgraduate series of the Box-Jenkins models are much lower than those of the Non-Seasonal Holt-Winters' model. The RMSE values for AR(1,1) model (undergraduate), which is 608.718, and for AR(2,1) model (postgraduate), which is 316.739 confirmed that the Box-Jenkins models are better than the Non-Seasonal Holt Winters models. Striking is the fact that all the ARIMA forecasts have better RMSE values than the Non-Seasonal Holt-Winters' models. The Mean Percentage Error (MPE) values of the Box-Jenkins forecasting models for both undergraduate and postgraduate are close to zero, which signifies good forecasting.

**Table 4.15 Box-Jenkins method**

<i>Best Performing Models for Forecasting</i>			
<b>Box-Jenkins methodology</b>	<i>Root Mean Square Error RMSE</i>	<i>Mean Percentage Error MPE</i>	<i>Adjusted R<sup>2</sup></i>
<i>UnderG-Model_1 (AR(1,1))</i>	<b>608.718</b>	-0.3401	0.84240
<i>PostG-Model_2(AR(2,1))</i>	<b>316.739</b>	0.1032	0.69342

The AR(1,1) and AR(2,1) model respectively gave better results as compared to the Non-Seasonal Holt-Winters' model for all the series. This implied that, AR(1,1) for undergraduate and AR(2,1) model for postgraduate were used to forecast future values for student enrolment.

#### **4.12 Forecasting future values**

The forecasting figures for undergraduate student enrolment seemed to had a decreasing trend as reflected in table 16. Similarly, the postgraduate figures displayed a decreasing trend up to the year 2011. The forecasting values for undergraduate showed a continuous decrease from next year (2010). The postgraduate forecasting value also showed a constant decrease from next year until 2011. These findings suggest that merger of institutions of higher learning in South Africa had also impacted on student enrolment. This is supported by the steady decreasing number of student enrolment, both undergraduate and postgraduate since from the implementation of merger in 2004.

**Table 4.16 Forecasting future values for undergraduate and postgraduate**

	<i>Forecasting Undergraduate-AR(1,1) model</i>			<i>Forecasting Postgraduate-AR(2,1) model</i>		
<i>Period</i>	<i>Forecast</i>	<i>Lower</i>	<i>Upper</i>	<i>Forecast</i>	<i>Lower</i>	<i>Upper</i>
31	6434	-359	9040	572	-159	644
32	6194	-304	8349	521	-130	6205

#### **4.13 CONCLUSION**

This chapter presented the data analysis of students' enrolment of the Mafikeng Campus of the North West University. The processes of Box-Jenkins forecasting method was followed with two different series' of data, for undergraduate and postgraduate respectively. Two AR models were ultimately identified as the best for forecasting, AR(1,1) for undergraduate and AR(2,1) for postgraduate'. The Non-Seasonal Holt-Winters forecasting method was compared with AR models, as an attempt to reveal the best performing model. Based on the assessment of Mean Percentage Error and Root Mean Square Error, AR models were identified as the accurate model to forecast student enrolment at the Mafikeng Campus of the North West University. Although the only weakness was that, the time series data for student enrolment was not sufficiently long; it required a minimum of fifty observations to build reasonable AR model.

## CHAPTER FIVE

### DISCUSSION, CONCLUSION AND RECOMMENDATIONS

#### 5.1 INTRODUCTION

This chapter presents the discussion of the findings from the previous chapter, conclusions and recommendations to the university management of the Mafikeng Campus of the North West University.

#### 5.2 DISCUSSION OF THE FINDINGS

This study employed two individual time series models, the Non-Seasonal Holt-Winters and Box-Jenkins models and tested them to forecast student enrolment. According to Box-Jenkins model, the best models to forecast student enrolment was produced by the AR(1,1) for undergraduate students' enrolment and AR(2,1) for postgraduate student enrolment. It should be kept in mind that the estimated ARIMA model is associated with several statistical problems. However, both the most accurate forecasts for the undergraduate and the most accurate forecast for the postgraduate are adequate. This was confirmed by Adjusted *R* values, which were all close to 1. Although the results of this study are based on a small projection timeframe, the data used for student enrolment was an insufficient. However, the researcher believed that this paper provides preliminary evidence that Box-Jenkins model provides both feasible and accurate forecasts of student enrolment at the Mafikeng Campus of the North West University. Box-Jenkins method is therefore more intuitive.

The descriptive analysis in the previous chapter revealed that the North West University (Mafikeng Campus) is increasingly losing undergraduate students since the begging of 2005 until this academic year 2009. The situation was worse for postgraduate enrolment. The proposal of merger during the past years might have

evoked a good impression to many people, which might have an influence on increment of student enrollment in 2004, during the commencement of merger process. In the prevailing climate after merger in 2004, the undergraduate and postgraduate student enrollment dropped. Further, the analysis indicated that the undergraduate enrollment decreased drastically during 2008 and 2009. This might be due to campus unrest which took long in 2008.

The forecasting models AR(1,1), indicated that the future enrolment for undergraduate student will not improve impressingly in the next two years, so the postgraduate model AR(2,1) is the case.

### **5.3 CONCLUSION**

The main objectives of this study was to model student enrolment at the Mafikeng Campus of the North West University, and to use the best and accurate model between Box-Jenkins method and Non-Seasonal Holt-Winters method to forecast future values of the student enrolment. It was depicted from the findings that Box-Jenkins forecasting model is performing better than Non-Seasonal Holt-Winters forecasting model. Then AR(1,1) for undergraduate and AR(2,1) for postgraduate was used to forecast future values for student enrollment. The forecasted figures for both undergraduates and postgraduates appeared to be gradually declining for the next two years.

The findings from the previous chapter revealed that the decreasing number of student enrolment started immediately after the implementation of merger in 2005. There is a clear evidence that merger contributed to the dropping number of student enrolment at Mafikeng Campus. This is further supported by continues campus unrest in the previous years after this campus was merged with other two campuses. Based on the findings of this study, various recommendations are made to university management

which might assist to improve the enrolment at both undergraduate and postgraduate level.

#### **5.4 RECOMMENDATIONS**

Based on the findings in the previous chapter, the following recommendations to the university management prevail.

##### **High quality academic programmes**

It is recommended that Mafikeng Campus of the North West University improve and introduce programmes which can required graduates to contribute towards the country's economic growth and the furtherance of the democratisation of our society through their role as enlightened and self-critical citizens. This might retain students and excite them about the possibilities of university life as a career, and excite them to be inquisitive enough to do research at the postgraduate level.

##### **Student and staff increased participation rates**

The lack of transparency in the decision-making process and the poor communication between the Student Representative Council (SRC), staff members are no doubt detrimental to the integration process. The management of the campus is encouraged to engage students in issues which affect students such as, fees increment, registration dates and rules, campus regulations e.t.c. The university staff member also demands to be consulted by the campus management on issues which affects them such as, wage increment, staff suspensions, e.t.c. The student and staff participation in discussions might assist the management to avoid regular campus unrest.

##### **Merger transformation**

It is recommended to the university stakeholders to engage themselves into personal, interpersonal, group and intergroup dynamics as this are significant determinants of

merger success or failure. In view of this, it is imperative for the university management to organise on-campus Student Representative Council (SRC) workshops/seminars on leadership and transformation.

### **Student tracking model**

It is further recommended to the campus management to introduce a student-tracking model, which will monitor and report students' transitions through the educational experience in Mafikeng Campus. This might also assist the university management to monitor outgoing students.

### **Bursary and funding**

Taking into consideration that Mafikeng Campus is still predominantly black institution, it is highly recommended to the university management to lobby bursaries from both private and public sector. This will assist also in creating network with particularly private sector and it might facilitate the process of assisting students with getting employment and creating a good reputation and image of the university.

### **Balancing the power of merger**

It is recommended to the national government to come up with a mechanism of striking a balance of power between merged institution, in a way that both sides would deem as fair and impartial.

### **Further research**

Due to the broad nature of the concept of student enrolment, many critical areas could not be dealt with exhaustively in this study and therefore further research is recommended in the following areas:

- Impact of other factor contributing to the decreasing number of student enrolment at the Mafikeng Campus of the North West University other than merger, such as;
  - a. lack of bursaries/funding,
  - b. lack of infrastructure such as; class rooms, computers, laboratories, academic staff, e.t.c
  - c. campus management style,
  - d. marketable programmes within different faculties
- performance of time series forecasting methods could also be investigated further, in the presence of sufficient time series data. Box-Jenkins forecasting model can still be tested with other forecasting models such as Neural Network models.

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**From:** "Phillip Serumaga-Zake" <Phillip.SerumagaZake@nwu.ac.za>  
**To:** "Robert Kettles" <16009827@nwu.ac.za>  
**CC:** "Kgomotso Taukobong" <16426878@nwu.ac.za>, <david.sebolai@nwu.ac.za>  
**Date:** 4/20/2009 3:18 PM  
**Subject:** Re: Fwd: permission to access electronic data

Dear Mr. Kettles

This serves to let you know that indeed Mr. Sebolai is doing a research study on the merger of North West University and he is supposed to use student enrolment figures. He would like you to help him access the data.

Your assistance in this matter will be highly appreciated.

Prof. Philip AE Serumaga-Zake

>>> Robert Kettles 4/17/2009 3:57 PM >>>

Dear Mr Sebolai

I am authorised to release the requested data to you on condition that your supervisor confirm that you are undertaking the study and that you will provide a copy of your findings to my office on completion.

The MIS has only data from 2000 to 2009.

Would this be sufficient as to retrieve data from years prior to this would require an interrogation of a redundant system that I no longer have access to - it has been archived at the institutional office.

Please let me know if this will be acceptable.

Regards

Robert Kettles  
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>>> Kgomotso Taukobong 2009/04/16 10:32 AM >>>

>>> David Sebolai <david.sebolai@gmail.com> 4/16/2009 9:54 AM >>>

Hi Kgomotso,

Please find the e-mail sent to Mr Kettles about two weeks back

Regards

David

----- Forwarded message -----

From: David Sebolai <david.sebolai@gmail.com>

Date: Fri, Apr 3, 2009 at 5:37 AM

Subject: permission to access electronic data

To: Robert.Kettles@nwu.ac.za

Cc: Phillip.SerumagaZake@nwu.ac.za

Dear Mr R.Kettles (Campus Registra)

This letter serves to introduce myself (David Sebolai), a registered student in the Faculty of Commerce and Administration, Mafikeng Campus of the North West University for Mcom (Statistics). I am conducting a research project on, "The impact of merger on student enrollment: the case of North West University, Mafikeng campus" towards partial fulfillment of my Mcom programme. The main objectives for this study are to observe the trend of students enrollment behaviour for Mafikeng Campus and to model the time series of the student enrollment and forecast the future student enrollment in this campus.\*\*

I would like to request your office to assist me in accessing electronic figures of student enrollment since the inception of the university (1980) to this academic year (2009). It will be highly appreciated if the figure can presented separately for undergraduate and postgraduate students on a yearly basis.

Your early positive response will greatly help me to complete this very important study.

Your cooperation will be highly appreciated.

David sebolai  
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