

**University of the Free State**  
**Department of Mathematical Statistics and Actuarial Science**

**And the**

**Centre for Research on Higher Education and Development**

The Capability Approach and Measurement: Operationalizing Capability  
Indicators in Higher Education

---

*By*

*Anesu Ruswa (2007031780)*

A thesis submitted in fulfilment of the requirements for the degree:

**Magister Scientiae: Mathematical Statistics (Dissertation)**

**PROMOTER: PROF. MELANIE WALKER**

**CO-PROMOTER: DR. DELSON CHIKOBVU**

**January 2015**

## Table of Contents

Table of Tables .....	v
Table of Figures .....	vi
Declaration .....	vii
Acknowledgements .....	viii
Abstract .....	ix
1 Introduction .....	1
1.1 Background .....	1
1.2 Research questions .....	3
1.3 Statement of the problem .....	4
1.4 Purpose of the study .....	5
1.5 Significance of the study .....	5
1.6 Assumptions, limitations and delimitations .....	6
1.7 Definitions .....	6
2 Literature Review .....	7
2.1 Background .....	7
2.2 The Capability Approach .....	8
2.2.1 Background of the Human Capability Approach .....	8
2.2.2 Operationalizing the Capability Approach .....	10
2.2.2.1 The adequate evaluative space: capability vs. (achieved) functioning .....	11
2.2.2.2 Lists of (essential, relevant) capabilities or functionings .....	11
2.2.3 Ideal-theoretical list for Higher Education capabilities proposed by Walker including Wilson-Strydom's modification .....	16
2.3 Measurement of capabilities .....	18
2.3.1 Capability Sets .....	18
2.3.2 Methods of measuring .....	<b>Error! Bookmark not defined.</b>
2.3.2.1 Factor analysis .....	20
2.3.2.2 Fuzzy Set theory .....	21
2.3.2.3 Structural Equation methods (SEM) .....	<b>Error! Bookmark not defined.</b>
2.4 South African Higher Education .....	23
2.5 Problems and previous solutions .....	26
2.5.1 The indexing, weighting and aggregation problems .....	26
2.6 Statistical issuances .....	31
2.6.1 Background .....	31
2.6.2 Latent Variables: Factor Analysis vs. Structural Equation Modelling ...	<b>Error! Bookmark not defined.</b>
2.6.3 Regression Analysis .....	31

2.6.3.1.	The Assumptions of linear regression.....	32
2.6.3.2.	Estimation of the Simple Linear Regression Coefficients .....	33
2.6.3.3.	Model selection .....	34
2.6.4	Model diagnostic techniques (Testing of models) .....	36
2.6.4.1.	Residual Analysis.....	36
2.6.4.2.	Test of normality .....	36
2.6.4.3.	The Jarque-bera Test.....	36
2.6.4.4.	Quantile – Quantile plots .....	37
2.6.4.5.	Homoscedasticity .....	37
2.6.4.6.	Independence of residuals .....	38
2.6.4.7.	Presence of Heteroscedasticity.....	39
2.6.5	Stabilizing the variance.....	39
2.6.4.8.	Weighted least square regression.....	40
2.6.4.9.	Simple least square regression with ARMA error terms.....	41
2.6.4.10.	Autoregressive Conditional Heteroscedasticity (ARCH) modelling .....	41
2.6.4.11.	Generalized Autoregressive Conditional Heteroskedasticity modelling.....	42
2.6.4.12.	Problems with a standard GARCH model .....	<b>Error! Bookmark not defined.</b>
3	Methodology Chapter .....	44
3.1	Data.....	44
3.1.1	List of relevant capabilities .....	44
3.1.2	Indicators of capabilities .....	47
3.2	Measuring Instrument .....	50
3.2.1	Background .....	50
3.2.2	Sampling .....	50
3.2.3	The questionnaire.....	52
3.2.4	Distribution .....	53
3.2.5	Data collection and handling.....	53
3.3	Synthesis .....	54
3.3.1	Coding.....	54
3.3.2	Threshold Analyses: Data Transformation .....	55
3.4	Regression Parameter Estimation Methods .....	58
3.4.1	OLS Bivariate model .....	58
3.4.2	OLS Multivariate Case.....	60
3.4.3	Maximum Likelihood Estimator.....	63
4	Chi-squared tests: Contingency table analysis.....	65
4.1	Introduction: Student perceptions .....	65
4.2	Background: Contingency tables and Chi squared tests .....	66
4.3	Contingency tables and Log-linear analysis .....	70
4.4	Wellbeing Perceptions and Variables: A contingency table analysis .....	71
4.5	Conclusion .....	82
5	Descriptive Statistics: Findings and results .....	83

5.1	Variables .....	83
5.2	Demographics .....	85
5.2.1	Gender .....	86
5.2.2	Age .....	87
5.2.3	Residential Profiles .....	87
5.2.4	Racial profiles .....	88
5.2.5	Faculties .....	89
5.3	Statistics of the continuous variables .....	89
5.4	Cross relationships .....	90
5.5	Correlations .....	93
5.5.1	Analysis of Variance (ANOVA) .....	94
5.6	Statistical tests for differences in Marks .....	95
5.6.1	Gender .....	95
5.6.2	Residential status .....	96
5.6.3	Race .....	97
6	Modelling –Results and discussions .....	100
6.1	Ordinary Least squares regression .....	100
6.1.1	Basic model and assumptions .....	100
6.1.2	Model fitting .....	102
6.1.3	Model testing .....	104
6.1.3.1	Scatter plots, residuals and $R^2$ .....	104
6.1.3.2	Overall F-Test for Regression .....	106
6.1.4	Testing of assumptions .....	106
6.1.4.1	Normality .....	107
6.1.4.2	Serial Correlation .....	108
6.1.4.3	Heteroscedasticity .....	109
6.1.4.4	Conclusion of assumption tests and data transformations .....	109
6.1.5	Logarithmic transformation .....	110
6.1.6	OLS Conclusion .....	111
6.2	Other Regression Models: Model selection .....	112
6.2.1	Quantile Regression .....	113
6.2.2	ML - ARCH (Marquardt) - Normal distribution .....	113
6.2.3	Step-wise regression model .....	114
6.2.4	Regression Conclusion .....	114
7	Path Modelling – Final Results and Discussions .....	115
7.1	Introduction-Path modelling .....	115
7.2	Limits of Regression Analysis .....	116
7.3	Multicollinearity .....	118

7.4	Model fit: Path Modelling.....	120
7.4.1	Saturated model.....	120
7.4.2	Reduced model.....	122
7.4.3	Final Model.....	124
7.5	The effect of conversion factors on the valued student capabilities .....	126
7.5.1	Educational Resilience- Conversion factors .....	128
7.5.2	Learning disposition.....	131
7.5.3	Bodily Health .....	133
7.5.4	Practical reasoning .....	136
7.6	Path Modelling Conclusion.....	137
8	Conclusions and recommendations .....	138
8.1	Analysis and results .....	138
8.2	Methodological discussions .....	140
8.3	Literature discussion .....	144
8.4	Conclusion .....	146
9	Bibliography .....	147
10	Appendixes .....	153
10.1	The questionnaire.....	153
10.2	Survey Demographics Results .....	165

## Table of Tables

Table 1 : Hypotheses and weights .....	29
Table 2 : Criteria for developing a capability set.....	46
Table 3 : Capability Indicators .....	47
Table 4: Likert_scale .....	54
Table 5 : Parameters resulting from Standard and Alternative Parameterization .....	56
Table 6: OLS_ Solving for a.....	59
Table 7: OLS_ Solving for b .....	60
Table 8: Chi-squared contingency table .....	66
Table 9: Chi- Squared decision table .....	69
Table 10: Logarithms of expected frequencies .....	70
Table 11: Educational resilience indicators .....	72
Table 12: Learning Disposition and Bodily Health Capability Indicators.....	73
Table 13: Bodily Integrity Capability Indicators .....	75
Table 14: Senses Imagination and Thought Capability Indicators .....	76
Table 15: Emotions Capability Indicators .....	77
Table 16: Practical reasoning Capability Indicators .....	78
Table 17: Affiliation Capability Indicators.....	79
Table 18: Leisure Capability Indicators.....	80
Table 19: Control over one's environment.....	81
Table 20: Variables.....	84
Table 21: General Statistics .....	90
Table 22: Race, gender and Average mark .....	91
Table 23: Language of instruction and faculty vs. Average mark .....	92
Table 24: Language of instruction vs. Home language .....	93
Table 25: Mixed Models - Type III Sum of Squares analysis .....	94
Table 26: Gender / Dunn-Sidak / Analysis of the differences between the categories with a confidence interval of 95%: .....	96
Table 27: Residential status / Dunn-Sidak / Analysis of the differences between the categories with a confidence interval of 95% .....	97
Table 28: Pair wise comparisons____Race / Fisher (LSD) / Analysis of the differences between the categories with a confidence interval of 95% .....	98
Table 29: Ordinary least squares Regression (The Independence model) .....	103
Table 30 : Breusch-Godfrey Serial Correlation LM Test: .....	108
Table 31: Transformed OLS .....	110
Table 32 : Model selection OLS .....	112
Table 33 : Model selection rules.....	113
Table 34 : Quantile regression.....	113
Table 35: ML - ARCH (Marquardt) - Normal distribution .....	114
Table 36: Significant capabilities .....	117
Table 37: Correlation Matrix .....	118
Table 38 : Multicollinearity test .....	119
Table 39: Regression weights .....	122
Table 40: Weights of the reduced model .....	123
Table 41: Regression Weights of the final model.....	125
Table 42: Effect of Conversion factors on Educational Resilience .....	128
Table 43: Learning disposition conversion factors .....	131
Table 44: Bodily Health conversion factors .....	133
Table 45: Practical reasoning conversion factors .....	137

## Table of Figures

Figure 1 : Schematic Representation of the Literature review .....	8
Figure 2 : Outline of the core relationships in the Capability Approach .....	9
Figure 3: Theoretical framework .....	10
Figure 4 : Strategies for the application of the Capability Approach .....	28
Figure 5 :Well-being perception .....	65
Figure 6: Aggregate perceived Wellbeing .....	71
Figure 7: P-P plot of marks.....	84
Figure 8: Gender.....	86
Figure 9: Age.....	87
Figure 10: Accommodation .....	88
Figure 11: Race.....	88
Figure 12: Faculties .....	89
Figure 13: Gender and Mark.....	95
Figure 14: Marks by residential status .....	96
Figure 15: Test for race vs. Mark .....	97
Figure 16: Scatterplot of Mark vs. individual capabilities .....	105
Figure 17 : Residual Plot (Bottom series are the residuals, the thin line is the actual and the flat is the fitted model).....	105
Figure 18: Test for normality of residuals .....	107
Figure 19: Independence model Amos .....	116
Figure 20: Saturated model.....	120
Figure 21: Dependence model with statistically significant covariances only .....	121
Figure 22: Reduced model with statistically significant capabilities only and all possible covariances .....	123
Figure 23: Final model with statistically significant capabilities and statistically significant covariances .....	124
Figure 24: Effects of conversion factors on the Educational resilience capability .....	130
Figure 25: Effects of conversion factors on Learning disposition .....	132
Figure 26: Conversion factors and Bodily Health .....	135
Figure 27: Practical reasoning and conversion factors .....	136
Figure 28 : Aggregate perceived wellbeing .....	139
Figure 29 : Aggregate Ranking of capabilities .....	140

## **Declaration**

I hereby declare that this work, submitted to the University of the Free State, for the degree Magister Scientiae: Dissertation is my own original work and has not previously been submitted for degree purposes at any other institution of higher learning. I further declare that all sources cited or quoted are indicated and acknowledged by means of a comprehensive list of references. Copyright hereby cedes to the University of the Free State.

.....

SIGNATURE

.....

DATE

## **Acknowledgements**

I hereby wish to express my gratitude to my supervisor, Professor Melanie Walker, for granting me the honour of being under her tutorage and for her guidance, patience and wisdom. I would also like to thank Dr Delson Chikobvu, my co-supervisor for the invaluable statistical insights.

I also extend my gratitude to Prof. Paul Anand, Dr. Merridy Strydom-Wilson and Dr. Sonja Loots for the advices and help in constructing the measuring instrument. I am eternally grateful to all the members of the Centre for Research on Higher Education and Development for the discussions, debates and continual support.

Tinashe, Pholani, Precious, Thobile, Sizwe –thank you for being there. My gratitude to the people who make me who I am: my strong beautiful Mom, Faith my beloved sister and Munya my rock.

I dedicate this work to Muano Maligudu who looked beyond my lack and saw a man. Thank you for being there for and with me. *Li do da duvha.*

Last but not least I would like to thank my mentor, brother and friend; Goodhope Ruswa, for all the love and support: Ndatenda Gushungo.

## **Abstract**

The thesis contributes to work in the field of operational measurement of Human Capabilities. Although a number of studies have examined the challenges posed in the measurement of Human Capabilities, there has not been a focus on the empirical merits of the methods and methodologies followed in identification and measurement of valuable capabilities especially in the Higher Education context. To this end, this study provides insights into the identification of valuable student capabilities through an exposition of the methods which can be followed to create and measure robust indicators of student capabilities. A quantitative inquiry determines which Human capabilities students in Higher Education institutions have reason to value and the results of this process are compared to a theoretical student capabilities literature. The thesis advocates for a human development approach over a human capital approach in evaluating the wellbeing of students. The study is significant in that it aids policy and decision makers in Higher Education to identify what students value and thus be in a position to fashion curricula, programmes and policies in a way which best benefits the subjects. To achieve the above mentioned goal, the thesis draws substantially on the work of Paul Anand, Amartya Sen, Flavio Comim, Enrica Chiappero Martinetti, Ingrid Robeyns, Melanie Walker and Sabina Alkire, among others, who have researched and advanced in the field of operational measurement of human capabilities in the Higher Education environment.

# 1 Introduction

The chapter presents the aims, significance, background and assumptions of the study.

## 1.1 Background

The measurement or analysis of ‘wellbeing’ has been a subject of sustained inquiry. Researchers have been trying to discover the best methods to measure ‘wellbeing’ which Sarah C White (2010) posits has three aspects: relational, subjective and material dimensions. Sociology as a discipline has explored the subjective and relational aspects of wellbeing, whereas classic Economics in the main and Welfare Economics in particular have focused to a large extent on measuring wellbeing through the lenses of the material dimension.

The most popular theory in classic economics of measuring wellbeing is Utility or Utilitarian theory which measures wellbeing using (subjective) happiness as a proxy (Berridge, 2000). This theory however is critiqued by, among others, Amartya Sen (1999), Sabina Alkire (2002) and Mozaffar Qizilbash (2008). They argue that the greatest weakness of the Utilitarian approach to welfare is that it is one-dimensional and does not take fully into account the fact that there are many other aspects, besides happiness and advantage that contribute to wellbeing. These other factors include the freedom to do and be what one values.

To fill this blank spot in Welfare research, Amartya Sen introduced the Capability Approach (Sen, 1985). In this approach he defines ‘wellbeing’ as the freedom to be and to do what is most valuable to you (Sen, 1999). The Capability Approach has a few core concepts which include capability, functioning and agency. These core concepts form the foundation on which the Capability Approach is operationalized.

The Capability Approach has been operationalized in numerous ways and in various fields ranging from Economics and Sociology to Health and Education many others. This study will be located in Higher Education and will, among other objectives, seek to

quantitatively interrogate various lists of core capabilities which have been drafted by researchers like Martha Nussbaum (2000), Melanie Walker (2006) and Merridy Wilson-Strydom (2010). The various lists were theoretically crafted and defended qualitatively. This research quantitatively investigated the validity of these lists.

An inter-disciplinary approach was used in the study. The problem was approached from statistical and social science perspectives. This duality was so as to add depth and breadth to the findings. Interdisciplinary research has a number of advantages over mono-disciplinary research. In the article “Ten Cheers for Interdisciplinary: The Case for Interdisciplinary Knowledge and Research” Moti Nissani (1997) identified the following as some of the advantages of an inter-disciplinary approach to research problems:

1. Creativity often requires interdisciplinary knowledge.
2. Immigrants often make important contributions to their new field.
3. Disciplinarians often commit errors which can be best detected by people familiar with two or more disciplines.
4. Some worthwhile topics of research fall in the interstices among the traditional disciplines.
5. Many intellectual, social and practical problems require interdisciplinary approaches.
6. Interdisciplinary knowledge and research serve to remind us of the unity-of-knowledge ideal.
7. Interdisciplinarians enjoy greater flexibility in their research.
8. More so than narrow disciplinarians, Interdisciplinarians often treat themselves to the intellectual equivalent of traveling in new lands.
9. Interdisciplinarians may help breach communication gaps in the modern academy, thereby helping to mobilize its enormous intellectual resources in the cause of greater social rationality and justice.
10. By bridging fragmented disciplines, interdisciplinarians might play a role in the defence of academic freedom (Nissani, 1997, pp. 201-216).

The only drawback of inter-disciplinary research could be a lack of disciplinary depth in all the fields involved, which could result in compromises in the quality of the results. This pitfall will be addressed by soliciting the aid of experts in the disciplines involved.

The research is founded firmly in a Post-Positivist research paradigm. According to Wildemuth (1993) the Post-positivist paradigm propagates the view that information derived from logical and mathematical probes is more valid than, or is truer than, that obtained from any other inquiry. Wildemuth's exaltation of the paradigm is controversial and contestable but the merits of the paradigm cited are also considerable reproof. Also, this paradigm has extra flexibility compared to a Positivist approach, in that it recognizes personal bias, knowledge and experience. In the case of this study, however, qualitative knowledge is also not excluded but is brought into conversation with quantitative data. The study draws on qualitative research by other scholars and introduces a quantitative argument to the literature. The empirical phase of the research is quantitative in nature, and data is mined and analysed quantitatively, thereby aligning the study with a post-positivist approach.

The aim of the research, significance of the study, problem statement, assumptions, limitations, delimitations and definitions of common terms will be given in the sections below.

The chapter that then follows will review relevant literature including measurement literature, capabilities measurement and common debates in Higher Education. After that the next chapter explains in detail the methods and methodologies used to collect the data, as well as those used to clean the data. This is followed by an exposition of the analysis methods used and initial findings. The last chapters will give the results, conclusion of the study and recommendations.

## **1.2 Research questions**

The research questions for this study are as follows:

- i. Which are the most valuable Human Capabilities for Higher Education students?
- ii. How can these valuable capabilities be measured?
- iii. What are the limitations in the measurement of capabilities?

### 1.3 Statement of the problem

The Department of Higher Education South Africa issued a White Paper in 1997 (Department of Higher Education, 1997), which was revised in 2013, stating the principles governing the Higher Education vision of the government. These include equity and redress, democratisation, development, quality, effectiveness and efficiency, academic freedom, institutional autonomy, and public accountability. What the government values to be and to do –its capabilities and functionings- are well documented but what students in Higher Education value to be and to do is not as meticulously documented. This study begins to address this challenge with the understanding that it is of great importance for policy makers to know what students value in order to tailor policies which are relevant and democratic. This concept of public deliberation in identifying valuable capabilities is supported by John M. Alexander (2008) in his book *Capabilities and Social Justice* and of course by Sen (2009) in *The Idea of Justice*.

Further, most institutions of Higher Education struggle financially (MacGregor, 2008) thus there is a need for universities to channel resources to areas of greatest need of the students. To do this, this study argues, it would be helpful to know what students value and what is the order of importance of these capabilities. In response to this problem, this study sets out to identify valuable student capabilities and rank them according to statistical significance.

Finally, much social science research misuses statistics as reported by the Raven Analytics company (Dodhia, 2007); therefore in this study I will aim at discovering the limits and delimitations of statistical inferences from capability measurement studies.

The above blind and blank spots are the premises that necessitate the study exploring valuable student capabilities.

#### 1.4 Purpose of the study

The project seeks to:

- Identify viable indicators of student capabilities
- Create a statistical model or models to measure capability indicators
- Draft a blueprint on
  - How best to create a list of capability indicators
  - How to clean ordinal and nominal data in order to analyse it statistically
  - The possible information and conclusions that can be derived from a quantitative data inquiry process.

#### 1.5 Significance of the study

The measurement of capabilities is critical if one is to compare capabilities between different settings, contexts or time dispensation. A rigorously probed rubric for the measurement of capabilities is necessary when attempting to measure and compare capabilities. However, nationally in South Africa, there is no published work on the measurement of capabilities. The only work recorded is internationally published. There has also been no focus on the measurement of student capabilities. This project addresses this and other blank spots in the field, and further makes a contribution to the international capabilities literature which also has not measured Higher Education capabilities quantitatively.

The measurement of student capabilities could allow Higher Education policy makers to accurately administer effective policy antidotes and inventions.

Further, the creation of a rubric or blueprint to measure capabilities in any context allows less quantitatively inclined researchers to interrogate quantitative data with confidence, ease and precision.

## 1.6 Assumptions, limitations and delimitations

The project assumes that students know and are able to articulate what they value. Also, for this project, lists of pre-drawn and published capabilities based on what is theoretically valuable educationally as well as empirical voices from other projects, were operationalized. In other words it is not assumed that not any old capabilities are appropriate as educational goals, but sufficient flexibility is incorporated to allow students to make choices about what they personally value. Further, the project assumes that the instrument used to capture student views on the various capabilities has exhaustive and easy to understand indicators of capabilities.

The above assumptions compromise the robustness of the conclusion in the sense that pre-drawn lists of capabilities are used and indicators thereof are crafted. A solution to this problem is to have in-depth interviews and focus groups to further interrogate a participatory set of capabilities which can be used. That noted, the lists employed in this project were rigorously interrogated and vindicated as will be seen in Chapter 2.

## 1.7 Definitions

*Human Capabilities* - capabilities are a person's real freedoms or opportunities to achieve functionings (Robeyns, 2011).

*Functionings* – Functionings are ‘beings and doings’, that is, various (plural) states of human beings and activities that a person can undertake and has reason to value (Robeyns, 2011).

*Statistical Model* – A statistical model is a set of probability distributions on the sample space that is a statistical model is a formalization of relationships between variables in the form of mathematical equations. A statistical model describes how one or more random variables are related to one or more other variables

*Regression* - A measure of the relation between the mean value of one variable and corresponding value of other variables

## 2 Literature Review

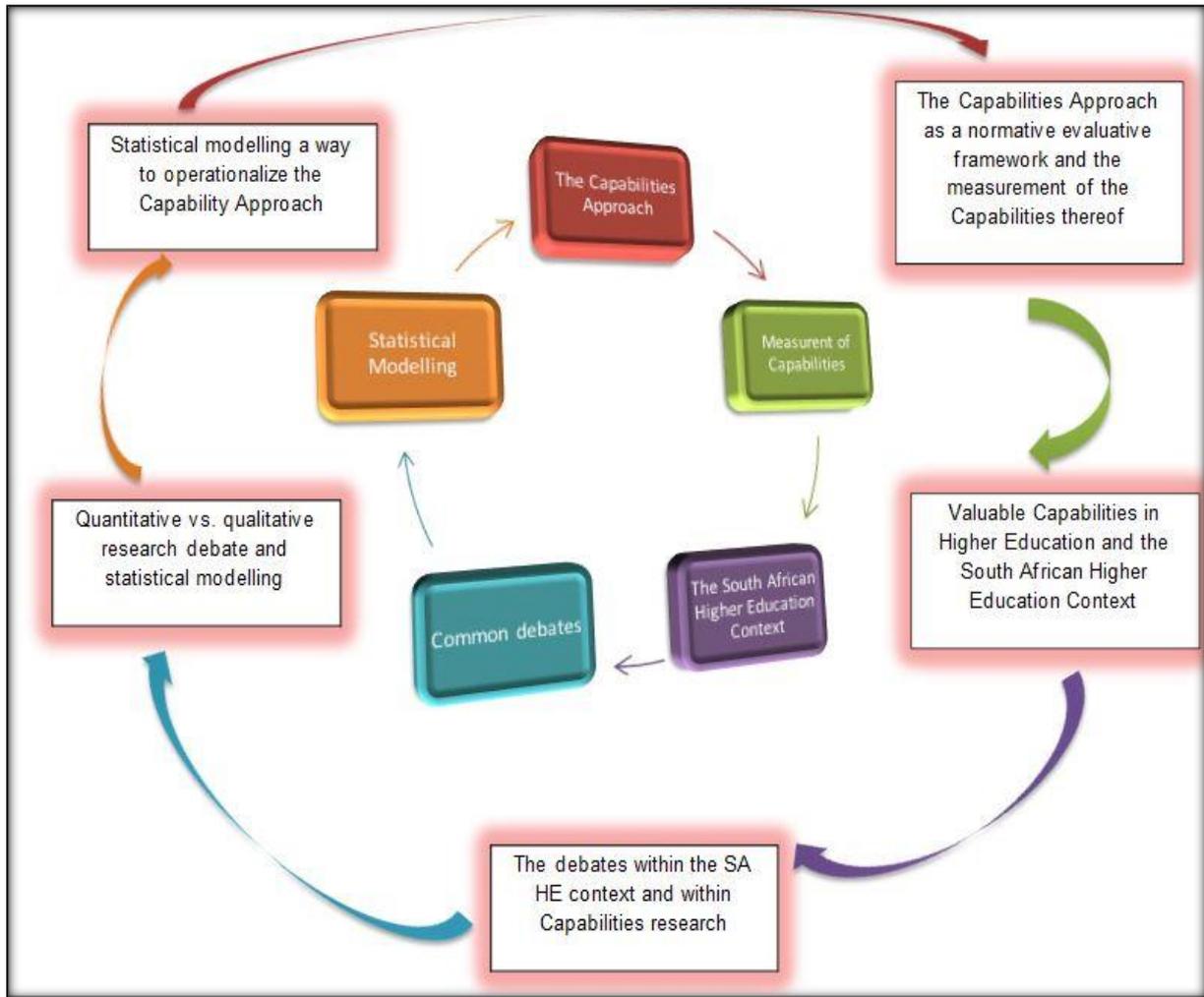
### 2.1 Background

The literature reviewed in this section will be divided into five main sections.

The sections are as follows:

- |      |                                   |                                      |
|------|-----------------------------------|--------------------------------------|
| i.   | <b>The theoretical framework:</b> | The Human Capability Approach        |
| ii.  | <b>The goal:</b>                  | Measurement of capabilities          |
| iii. | <b>The environment:</b>           | Higher Education                     |
| iv.  | <b>The debates:</b>               | Problems and previous solutions      |
| v.   | <b>The Analysis:</b>              | Regression and Statistical modelling |

Below is a schematic representation of the sections and how they relate to each other:



**Figure 1 : Schematic Representation of the Literature review<sup>1</sup>**

## 2.2 The Capability Approach

### 2.2.1 Background of the Human Capability Approach

The Capability Approach is a normative evaluative framework developed by Amartya Sen (1979) to address issues around poverty and the idea of justice. The approach has at its core, ideas of deliberative democracy, well-being, development and justice. Sen defines capabilities as the achievable freedoms one has at one's disposal; Sen defines functionings as the freedoms to 'do' and 'be' what one has reason to value (Sen, 1979). These freedoms are

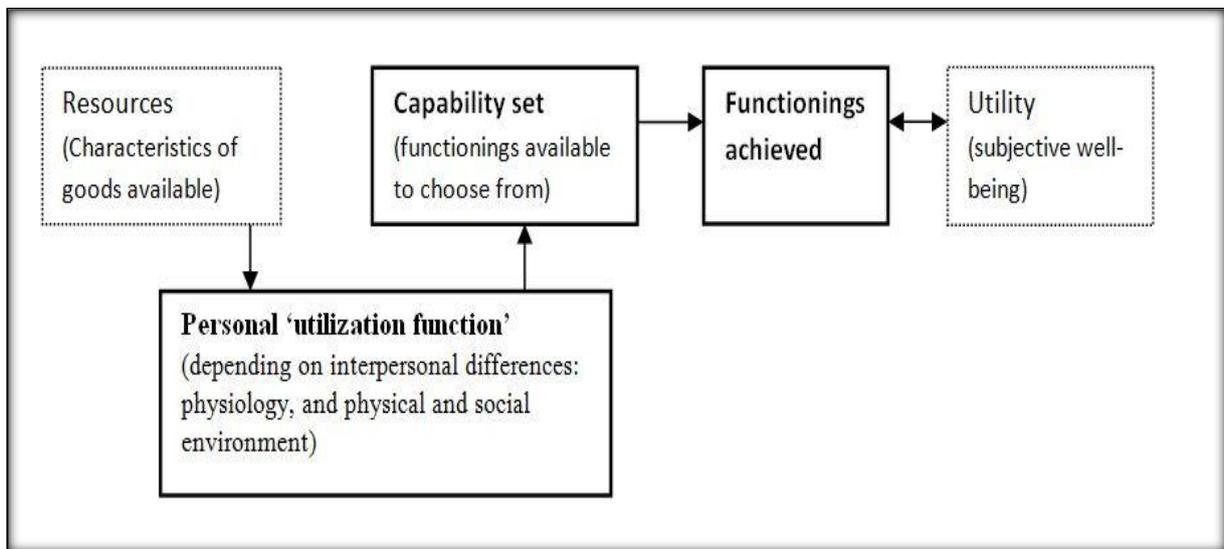
<sup>1</sup> This figure was done by the researcher to show the chronology of the sections and it by no means implies the sections are neither dependent nor procedural.

related to the intrinsic characteristics of people (age, gender, health etc.), as well as social arrangements and environmental circumstances.

The Capability Approach has since been expounded on, further elucidated to and corroborated by many researchers including Martha Nussbaum in her philosophical work and in collaborations with Sen (see. (Nussbaum, 1988) & (Sen & Nussbaum, 1993)).

The approach is viewed in mainstream economics as an alternative Economic Welfare theory. Below is an outline of the core relationships in the Capability Approach as summarized by Thomas Wells (2012):

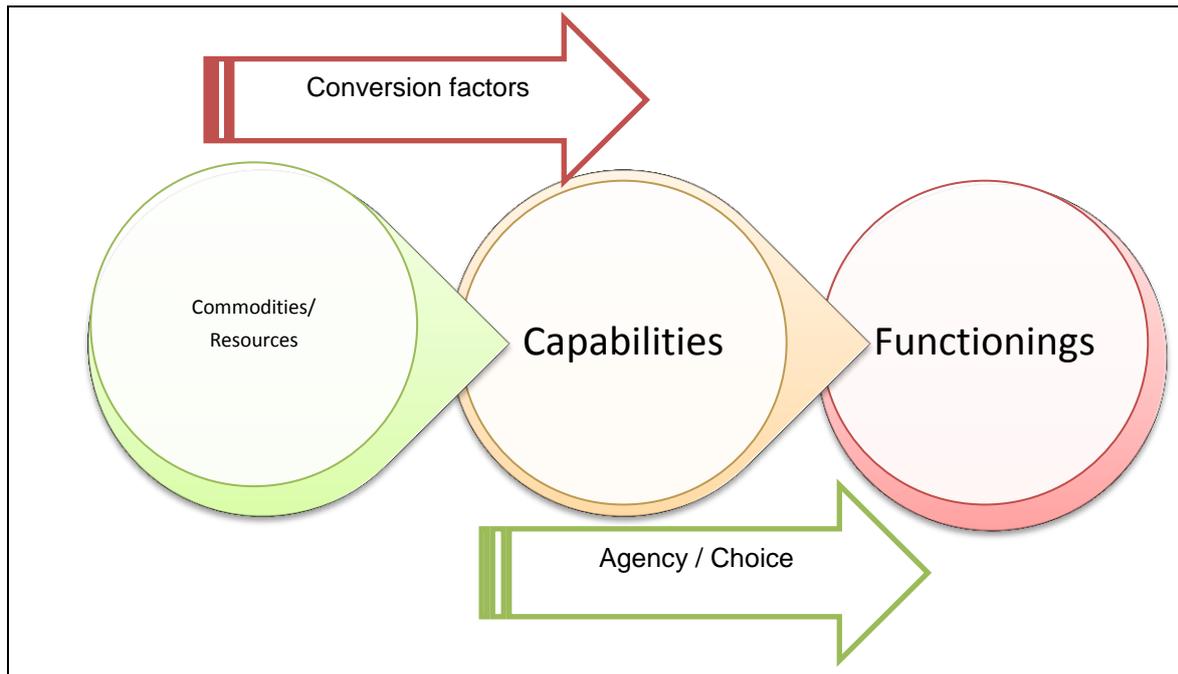
### The Human Capability Approach



**Figure 2 : Outline of the core relationships in the Capability Approach**

The core ideas of the Human Capability Approach are summarized in the table above. Conversion factors are the social, environmental, economic and individual conditions that facilitate the conversion of an individual’s capabilities into functionings. For example a student’s capability is to be able to pass a module, the functioning is actually passing. It is important to note that the ability to convert (i.e. the conversion function) resources into well-being depends on a set of personal and environmental characteristics (i.e. the conversion factors). Related to this is the issue of agency. The Capability Approach encourages the expansion of an individual’s agency/ choices in choosing what they value. A summary of the Theoretical Framework which I will use is given below:

## The Theoretical Framework



**Figure 3: Theoretical framework**

### 2.2.2 Operationalizing the Capability Approach

The Capability Approach, as Ingrid Robeyns (2009) puts it, is an interdisciplinary approach with potential applications in various spheres of existence and relevance in numerous fields of study. However, the approach has not really been used as broadly as it should due to a number of factors including its novelty and implicit challenges which lie in its operationalization. Enrica Chiappero Martinetti (2000) addressed some of the challenges affecting the application or operationalization of the approach and suggests a number of ways to go about operationalizing the Capability Approach. What is of interest in this study are the empirical issues to be dealt with in operationalizing the Capability Approach which Chiappero Martinetti (2000). She argues that the following issues must be dealt with in operationalizing the Human Capability Approach:

- a) The adequate evaluative space: capability vs. (achieved) functioning
- b) A list of (essential, relevant) capabilities or functionings
- c) A set of indicators related to the selected dimensions of well-being and adequate criteria to measure and represent them
- d) How (and if) to aggregate the elementary indicators to obtain an overall evaluation for each single dimension (functioning/capability) of well-being
- e) How (and if) to add up all the dimensions and to reach an overall evaluation of wellbeing (Chiappero-Martinetti, 2000, pp. 207-239).

I will use the five point guideline suggested above as a guide to the way in which I will operationalize the Capability Approach in Higher Education. The last part of this sub-section explicitly focuses on and elucidates the first two issues, and the rest of the thesis will implicitly address the last three issues posed by Chiappero Martinetti.

#### ***2.2.2.1. The adequate evaluative space: capability vs. (achieved) functioning***

The difference between capabilities and functionings is critical in the operationalization of the approach. Martha Nussbaum (2011) defines capabilities as personal powers, and functionings as a realisation of capabilities. These definitions ease the debate on whether to measure capabilities or functionings as it identifies functionings as realisations of capabilities. This effectually means by measuring functionings one measures capabilities. Thus it is not really essential to differentiate whether they are functionings or capabilities being measured. This line of argument is congruent with a recent publication by Paul Anand et al. (2013) where they categorically state, probably for the first time in measurement literature, that one can actually measure capabilities through the conventional measurement of functionings. This debate motivates the measurement of student capabilities through an evaluation of their functionings and agency as will be presented in this thesis. The main assumption is that the capability indicators which will be generated will reflect the student's agency.

#### ***2.2.2.2. Lists of (essential, relevant) capabilities or functionings***

One of the extended debates within the capabilities literature is on the use of pre-determined lists of valuable or relevant capabilities. Those who argue for lists of capabilities like Martha Nussbaum purport that a list is necessary as a guideline for selecting capabilities in any environment. Conversely, those who argue against lists like Amartya Sen say that valuable or useful capabilities should be identified through processes of democratic deliberation. A few researchers have theoretically drawn up lists of core capabilities which they claim are by no means conclusive; both sides have equal merits and insignificant differences. Capabilities can be observed or studied on two levels, namely individual and collective. On an individual level, different people treasure different things and thus their valuable states of 'being' are different. This implies that they have different functionings, different realisations of being. On a corporate or collective level, societies have unique potentials and unique valuable states of 'being'. Thus it is important for any study to identify the key or core capabilities applicable to any group or individual.

Given that there are numerous capabilities in the world, an open-ended approach in Human Capability studies would lead to the study being snowed under by trivial and irrelevant capabilities, and even by people's 'adapted preferences' (Nussbaum, 2011) in which they may choose something which does not necessarily advance their wellbeing or may settle for something thinking it is the best they can do (for example only getting 50% in all their examinations). The debate about using predetermined lists of capabilities has been fierce in the capabilities circles, though research has shown that the existing lists unremarkably capture most of the valuable capabilities. Quantitative researchers like Sabina Alkire (2002) have interrogated Nussbaum's list together with over 39 other lists of capabilities and have found a strong convergence in the capabilities identified thereby showing that generic lists of capabilities are powerful instruments in capability studies.

Mozaffar Qizilbash (1996) echoes these sentiments by saying that there is a large degree of similarity between the lists, and he and others point to Nussbaum's account as a general, high-level account of capabilities that public policy must address. Taking into cognisance the above arguments, Nussbaum's list of capabilities was used as a backdrop for the capability set. As mentioned above, the study is situated in the Higher Education context so Nussbaum's list of core capabilities was augmented with capabilities which are specific to Higher Education, as suggested by Melanie Walker (2006) and Merridy-Wilson Strydom (2010).

Martha Nussbaum (2000, pp. 78-80) has developed the following list of capabilities through philosophy and observation as central to all person's wellbeing. This list has been theoretically validated by many scholars and is operationalized in various contexts. The list contains 10 points and descriptions as given below<sup>2</sup>:

**1. Life:**

Being able to live to the end of a human life of normal length; not dying prematurely, or before one's life is so reduced as not to be worth living.

**2. Bodily Health:**

Being able to have good health, including reproductive health; to be adequately nourished; to have adequate shelter.

**3. Bodily Integrity:**

Being able to move freely from place to place; having one's bodily boundaries treated as sovereign, i.e. being able to be secure against assault, including sexual assault, child sexual abuse, and domestic violence; having opportunities for sexual satisfaction and for choice in matters of reproduction.

**4. Senses, Imagination and Thought:**

Being able to use the senses, to imagine, think and reason – and to do these things in a 'truly human' way, a way informed and cultivated by adequate education, including, but by no means limited to, literacy and basic mathematical and scientific training. Being able to use imagination and thought in connection with experiencing and producing self-expressive works and events of one's own choice, religious, literary, musical, and so forth. Being able to use one's mind in ways protected by guarantees of freedom of expression with respect to both political and artistic speech, and freedom of religious exercise. Being able to search for the ultimate meaning of life in one's own way. Being able to have pleasurable experiences, and to avoid unnecessary pain.

---

<sup>2</sup> The descriptions are given because they are the basis for the selection of capability indicators used in the next chapter

## **5. Emotions:**

Being able to have attachments to things and people outside ourselves; to love those who love and care for us, to grieve at their absence; in general, to love, to grieve, to experience longing, gratitude, and justified anger. Not having one's emotional development blighted by overwhelming fear and anxiety, or by traumatic events of abuse or neglect. (Supporting this capability means supporting forms of human association that has been shown to be crucial in their development.)

## **6. Practical Reasoning:**

Being able to form a conception of the good and to engage in critical reflection about the planning of one's life. (This entails protection for the liberty of conscience.)

## **7. Affiliation:**

a. Being able to live with and towards others, to recognise and show concern for other human beings, to engage in various forms of social interaction; to be able to imagine the situation of another and to have compassion for that situation; to have the capability for both justice and friendship. (Protecting this Capability means protecting institutions that constitute and nourish such forms of affiliation, and also protecting freedom of assembly and political speech.)

b. Having the social bases of self-respect and non-humiliation; being able to be treated as a dignified being whose worth is equal to that of others. This entails, at a minimum, protections against discrimination on the basis of race, sex, sexual orientation, religion, caste, ethnicity, or national origin. In work, being able to work as a human being, exercising practical reasoning and entering into meaningful relationships of mutual recognition with other workers.

## **8. Other Species:**

Being able to live with concern for and in relation to animals, plants, and the world of nature.

## **9. Play:**

Being able to laugh, to play, to enjoy recreational activities.

#### **10. Control over One's Environment:**

- a. Political: Being able to participate effectively in political choices that govern one's life; having the right of political participation, protections of free speech and association.
- b. Material: Being able to hold property (both land and movable goods), not just formally but in terms of real opportunity; and having property rights on an equal basis with others; having the right to seek employment on an equal basis with others; having the freedom from unwarranted search and seizure (Nussbaum, 2000).

Nussbaum's list, though impressive in its expansiveness and widely accepted as a comprehensive guide for selecting relevant capabilities, has met with a number of criticisms, including from Sen who refuses to endorse Nussbaum's fixed and universal list, arguing that capabilities are forever changing and cannot be encapsulated in a generic list. Rather, their identification should be as a result of a deliberative democratic process. Robeyns' (2009) critique is that Sen's refusal to neither endorse nor discard the list serves to show how close Sen's and Nussbaum's conceptualisations of the Human Capability Approach really are. Researcher's like Wolff and Shalit have empirically validated Nussbaum's list, showing that the list is not just a normative construct but a viable tool (Wolff & de-Shalit, 2007). This assertion gives impetus to the methodology which will be used in this study.

Ingrid Robeyns (2003, p. 64) advocates against sticking to a predetermined list of capabilities and contends that any list of capabilities should be tested to see if all the items on it are useful in the specific context in relation to the overall judgement and/or goal. She suggests that different lists should be used for different contexts.

Robeyns' sentiments are echoed by Melanie Walker who says:

“There is a valid case for a list but this should be for specific purposes, or evaluation or critique. It should not be fixed or canonical, it should not be hierarchically ordered and it should in some way include participation and dialogue.” (Walker, 2006, p. 49)

In this study, the goal is to operationalize capability indicators in Higher Education, thus it is critical to find a capability set relevant to the Higher Education realm. Walker

produced an empirically grounded list of capabilities germane to Higher Education, which was then adapted and modified for transitions into Higher Education by Merridy Wilson-Strydom (2012). The list proposed is as follows:

### **2.2.3 Ideal-theoretical list for Higher Education capabilities proposed by Walker including Wilson-Strydom's modification<sup>3</sup>**

**1. Practical Reasoning:** Being able to make well-reasoned, informed, critical, independent, intellectually acute, socially responsible, and reflective choices. Being able to construct a personal life project in an uncertain world. Having good judgment.

**2. Educational Resilience:** Able to navigate study, work and life. Able to negotiate risk, to persevere academically, to be responsive to educational opportunities and adaptive constraints. Self-reliant. Having aspirations and hopes for a good future.

**3. Knowledge and Imagination:** Being able to gain knowledge of a chosen subject – disciplinary and/or professional – its form of academic inquiry and standards. Being able to use critical thinking and imagination to comprehend the perspectives of multiple others and to form impartial judgments. Being able to debate complex issues. Being able to acquire knowledge for pleasure and personal development, for career and economic opportunities, for political, cultural and social action and participation in the world. Awareness of ethical debates and moral issues. Open-mindedness. Knowledge to understand science and technology in public society.

**4. Learning Disposition:** Being able to have curiosity and a desire for learning. Having confidence in one's ability to learn. Being an active inquirer.

**5. Social Relations and Social Networks:** Being able to participate in a group for learning, working with others to solve problems or tasks. Being able to work with others to form effective or good groups for collaborative and participatory learning. Being able to form good networks of friendship and belonging for learning support and leisure. Mutual trust.

---

<sup>3</sup> The list also has descriptions so as to contextualize the meanings.

**6. Respect, Dignity and Recognition:** Being able to have respect for oneself and for and from others, being treated with dignity, not being diminished or devalued because of one's gender, social class, religion or race; valuing other languages, other religions and spiritual practices and human diversity. Being able to show empathy, compassion, fairness and generosity, listening to and considering other person's points of view in dialogue and debate. Being able to act inclusively and being able to respond to human need. Having competence in inter-cultural communication. Having a voice to participate effectively in learning; a voice to speak out, to debate and persuade; to be able to listen.

**7. Emotional Integrity, Emotions:** Not being subject to anxiety or fear which diminishes learning. Being able to develop emotions for imagination, understanding empathy, awareness and discernment.

**8. Bodily Integrity:** Safety and freedom from all forms of physical and verbal harassment in the Higher Education environment

**9. Language, competence and confidence:** Being able to understand, read, write and speak confidently in the Language of instruction.

In-order to fully operationalize capability indicators in Higher Education a conglomerate of the above lists shall be used.

## 2.3 Measurement of capabilities

### 2.3.1 Capability Sets

The Human Capability Approach is a normative evaluative framework and as such can be used to evaluate real freedoms (Comim, et al., 2008). The main quantitative empirical applications of the Human Capability Approach are in the fields of Economics, Health and Econometrics championed by Sabina Alkire, Flavio Comim, Mozaffar Qizilbash, Paul Anand and Enrica Chiappero Martinetti among others.

As mentioned above, functionings are what a person manages to be and do and thus they can be more easily analysed and measured than capabilities which are the real opportunities (potentials) an individual has acquired (Basu, 1987).

The measurement of capabilities was first hinted at by Sen in his 1985 monograph where he suggests an empirical approach to Welfare Economics, different from conventional methods at that time (Sen, 1985). Previously, most of the approaches used to evaluate welfare and wellbeing were from a Utilitarian perspective plied by Human Capital Theory (Schokkaert & Van Ootegem, 1990). These approaches looked at wellbeing or happiness as a bi-product of economic wellbeing and concluded that income and wellbeing had a positive correlation (Roemer, 1998).

Wellbeing has often been viewed as a collection of states. These valued states of being can be redacted into a set and measured. This set is referred to as the Capability set. Let 'u' be the set of valued functionings, Sen argues that the set can be represented as:

$$u = h(f(c(x))) \dots \quad (2.1)$$

where  $h(.)$  is a 'happiness' function related to 'functionings achieved',  $f(.)$  is a function that maps goods characteristics onto functionings achieved, and  $c(.)$  is a function that maps the consumer's bundle of goods onto a vector of characteristics. A key element of the capabilities approach both in Sen's original monograph and as it has developed is the distinction between functionings achieved - what a person is or does – and capabilities in the

sense of the functionings that is feasible for a person to achieve (Sen, 1985). To identify this concept, Sen introduces a set  $Q$  which is defined thus (Sen, 1985, p. 13):

$$Q = \{f(c(x))\} \quad \dots \quad (2.2)$$

...where the set of feasible functions is dependent on a person's own features and their entitlements to commodities. This personalisation of the set adds a new dimension of vantage over other Welfare theories. This then means the set  $Q$  is subjective to the individual. Paul Anand (Anand, et al., 2005b) defines Subjective Wellbeing (SWB) as the freedom a person has thus:

$$SWB = g(Q) \quad \dots \quad (2.3)$$

...where  $g(.)$  can be viewed as just a different 'happiness' function to  $h(.)$ , the function defined above.

There are different methods however to measure the capability set defined above. These methods are described below.

## 2.3.2 Methods of measuring

### 2.3.2.1 Factor analysis

One of the most commonly used statistical methods in social science is factor analysis. There are two types of factor analysis: Confirmatory Factor Analysis (CFA) and Explanatory Factor Analysis (EFA) (Lelli, 2001). Generally, Factor analysis is used to ascertain relationships between variables and it starts with a correlation matrix for all individual variables. The algorithm initially assumes that only one underlying factor can adequately account for the association among variables, subtests, or items. In other words, it begins with the assumption that a one factor model can account for the correlations among item responses. To test this assumption, the algorithm must estimate the correlation between the underlying factor and each variable to determine if the correlation between the items is equivalent to the product of the path coefficients. The variable-total correlation can then be used as a proxy for the correlation between the observed items and the unobserved latent variable or factor. Furthermore, we can estimate what the correlation between variables *should* be if the one factor model fits the data using what we know about path diagrams and we can compare that to what the actual correlation between variables actually is (Guttman, 1954).

Factor analysis is used to create a smaller set of variables (the factors) that capture the original information nearly as well as the larger set of variables (the items). Some factor analytic methods, primarily those based on maximum likelihood estimation and confirmatory models use a statistical criterion which amounts to conducting an inferential test to determine whether the residual matrix contains an amount of co-variation that is statistically greater than zero. If so the process continues until this is no longer the case; if not the process stops. Two widely and commonly used non-inferential procedures to determine when enough factors have been extracted are the eigenvalue rule and the Scree test.

The eigenvalue rule makes use of the fact that an eigenvalue represents the amount of information captured by a factor. In fact, when principal components analysis is used to extract factors from a  $k$  variable scale an eigenvalue of 1 corresponds to  $1/k$  % of the total information available in the variables. Therefore, a factor with an eigenvalue of 1 contains the same proportion of total information as does the typical single variable. For this reason,

the eigenvalue rule states that only factors with eigenvalues greater than one should be retained. Intuitively, this rule is subject to interpretation.

The Scree test rule is also based on eigenvalues but this rule uses relative, as opposed to absolute, values as a criterion. It is based on a plot of eigenvalues associated with successive factors, each of which will diminish in value because they are based on smaller and smaller residual matrices. This rule is more subjective than the eigenvalue rule. After either the Scree or eigenvalue rule the hypothesized structure may not be optimal mathematically. The final solution should be based both upon the hypothesized structure and the eigenvalues (Guttman, 1954).

### **2.3.2.2. Fuzzy Set theory**

Fuzzy set theory is a mathematical procedure introduced by Prof Lotfi A. Zadeh (1965) to model and forecast the whole domain of mathematics which deals with imprecise information. Many argue that the approach has many applications in different fields where uncertainty needs to be modelled. The theory has been applied in Engineering in the creation of various systems like the subway system and elevators. Von Altrock (1997) further led the application of the Fuzzy set theory in the fields of Business and Finance. This advent of business applications of the theory gave birth to a number of further applications in economics. Scholars like Chiappero-Martinetti (2000), Lelli and Cheli-Lemmi (2001) have applied Fuzzy set theory to solve a number of economic problems around poverty reduction, social inequality and disadvantage (Chiappero, 2000; Lelli, 2001; Cheli & Lemmi, 1995). These scholars have used the theory in the capabilities framework.

Tindara Addabbo, Maria Laura Di Tommaso and Gisella Facchinetti describe Fuzzy Set theory mathematically as:

A fuzzy system can be described as a function approximator. More specifically it aims at performing an approximate implementation of an unknown mapping  $f: A \subseteq \mathbb{R}^n \rightarrow \mathbb{R}^m$  where  $A$  is a compact of  $\mathbb{R}^n$ . (Addabbo, et al., 2004)

The following are the main phases of a Fuzzy System design according to Addabbo:

1. Identification of the problem and choice of the type of Fuzzy Expert System, which best suits the problem requirement. A modular system can be designed. It consists of several fuzzy modules linked together. A modular approach may greatly simplify the design of the whole system, dramatically reducing its complexity and making it more comprehensible.
2. Definition of input and output variables, their linguistic attributes (fuzzy values) and their membership function (fuzzification of input and output).
3. Definition of the set of heuristic fuzzy rules. (IF -THEN rules).
4. Choice of the fuzzy inference method (selection of aggregation operators for precondition and conclusion).
5. Translation of the fuzzy output in a crisp value (fuzzification methods).
6. Test of the fuzzy system prototype, drawing of the goal function between input and output fuzzy variables, change of membership functions and fuzzy rules if necessary, tuning of the fuzzy system, validation of results.

Fuzzy theory functions on two levels; the first is a theoretical one where information is obtained from interviews with experts and other qualitative inquiries. The second involves a more mathematical interrogation. Addabbo et.al (2004) argues that the two approaches differ in that the latter does not require the history of the problem, but it relies on the experience of experts who have worked in the field, and the latter is based on past data and projects into the future the same structure of the past. The latter has a more econometric outlook than the former.

## 2.4 South African Higher Education

Robert J. Barro and Jong-Wha Lee purport that education is the main determinant of economic progress in any country as it creates a pool of human capital (Barro & Lee, 2001). This general assertion is true even for South Africa. While the quality of South African basic or primary and high school education has been the subject of great debate locally and internationally overall, despite some variations, Higher Education is of a good standard and does well on a continental level (Beck, 2013). South African universities dominate the top 10 of all rankings of African universities. Coupled with the good tertiary education, South African has a very strong economy as is consistent with Barro and Lee's argument. This direct positive relationship between South African economic prowess or dominance in Africa and its Higher Education outputs is the basis of my interest in studying if students really have the freedoms to do and be what they value.

The current South African minister of Higher and Tertiary Education, Blade Nzimande in a Stakeholder Summit on Higher Education (Nzimande, 2010), emphasised the ministry's commitment to capacitate institutions of higher learning to produce highly skilled graduates who are also aware of their social responsibilities as citizens. This is in line with Human Development Theory in which the Human Capabilities Approach is rooted (Walker & Unterhalter, 2007). Human Development Theory generally and the Capability Approach in particular is a departure from Utilitarian Human Capital Theory which commodified people and placed value on them based on how much of their skills, knowledge and abilities can be traded or are translatable into explicit economic value. This approach limited the agency of individuals as they are forced to do that which is deemed economically valuable and not necessarily what they themselves value (Lanzi, 2007). For example, the approach would argue for more jobs but not necessarily better jobs or better lives. Lanzi (2007) captured this dilemma aptly by describing it as social injustice to only characterize people as economic units. Nonetheless Human Capital Theory has proved itself as effective in creating economic growth, but is wanting in addressing the core values of human development. Deneulin *et.al* (2006) advocate the Capabilities Approach as the ultimate approach or normative framework which can transform unjust capitalistic structures into more humane ones (Deneulin, et al., 2006).

In January 2014 the Minister of Higher Education and Training in South African issued a White Paper<sup>4</sup> on Higher Education (Adopted by Cabinet in November 2013) which alluded to the government's vision for the Higher Education environment into the future. The White Paper contained the same rhetoric exhibited by the 1997 White Paper on Higher Education regarding social justice and human development and, like its predecessor, lacked clear executable plans on achieving social justice. Further, the notion of social justice was linked to that of redressing the maladies of apartheid instead of broadening it to other forms of social injustices which are evident in the country. The White Paper concludes by saying:

“This White Paper has set out a vision of a transformed post-school system which is an integral part of the government's policies to develop our country and improve the economic, social and cultural life of its people. Central to these policies is the determination to bring about social justice, to overcome the legacy of our colonial and apartheid past, and to overcome inequity and injustice whatever its origins.” DHET (2014, pg. 7)<sup>5</sup>

This means the South African Higher education context is still utilitarian in practise though it includes Human Development rhetoric.

The distinction among the theories though present is not as critical as some scholars have put it to be Ingrid Robeyns (2006) argues that capabilities, human rights and human capital theories have smoother seams than other scholars suggest. Further, she argues that the three approaches to education can complement each other instead of antagonizing one another (Robeyns, 2006). She concludes that the three approaches relate in the following ways:

1. **Human capital** is always only instrumental; it should therefore only enter our normative analysis when thinking about efficiency concerns and thinking about some of the content of education, but it should never function as the overarching theoretical framework used to guide educational policies, fiscal policies and budgetary decisions.

---

<sup>4</sup> The whitepaper is available online from <http://www.dhet.gov.za/LinkClick.aspx?fileticket=236NoC18IB4=&tabid=36> as accessed on 21 February 2014

<sup>5</sup>[www.dhet.gov.za](http://www.dhet.gov.za)

2. **Rights** clearly are important in daily discourse. However, at the theoretical level, rights always need a prior moral criterion. Rights could in some contexts be only one possible instrument to reach the goal of expanding educational capabilities. Rights justification will proceed by showing how the right to X is required to serve some capability. If there is no capability that it serves, then it is not a fundamental right.
  
3. **Capabilities**- One of the ultimate aims is to expand people's capabilities, including the capability of education. Rights are an instrument in reaching that goal (Robeyns, 2006).

Therefore the ideal ultimate deliverable of any Higher Education system is an expansion in the capabilities of the students.

## **2.5 Problems and previous solutions**

The previous sections have reviewed literature on the Capability framework, measurement of capabilities and the South African Higher Education environment. The last section of this chapter will review literature on the statistical methods which can or may be used in the analysis of the data for this study. This section will provide a short glimpse into some of the problems and solutions found in measuring Human Capabilities.

### **2.5.1 The indexing, weighting and aggregation problems**

The most known index of wellbeing is the Human Development Index which is used to compare and rank countries. The Human Development Index is a function of a country's Gross Domestic Product (GDP), life expectancy and literacy rates (prior to 2010). This index is arguably very effective in comparing the development between countries but cannot be modified to work for individuals and societies. The Human Capability Approach as explained by Sen solves this problem by defining and distinguishing the relationship between an individual and a group (Sen, 1985). The approach values both individual and collective capabilities and has at its core values which promote individual agency and choice.

Comim identified weighting and incompleteness, aggregation and availability of data as the major challenges that can be found in operationalizing the Capability Approach (Comim, 2001). These challenges are not new but have been noted by leading researchers on the Human Capabilities Approach like Sen (1992; 1999).

As said the above, the greatest advantage of the capabilities approach over other evaluative frames of wellbeing is the ability of the approach to facilitate the modelling of individual capabilities. This concept has been empirically proven for example in dealing with deprivation or individual living standards where a micro index of deprivation and living standards is created. In this example, the index allows individual deprivation to be studied as opposed to the other indexes which operate on a macro level. Andrea Brandolini and Giovanni D'Alessio (1998) give the index as:

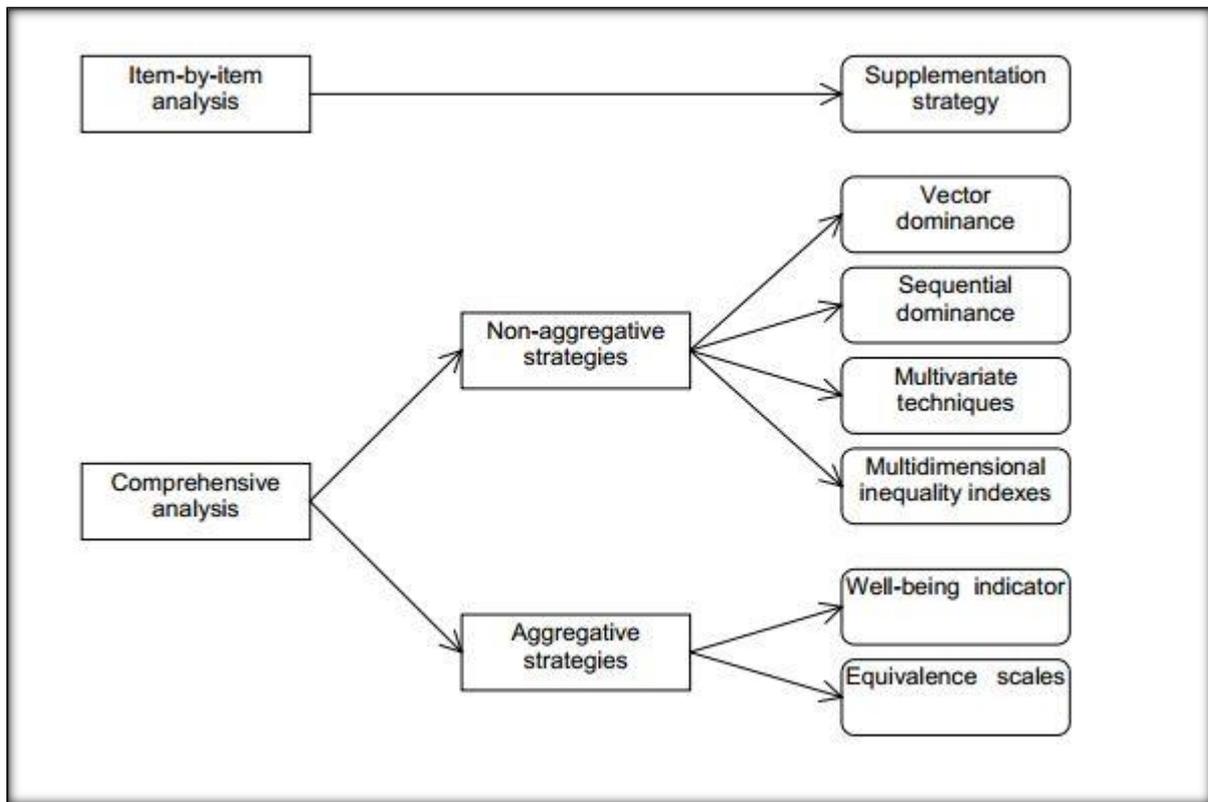
$$Z_i = \sum_j w_j z(x_{ij}) \quad \dots \quad (2.5)$$

And the living standard index is given by:

$$S_i = \sum_j w_j s(x_{ij}) \quad \dots \quad (2.6)$$

Where  $Z_i$  and  $S_i$  are indexes of deprivation and standard of living respectively and  $z(\cdot)$  and  $s(\cdot)$  are non-increasing and non-decreasing functions, respectively, of the amount  $x_{ij}$  possessed by the  $i$ th family of the  $j$ th attribute and  $w_j$  is the corresponding weight (Brandolini & D'Alessio, 1998).

Andrea Brandolini and Giovanni D'Alessio (Brandolini & D'Alessio, 1998) looked at some of the challenges faced in measuring capabilities or vectors of functionings. They propose the strategies given in the table below in-order to solve the problem making use of vector dominance, sequential dominance, multivariate statistical techniques or multidimensional inequality indexes.



**Figure 4 : Strategies for the application of the Capability Approach**

The different strategies in the table above have been used by different researchers to come up with numerous measurement hypotheses in the creation of multivariate capability<sup>6</sup> indexes. The table below will show a summary of these hypotheses that are common in literature. Also, it will show the different weights and weight functions that have been used.

Since  $z(\cdot)$  and  $s(\cdot)$  be non-increasing and non-decreasing functions, respectively, of the amount<sup>7</sup>  $x_{ij}$  possessed by the  $i$ th family of the  $j$ th attribute and  $w_j$  is the corresponding weight. Further let  $x'_j$  represent social norm for the  $j$ th attribute such that if  $x'_j$  shows the definitely deprived (in the example of deprivation)  $x''_j$  would show the definitely not deprived.

<sup>6</sup> Most of the hypothesis cited have been applied in the studies on deprivation and inequality and have not been operationalized in different contexts.

<sup>7</sup> Amount in this case refers to the measurement of wealth which in most cases is Net-Income.

**Table 1 : Hypotheses and weights**

Researcher	Specification of the function of $z(x_{ij})$	Specification of the weights
<p>Townsend (Townsend, 1979)</p> <p>Mack and Lansley (Mack &amp; Lansley, 1985)</p> <p>Mayer and Jencks (Mayer &amp; Jenks, 1989)</p> <p>Federman (Federman, et al., 1996)</p>	$\begin{cases} 1 & \text{if } x_{ij} < x'_j \\ 0 & \text{if } x_{ij} \geq x'_j \end{cases}$	$w_j = 1$
<p>Nolan and Whelan (Nolan &amp; Whelan, 1996)</p>	$\begin{cases} 1 & \text{if } x_{ij} < x'_j \\ 0 & \text{if } x_{ij} \geq x'_j \end{cases}$	<p>Factor analysis</p>
<p>Desai and Shah (Desai &amp; Shah, 1988)</p>	<p><math>\widehat{x}_{ij} -- \widetilde{x}_{ij}</math></p> <p>Where:</p> <p><math>\widehat{x}_{ij} = E[X_{ij}   Y_i]</math> and</p> <p><math>\widetilde{x}_{ij} =</math> mode of the distribution of <math>j</math></p>	$w_j = 1 - \widehat{v}_j$
		<p>Where:</p> <p><math>\widehat{v}_j</math>: proportion of the deprived</p>

<p>Ceriolo and Zani (Cerioli &amp; Zani, 1990)</p>	$\begin{cases} 1 & \text{if } x_{ij} = x_j^1 \\ \frac{x_j'' - x_{ij}}{x_j'' - x_j'} & \text{if } x_j' \leq x_{ij} < x_j'' \\ 0 & \text{if } x_{ij} \geq x_j'' \end{cases}$ <p>Where :</p> <p style="text-align: center;"><math>x_j', x_j''</math>: Critical values</p>	<p><math>w_j = -\ln(\widehat{v}_j)</math></p> <p>Where: <math>\widehat{v}_j</math>: proportion of deprived</p>
<p>Cheli <i>et al.</i> (1994) (Cheli, et al., 1994)</p> <p>Cheli and Lemmi (Cheli &amp; Lemmi, 1995)</p> <p>Lemmi <i>et al.</i> (Lemmi, et al., 1996)</p>	$\begin{cases} 1 & \text{if } x_{ij} = x_j^1 \\ z(x_j^{k-1}) - \frac{\phi(x_j^k) - \phi(x_j^{k-1})}{\phi(x_j^k) - \phi(x_j^1)} & \text{if } x_{ij} \\ 0 & \text{if } x_{ij} \end{cases}$ <p>Where:</p> <p><math>x_j^k</math>: Occurances of <math>x_{ij}</math> (the higher <math>k</math>, the lower the deprivation)</p> <p><math>\phi(x_j^k)</math>: Cumulative distribution function</p>	<p><math>w_j</math></p> $= -\ln\left[\frac{1}{n} \sum_i z(x_{ij})\right]$
<p>Hirschberg <i>et al.</i> (1991) (Hirschberg, et al., 1991)</p>	$\frac{x_{ij} - \mu_j}{\sigma_j}$	$w_j = \frac{1}{m_c m_j}$ <p>Where: <math>m_c</math>: number of clusters <math>m_j</math>: Number of attributes in same cluster as <math>j</math></p>
<p>UNDP (UNDP, 1995)</p>	$\frac{x_{ij} - \min x_{ij}}{\max x_{ij} - \min x_{ij}}$	<p><math>w_j = 1</math></p>

The above table is an example where the Capability Approach was applied to deprivation studies. The example shows the close link between statistics and economics in the measurement of capabilities. The next section describes some of the statistical concepts used in previous works.

## 2.6 Statistical issues

### 2.6.1 Background

As mentioned above, economists have for decades used subjective wellbeing (SBW) data to measure wellbeing; Sen suggested an empirical approach to welfare economics different from conventional methods (Sen, 1985). This method as explained above gives a model of Subjective Well-being which can be statistically analyzed. The statistical methods which have been used in similar studies before are given below.

The indicators shown in the models above have latent variables and as such can be analysed using Confirmatory Factor Analysis, Explanatory Factor Analysis or Structural Equation Methods (Lovell K, 1994). Most Social Science research uses Factor Analysis methods (Robeyns, 2012) which are effective in showing correlation and causation but say nothing about the applicability of the model itself to the study. Structural Equation Modelling (SEM) however solves this problem and generally produces results which are richer in scope. Regression analysis and Path modelling are special forms of SEM.

### 2.6.2 Regression Analysis

Most capabilities researchers like Paul Anand (2006) use Regression Analysis to measure capabilities. Regression analysis includes any statistical technique of modelling and analysing several variables, when the focus is on the relationship between a dependent (response) variable and one or more independent (explanatory) variables (Seber & Lee, 2003). Regression analysis helps us understand how the typical value of the dependent variable changes when any one of the independent variables is varied, while the other independent variables are held fixed. Regression analysis is now the most widely used statistical technique, for example linear regression to handle data with a linear relationship:

$$y = \beta_0 + \beta_1x_1 + \beta_2x_2 + \beta_3x_3 + \cdots + \beta_px_p + \varepsilon \quad \dots \quad (2.7)$$

Where  $y$  is the dependent variable (the SWB in this case),  $x_i$  is the independent variable (capability indicators),  $\beta_i$ 's the model parameters,  $\mathcal{E}$  is the random error term and  $p$  is the order of the multiple regression models.

### 2.6.3.1. The Assumptions of linear regression

For the model:

$$y = \beta_0 + \beta_1 x_{1t} + \beta_2 x_{2t} + \beta_3 x_{3t} + \dots + \beta_p x_{pt} + \mathcal{E}_t \quad \dots \quad (2.8)$$

According to Geoffrey S. Watson (1964) the basic assumptions for regression analysis which need to be checked are:

1. *Linearity*: the dependent and the independent variables should have a linear relationship.
2. *Normality*: the errors  $\mathcal{E}_t$ 's at each time period  $t$  are normally distributed. Where  $t$  is the length of the series.
3. *Zero mean*: the error is assumed to be a random variable with a mean zero conditional on the explanatory variable.

$$E(\mathcal{E}_t) = 0 \quad \dots \quad (2.9)$$

4. *Homoscedasticity*: the variance of the errors is constant across observations.

$$\text{Var}(\mathcal{E}_t) = \sigma^2 \quad \dots \quad (2.10)$$

5. *No- autocorrelation*: the errors are uncorrelated.

$$\text{Cov}(\mathcal{E}_i; \mathcal{E}_j) = 0, \text{ for times } i \neq j \quad \dots \quad (2.11)$$

That is, the random error term  $\mathcal{E}_t$ , are independent and identically normally distributed with mean zero and constant variance  $\sigma^2$ .

$$\mathcal{E}_t \sim N(0; \sigma^2) \quad \dots \quad (2.12)$$

These assumptions imply that the parameter estimates will be unbiased, consistent and efficient in the class of linear unbiased estimators (Dielman, 1991).

### 2.6.3.2. Estimation of the Simple Linear Regression Coefficients

In this research, the ordinary least squares technique and Maximum Likelihood(MLE) technique is used to estimate the regression coefficients. For the simple linear regression model:

$$y_t = \beta_0 + \beta_1 x_t + \varepsilon \quad \dots \quad (2.13)$$

The estimates are given by:

$$\hat{\beta}_1 = \frac{\sum_{t=1}^T (x_t - \bar{x})(y_t - \bar{y})}{\sum_{t=1}^T (x_t - \bar{x})^2} \quad \dots \quad (2.14)$$

And

$$\hat{\beta}_0 = \bar{y} - \hat{\beta}_1 \bar{x} \quad \dots \quad (2.15)$$

Where  $\bar{x}$  is the mean of the  $x$  values and  $\bar{y}$  is the mean  $y$  values. Under the assumption that the population error term has a constant variance and the estimate of the variance is given

By:

$$S^2 = \frac{SSE}{N-2} \quad \dots \quad (2.16)$$

Where  $SSE = \sum (y_i - \hat{y}_i)^2$  is the sum of square for the errors,  $S^2$  is called the Mean Square Error (MSE) of the regression. The standard errors of the parameter estimates are given by:

$$S_{\beta_0} = \hat{\sigma}_\varepsilon \sqrt{\frac{1}{n} + \frac{\bar{x}^2}{\sum_{t=1}^T (x_t - \bar{x})^2}} \quad \dots \quad (2.17)$$

$$S_{\beta_1} = \hat{\sigma}_\varepsilon \sqrt{\frac{1}{\sum_{t=1}^T (x_t - \bar{x})^2}} \quad \dots \quad (2.18)$$

The main aim of performing the regression analysis (Dielman, 1991) is to find out if:

1. The independent variable truly influences the dependent variable.
2. There is adequate fit of the data to the model.
3. The model adequately predicts responses.

### **2.6.3.3. Model selection**

It is always important to find the model which best fits the data in order to make the correct inferences. Thus this subsection focuses on the ways in which models can be selected. In the book *Model Selection and Multimodel Inference* (P. Burnham & R. Anderson, 2002) there are several techniques of selecting a good model which include:

- ***P values***

The probability of drawing a t statistic (or a z statistic) as extreme as the one actually observed, under the assumption that the errors are normally distributed, or that the estimated coefficient are asymptotically normally distributed will be used. This probability is also known as the *p value*. A *p value* of lower than the significance level is taken as evidence to reject the null hypothesis of a zero coefficient.

- ***Information Criterion***

The notion of an information criterion is to provide a measure of information that strikes a balance between the measure of goodness of fit and parsimonious specification of the model.

a) Akaike Information Criterion

The Akaike Information Criterion (AIC) assumes that the model errors are normally and independently distributed. AIC is computed as:

$$AIC = -\frac{2l}{T} + \frac{2k}{T} \quad \dots \quad (2.19)$$

Where  $l$  is the log-likelihood;  $k$  is the number of parameters to be estimated using  $T$  observations. The model with the lower AIC value is preferred and hence selected.

AIC is often used in model selection for non- nested alternatives.

b) Schwarz Criterion

The Schwarz Criterion also known as the Bayesian Information Criterion (BIC) is an alternative to the AIC that imposes a large penalty for additional coefficients. Like the AIC the BIC assumes that the model errors are normally distributed and the model with the least BIC is also selected. BIC is computed as:

$$\text{BIC} = -\frac{2l}{T} + \frac{k \log T}{T} \quad \dots \quad (2.20)$$

Where  $T$  is the sample size, is the maximized value of the likelihood function for the estimated model (Tsay, 2002).

- F- static

The F- statistic in multiple regression analysis test the hypothesis that the slope coefficients in the regression are zero.

$$F = \frac{R^2 / (k-1)}{1-R^2 / (T-k)} \quad \dots \quad (2.21)$$

...Where  $k$  is the number of parameters to be estimated and  $R^2$  is the measure of variation in the dependent variable caused by the explanatory variables. Under the null hypothesis with normally distributed errors this statistic has an F distribution with  $k - 1$  numerator degrees of freedom and  $T - k$  denominator degrees of freedom. If the p value is less than the significance level  $\alpha$ ., the null hypothesis that is, the slope coefficients are equal to zero is rejected. *F tests* are criticized for the fact that the test is a joint test, so that even if all the *t statistics* are insignificant, the *F statistic* could be highly significant (Tsay, 2002).

### 2.6.3 Model diagnostic techniques (Testing of models)

#### 2.6.4.1. Residual Analysis

As mentioned above conclusions concerning relationships of any system must be based on a model of best fit, that is, a model which seems to fit the data well. A model is plausible if none of its assumptions are grossly violated. Thus, before a model is used to make inferences it must be subjected to diagnostic checking for adequacy (Engle & F, 1982). The residuals are defined as  $\varepsilon_t = y_t - \hat{y}_t$ , where  $y_t$  are observed values  $\hat{y}_t$  are values predicted by the model. A plot of residuals against time should not show any obvious patterns.

#### 2.6.4.2. Test of normality

Gross or minor violation of normality of residuals compromises the estimation of regression coefficients. Sometimes the error distribution is skewed by the presence of a few large outliers since parameter estimation is based on the minimisation of squared error. A few extreme observations can exert a disproportionate influence on parameter estimation. The tests for normality are given in sections to follow.

#### 2.6.4.3. The Jarque-bera Test

The first test of normality is the Jarque-bera (JB) Test (Thadewalda & Büninga, 2007). The Jarque-bera test is a two-sided goodness of fit test suitable when a fully-specified null distribution is unknown and its parameters must be estimated. The test statistic is:

$$JB = \frac{n}{6} \left( S^2 + \frac{(k-3)^2}{4} \right) \dots \quad (2.22)$$

The JB statistic has an asymptotic chi-square distribution with two degrees of freedom and can be used to test the null hypothesis that the data are from a normal distribution. The null hypothesis is a joint hypothesis of both the skewness and excess kurtosis being zero, since samples from a normal distribution have an expected skewness of zero and an expected excess kurtosis of zero. Any deviation from skewness of zero and kurtosis of zero increases is the JB statistic. The weakness of the JB is that it is not a powerful test for small samples

(Bera, 1987). The best alternative if there is a small sample is to generate a Quantile–Quantile (Q – Q) plot using the normal distribution. A straight line in a Q – Q plot indicates normality (Chambers, 1983).

#### ***2.6.4.4. Quantile – Quantile plots***

A Q – Q plot is a probability plot which is a graphical method for comparing two distributions by plotting their quantiles against each other. If the two distributions being compared are similar, the points in the Q – Q plot will approximately lie on the line  $y = x$ . If the distributions are linearly related, the points in the Q – Q plot will approximately lie on a line, but not necessarily on the line  $y = x$ . If the points follow the line  $y = x$  they suggests that the data are normally distributed (Chambers, 1983).

#### ***2.6.4.5. Homoscedasticity***

An assumption of a constant variance in the error terms or innovations of a data series is referred to as an assumption of homoscedasticity. Violations of homoscedasticity make it difficult to gauge the true standard deviation of the forecast errors, usually resulting in confidence intervals that are too wide or too narrow.

##### **a) Plot of residuals against predicted values**

If the assumptions of linearity, independence, Homoscedasticity and normality of General Linear Model are held, then it implies that a plot of residuals against predicted values should show a good fit characterized by small residuals with no apparent structure or pattern.

##### **b) Plot of residuals against independent variables**

A plot of residuals against predicted values results in a horizontal band to indicate a good model.

### 2.6.4.6. Independence of residuals

Ideally, the residuals must not be auto - correlated. Serial correlation in the residuals means that there is room for improvement in the model, and extreme serial correlation is often a sign of a wrongly specified model. Serial correlation is also sometimes a by-product of a violation of the linearity assumption.

#### a) Durbin – Watson Statistic

The Durbin-Watson Test is used to test for presence of auto-correlation. The hypothesis to be tested is:

$$H_0 : \rho = 0 \text{ against } H_1 : \rho \neq 0$$

The above hypothesis is tested indirectly by testing the hypothesis

$$H_0 : \mu_d = 2 \text{ Against } H_1 : \mu_d \neq 2$$

Where  $\mu_d = E(d)$  and the test statistic; is given by:

$$d = \frac{\sum_{t=2}^T (\hat{\mu}_t - \hat{\mu}_{t-1})^2}{\sum_{t=1}^T \hat{\mu}_t^2} \quad \dots \quad (2.23)$$

And

$$p^- = \frac{\sum_{t=2}^n \hat{\mu}_t \hat{\mu}_{t-1}}{\sum_{t=1}^n \hat{\mu}_t^2} \quad \dots \quad (2.24)$$

For large  $n$ .

The decision rule is,

- If  $d < d_L$  reject  $H_0$  in favour of  $H_1$ , i.e in favour of positive correlation.
- If  $d > d_u$  reject  $H_0$  if in favour of  $H_1$ , i.e in favour of negative correlation.

- If  $d_u < d < 4 - d_u$  accept if there i.e. there is no auto-correlation.
- If  $d_L < d < d_u$  the test is considered inconclusive.
- If  $4 - d_L < d < 4 - d_L$  the test is again inconclusive.

(Gujarati, 1995)

## b) Autocorrelation plots of the residuals

A plot of the Autocorrelation Function, of the residuals  $\{\mu_t\}$  against the lag is often performed. If there is no auto-correlation then the Autocorrelation Function coefficients should lie within the 95% confidence band  $\pm \frac{1.96}{\sqrt{n}}$

Where  $n$ , is the sample size. If outside the 95% confidence band there is auto-correlation of some sort. The advantage of this graphical test is that it applies not only to first order autocorrelation, but also to all forms of auto-correlation (Dielman, 1991).

### ***2.6.4.7. Presence of Heteroscedasticity***

If analysis of residuals against the fitted values shows that the assumption of constant variance, a property called homoscedastic is not true. Unequal variances for different setting of the independent variable(s) is said to be heteroscedastic. Weighted regression, autoregressive moving average (ARMA) error models and other models can be used to correct for the effects heteroscedasticity.

## **2.6.4 Stabilizing the variance**

The variance of the innovations is stabilized in order to satisfy the standard regression assumption of homoscedasticity using:

- a) Weighted least square regression.
- b) Simple least square with ARMA error terms.

### 2.6.4.8. Weighted least square regression

The least square criterion weighs each observation equally in determining the estimates of the parameters. The procedure treats all of the data equally giving less precise measured points more influence than they should have and gives highly precise points too little influence. The weighted least squares weighs some observations more heavily than others giving each data point its proper amount of influence over the parameter estimates, and this maximizes the efficiency of parameter estimation. Weighted least square reflects the behaviour of the random errors in the model. To find the parameters of the weighted least square method we minimize:

$$WSSE = \sum_{t=1}^T w_t (y_t - \widehat{y}_t)^2 = \sum_{t=1}^T w_t (y_t - \widehat{\beta}_0 - \widehat{\beta}_1 x_{t-1})^2 \dots (2.25)$$

Where  $w_t$  is the weight assigned to the  $t^{th}$  observation. The weight  $w_t$  in this case can be taken as the reciprocal of the variance of that observation's error term,  $\sigma^2_t$  i.e.

$$w_t = \frac{1}{\sigma^2_t} \dots (2.26)$$

Observations with larger error variances will receive less weight (and hence have less influence on the analysis) than observations with smaller error variances.

Parameter estimates  $\widehat{\beta}_0$  and  $\widehat{\beta}_1$  for the model  $y_t = \beta_0 - \beta_1 x_{t-1} + \varepsilon_t$  are derived as:

$$WSSE = \sum_{t=1}^n w_t (y_t - \widehat{\beta}_0 - \widehat{\beta}_1 x_{t-1})^2 \dots (2.27)$$

$$\frac{\partial WSSE}{\partial \widehat{\beta}_1} = -2 \sum_{t=1}^n w_t (y_t - \widehat{\beta}_0 - \widehat{\beta}_1 x_{t-1}) = 0$$

$$-\sum_{t=1}^n y_t x_{t-1} w_t + \widehat{\beta}_0 \sum_{t=1}^n x_{t-1} w_t + \widehat{\beta}_1 \sum_{t=1}^n x_{t-1}^2 w_t = 0$$

Substituting  $\widehat{\beta}_0$

$$\hat{\beta}_1 = \frac{\sum_{t=1}^n y_t x_{t-1} w_t - \frac{(\sum_{t=1}^n y_t w_t)(\sum_{t=1}^n x_{t-1} w_t)}{\sum_{t=1}^n w_t}}{\sum_{t=1}^n x_{t-1}^2 w_t - \frac{(\sum_{t=1}^n x_{t-1} w_t)^2}{\sum_{t=1}^n w_t}} \dots \quad (2.28)$$

Derived from:  $\text{WSSE} = \sum_{t=1}^n w_t (y_t - \hat{y}_t)^2$ , advanced by (Mendenhall, 1989)

The biggest disadvantage of weighted least squares is the fact that the theory behind this method is based on the assumption that the weights are known exactly. This is almost never the case in real applications, instead estimated weights are used (Carroll, 1988)

#### 2.6.4.9. Simple least square regression with ARMA error terms

For the simple least square regression model:  $y_t = \beta_0 + \beta_1 x_t + \alpha_t$ , an alternative approach to stabilize the variance of  $\alpha_t$ , the error term, can be done by adding a moving average term. The series  $\alpha_t$  of the error term can also be expressed in terms of random errors of its past values, which is then a moving average MA(q) model, where,

$$\alpha_t = c - \theta_1 \mathcal{E}_{t-1} - \theta_2 \mathcal{E}_{t-2} - \dots - \theta_q \mathcal{E}_{t-q} + \mathcal{E}_t \quad \dots \quad (2.29)$$

where  $\theta_j (j = 1, 2, \dots, q)$  are the weights for the moving average terms.  $\alpha_t$  is assumed to be Gaussian white noise, which are independent, identically distributed random variables with mean of zero and constant variance

$\mathcal{E}_t \sim N(0; \sigma^2)$  for all t and  $-1 < \theta_j < 1$  (MacDonald & MacKinnon, 1985).

#### 2.6.4.10. Autoregressive Conditional Heteroscedasticity (ARCH) modelling

In modelling using conventional OLS models of the form  $y_t = a_0 + a_1 y_{t-1} + \varepsilon_t$  where the variance of the innovations  $\{\varepsilon_t\}$  is not constant, the conditional variance can be modelled as an Autoregressive AR (q) process by taking the squares of the estimated residuals

$$\hat{\varepsilon}_t = \alpha_0 + \alpha_1 \hat{\varepsilon}_{t-1}^2 + \alpha_2 \hat{\varepsilon}_{t-2}^2 + \dots + \alpha_q \hat{\varepsilon}_{t-q}^2 + v_t \quad \dots \quad (2.30)$$

Where  $v_t$  is a white-noise process.

The equation  $\hat{\varepsilon}_t = \alpha_0 + \alpha_1 \hat{\varepsilon}_{t-1}^2 + \alpha_2 \hat{\varepsilon}_{t-2}^2 + \dots + \alpha_q \hat{\varepsilon}_{t-q}^2 + v_t$  is known as an Autoregressive Conditional Heteroscedastic (ARCH) model.

Thus an ARCH model is a model with residuals coming from an OLS model. When  $\alpha_1, \alpha_2, \dots, \alpha_q$  are all equal to zero,  $\hat{\varepsilon}_t^2 = \alpha_0$  and thus we have the situation of a constant variance (Enders, 2010)

#### **2.6.4.11. Generalized Autoregressive Conditional Heteroskedasticity modelling**

In dealing with heteroscedasticity, Bollerslev (1987) extended Engel's original work by developing a technique that allows the conditional variance to be an ARMA process. Enders (2010) explains the extension of Engel's work by Bollerslev as follows;

Let the heteroscedastic error process be that,

$$\varepsilon_t = v_t (h_t)^{\frac{1}{2}} \quad \dots \quad (2.31)$$

where  $\sigma_v^2=1$  and

$$h_t = \alpha_0 + \sum_{i=1}^q \alpha_i \varepsilon_{t-i}^2 + \sum_{i=1}^p \beta_i h_{t-i} \quad \dots \quad (2.32)$$

Since  $v_t$  is a white-noise process, the conditional and unconditional means of  $\varepsilon_t$  are equal to zero, therefore taking the expected value of  $\varepsilon_t$ , it is easy to verify that

$$E(\varepsilon_t) = E(v_t (h_t)^{\frac{1}{2}}) = 0 \quad \dots \quad (2.33)$$

The important point is that the conditional variance of  $\varepsilon_t$  is given by  $E_t(\varepsilon_t^2) = h_t$ . Therefore, the conditional variance of  $\varepsilon_t$  is the ARMA process given by the expression  $h_t$  in equation (28). This model is a generalised ARCH (p, q) model called GARCH (p, q) which allows for both autoregressive and moving average components in the heteroscedastic variance.



## 3 Methodology Chapter

The study seeks to identify and measure capabilities which are valued by students in Higher Education. As mentioned in Chapter 1, the objectives of the study are:

- Identify viable indicators of student capabilities
- Create a statistical model or models to measure Capability indicators
- Draft a blueprint on:
  - How best to create a list of Capability Indicators
  - How to clean ordinal and nominal data in order to analyse it statistically
  - The possible information and conclusions that can be derived from a quantitative data inquiry process.

To answer the above research questions and meet the stated objectives, the study was carried out in the ways described in the sections below. The chapter shall elucidate on the methods used to gather, clean and synthesize the data.

### 3.1 Data

#### 3.1.1 List of relevant capabilities

In the measurement of capabilities the most important step is to identify the capability set one is to work with. There are a number of ways to identify this set. Sen (1985) argues that the capability set for any group should be identified through a democratic process of public deliberation (Sen, 1985). This transcendental view of public processes has been critiqued by scholars like Robeyns (2005) who argue that processes of public deliberation are seldom perfectly democratic, as some elements in communities have more power and voice than others and more often than not, the outcomes of such processes reflect the views of just a few powerful individuals (Robeyns, 2005). In as much as I agree with Sen that democratic deliberation is the ideal for selecting a capability set, I am appreciative of the fact that such processes are difficult to realize in actuality because of a number of confounding variables.

Martha Nussbaum (Nussbaum, 2003) provides a pragmatic solution to this conundrum by suggesting a universal list of capabilities. These capabilities she contends are reflective of the general capabilities that people value. The list contains the ten capabilities cited in the previous chapter. As noted earlier, debates about lists of capabilities have been widespread, even though research shows that the existing lists are often fairly similar. As mentioned in the previous chapter, quantitative researchers like Sabina Alkire (Alkire, 2002) have interrogated Nussbaum's list together with over 39 other lists of capabilities and found a strong convergence in the capabilities identified, thereby showing that generic lists of capabilities are powerful instruments in capability studies.

I was therefore persuaded by the arguments above to use Nussbaum's list of capabilities as a backdrop for the capability set. Also as mentioned above, my study is situated in the Higher Education context so I augmented Nussbaum's list of core capabilities with a few capabilities which are applicable to Higher Education in the South African context. Of note is the Language capability which was suggested by Merridy-Wilson Strydom (Wilson-Strydom, 2010). This capability looks at language competency and confidence. The capabilities from these three lists were thoroughly discussed and defended with various entities<sup>8</sup>; some were combined and truncated in the following form:

- Educational Resilience
- Learning Disposition: Language, competence and confidence
- Bodily Health
- Bodily Integrity
- Senses, Imagination, and Thought
- Emotions
- Practical reasoning
- Affiliation
- Leisure
- Control over one's environment

---

<sup>8</sup> The lists were discussed in a panel with the supervisor and the co-supervisor

Ingrid Robeyns gives guidelines for the creation of a capability set and these guidelines were the ones used to validate the list of capabilities which will be used in this project (Robeyns, 2003). The list has the following points which were all considered and met in the preparation of the final capability set shown above:

**Table 2 : Criteria for developing a capability set**

1. **The criterion of explicit formulation:** This is the most basic criterion and implies that the list should be explicit, discussed and defended.
2. **The criterion of methodological justification:** The method used for generating a list must be clearly explained, scrutinised and defended as the most appropriate method for the specific issue at hand.
3. **The criterion of sensitivity to context:** The level of abstraction at which the list is pitched should be appropriate to meet the specific objectives for which it was formulated. A pragmatic approach is recommended taking into account that it is important to speak the language of the debate into which one wishes to engage.
4. **The criterion of different levels of generality:** If the list being developed aims at an empirical application or wishes to lead to specific policy and intervention proposals, then at least two stages should be followed in its design. The first stage involves drawing up an ‘ideal’ list that is unconstrained by the limits of data or measurement, or of socioeconomic or political feasibility. The second stage is focused on drawing up a more pragmatic list that takes such constraints into account.
5. **The criterion of exhaustiveness and non-reduction:** The capabilities included in the list should include all important elements, each of which should not be reducible to the other. While there may be, and often is, some overlap, this should not be substantial. This does not exclude the possibility of a subset having such an important status that it requires consideration on its own, independent of the overall set.

### 3.1.2 Indicators of capabilities

The next step after the identification of a capability set is to create measurable and meaningful indicators of these capabilities. Atkinson (2002) sheds light on what social indicators should both cover and how they are to be framed. Paul Anand further says in the creation of social indicators the concern should be in the existence of a normative justification as well as certain qualities of taxonomy particularly the diversity and comprehensiveness of its constituent elements.

Taking all that into account and using literature as a north-star, indicators for the selected capabilities were identified. The comprehensiveness and comprehensibility of these indicators was validated through rigorous inquiry by panels of different experts<sup>9</sup> over a couple of months.

The indicators for the capabilities which were identified are as follows:

**Table 3 : Capability Indicators**

<b><u>Educational Resilience</u></b>	<b><u>Bodily Health</u></b>	<b><u>Bodily Integrity</u></b>
1. I cope well with academic pressure and challenges. 2. I do not wish I was studying towards another degree.(i.e. enjoy what the degree that I am registered for) 3. I am able to ‘bounce’ back from academic setbacks	1. My health does not in any way limit my daily activities compared with most people of my age 2. I have enough to eat every day 3. I live in adequate accommodation which is conducive for my studies 4. I can afford specialized or private	1. I feel very safe walking alone in the area near my residence (on campus or off-campus) DURING THE DAY time 2. I feel very safe walking alone in the area near my residence (on campus or off-campus) AFTER DARK. 3. I can afford decent clothing

<sup>9</sup> These include Paul Anand- who commented on the list; various researchers affiliated to the Centre for Research on Higher Education and Development at the University of the Free State, Bloemfontein.

<p>4. I was able to deal with the transition from school to University</p> <p>5. I aspire to succeed in my University degree</p>	<p>medical care.</p> <p>5. The university has facilities to cater for all my medical needs</p>	<p>4. I am NOT likely to be a victim of sexual assault during the course of my studies</p> <p>5. I have not been a victim of physical harassment during the course of my studies</p>
<p><b><u>Senses, Imagination, and Thought</u></b></p> <p>1. I can use reasoning to reflect critically on my own beliefs and values</p> <p>2. I can find evidence, examples and reasons to support my views</p> <p>3. I use my imagination and creativity in learning and thinking: To think of what might be, not just what is.</p> <p>4. The knowledge I gain in my studies is extremely important for my for what I want to be someday</p>	<p><b><u>Emotions</u></b></p> <p>1. I value the social support structures that are at my disposal in the university</p> <p>2. At present it is easy for me to enjoy the love care and support of my immediate family and friends</p> <p>3. It is easy for me to express feelings of love, happiness and gratitude compared to other students</p> <p>4. I usually do not express feelings of anger and hatred compared to other students</p> <p>5. I am not fearful or anxious in learning</p>	<p><b><u>Practical Reasoning</u></b></p> <p>1. My idea of a good life is based on my own judgment.</p> <p>2. I have a clear plan of how I would like my life to be.</p> <p>3. I constantly evaluate how I lead my life and where I am going in life</p> <p>4. I have been contributing positively to the community during my studies.</p> <p>5. I find it easy to solve problems which I did not anticipate.</p>

<p>5. I am learning to think about the contents of my academic subjects critically</p> <p>6. I find pleasure in what I am studying.</p>	<p>situations</p>	
<p style="text-align: center;"><b><u>Affiliation</u></b></p> <p>1. I respect, value and appreciate other people.</p> <p>2. I normally meet up with friends or family for a drink or a meal at least once a month.</p> <p>3. I find it easy to imagine the situations of other people and to feel concern. (i.e. 'to put myself in others' shoes').</p> <p>4. I find it easy to relate to my peers in the classroom.</p> <p>5. I am able to participate successfully in groups for learning</p>	<p style="text-align: center;"><b><u>Leisure</u></b></p> <p>1. I have recently been spending time in recreational activities.</p> <p>2. I play sport at the university</p> <p>3. I attend social functions on campus</p> <p>4. I have time to participate in other things on campus besides school work</p> <p>5. I belong to a social club/student association.</p>	<p style="text-align: center;"><b><u>Control over One's Environment</u></b></p> <p>1. I am able to participate in the political activities that affect my life if I want to</p> <p>2. My field of study makes use of my skills, abilities and talents</p> <p>3. I find it easy to relate to my peers in the classroom</p> <p>4. My fellow classmates and lecturers treat me with respect</p> <p>5. I am free to express my political views on campus.</p> <p>6. I am free to practice my religion as I want to on campus.</p>

## **3.2 Measuring Instrument**

### **3.2.1 Background**

A list of capabilities and indicators was crafted in the previous section with the objective of using that list of capabilities captured in indicators as a basis for the identification of valuable student capabilities. This section elucidates on how the study was carried out. Of note, the target population from which the sample was drawn will be described and discussed. From there, the nature of the sample will be explicated. The following sub-sub-sections will provide a motivation for the measuring instrument of choice and a thorough exposition of how the instrument was created and distributed. The rest of the chapter will then describe the nature of the data and the transformations necessary for the data to be analysed properly.

### **3.2.2 Sampling**

The study was done at the Bloemfontein campus of the University of the Free in South Africa. The University of the Free State (UFS) was ideal because there is ethnic, racial and gender demographic diversity in the student population. Further there are seven academic faculties, twenty-three on-campus residences, over sixty student-led and run societies and twenty-four thousand three hundred and ninety-six students affiliated to its main campus. These dynamics make UFS a viable university to study student capabilities.

Yates (1949) provided an exposition of most of the classic sampling methods and concluded that Simple Random Sampling was the best sampling methods if the required outcome is a thoroughly representative sample. This view is supported by McLeod and Bellhouse (1983) who suggest an algorithm for Simple Random Sampling. The name Simple Random Sampling technique gives the spurious impression that it is not statistical but this is not the case. The statistical sampling method behind the simple random sampling technique is as follows:

Let  $P_{k,n}$  be the probability that any particular sample is chosen at the  $k^{\text{th}}$  step of the sampling process,  $k = n, \dots, N$ .

The first  $n$  steps correspond to obtaining the initial sample. The initial step  $k = n$  corresponds to selecting the first  $n$  members of the population so that  $P_{n,n} = 1$ .

Now assume  $P_{k,n} = 1 / \binom{k}{n}$  for  $k > n$ . Then when the  $(k + 1)^{\text{th}}$  member of the population is encountered, either:

- (a) the updated sample does not contain the  $(k + 1)^{\text{th}}$  member, or
- (b) the  $l^{\text{th}}$  population member (for some  $1 < l < k + 1$ ) which was present in the current sample is replaced by the  $(k + 1)^{\text{th}}$  member.

When (a) occurs, the probability of the updated sample is:

$$P_{k+l,n} = P_{k,n} \left[1 - \frac{n}{k+1}\right] = \frac{1}{\binom{k+1}{n}} \dots \quad (3.1)$$

When (b) occurs, the probability that the  $l^{\text{th}}$  member was chosen from among the  $n$  sample members is  $1/n$ . The updated sample could also be obtained if the  $l^{\text{th}}$  member was replaced by any of the other  $(k - n)$  population members not in the current sample. Since each of these possible samples has probability  $P_{k,n}$ , the unconditional probability of the updated sample is :

$$P_{k+l,n} = P_{k,n} \left[n/(k + 1)\right] \left[(1/n) + (k - n)/n\right] = \frac{1}{\binom{k+1}{n}} \dots \quad (3.2)$$

The result follows by induction.

It is observed that in the study that simple random sampling was not operationalized in isolation rather it was combined with a convenience sampling technique whereby the whole population (24 296 students) was approached and presented with the measuring/data collecting instrument via electronic means. The distribution of the instrument to the entire population with each having an equal chance of replying is the random sampling part and the option for the recipients not to participate led to the convenience sampling technique.

Through these, a sufficiently large sample (1504) was obtained comprising of willing respondents.

Tanaka (1987) recommends a statistical method of finding the minimum sample size which can be sufficient for a given population. Thus, to get the minimum sample size  $n$  for a population of  $N = 24\ 396$  with a confidence level of  $x\%$  and a Margin of error of  $\pm e$  we use the following relationship:

$$n = \frac{Z^2 \cdot p \cdot (1-p)}{e^2} \quad \text{or} \quad n = \left( \frac{Z_{(1-\frac{\alpha}{2})} \cdot x \cdot \sigma}{e} \right)^2 \quad \dots \quad (3.3)$$

Where:

Z = Z value from the normal table (e. g. 1.96 for 95% confidence level)

p = percentage picking a choice, expressed as decimal

e = confidence interval or margin of error, expressed as decimal (e. g., .04 =  $\pm 4$ )

Thus for a confidence Interval of 99% and a margin of error of 4 the minimum required sample size is 1040.

### 3.2.3 The questionnaire

There are a couple of instruments which were considered to obtain data for this study but none of them could work for the required sample size and the objectives of the study as well as a survey. Noting that there are various kinds of surveys, a cross-sectional survey was chosen for this project. Blalock (1972) explains the advantages of cross-sectional surveys citing their usefulness in providing data for statistical research. He further notes that cross-sectional surveys provide valuable data in determining relationships, causality and correlations between variables.

Thus a survey was constructed based on the capability indicators. The survey had 89 questions and contained demographic question as well as questions on the indicators of capabilities. Of note, the survey also had a section where students could rank the capabilities according to how much they value each of them. There is also a section where students have to give a numeric indication of their wellbeing. This perception of Wellbeing will be

reconciled in the following chapter with their score for wellbeing which will be obtained from the analysis of the capability indicators in the survey.

The final version of the questionnaire is given in the appendix.

### **3.2.4 Distribution**

Given the expansiveness of the questionnaire and the size of the population, it was practically unfeasible to distribute the survey in hardcopies so an electronic version on the Evasys Electronic Survey Platform<sup>10</sup> was created with the aid of the Directorate for Institutional Research and Planning (DIRaP) at the University of the Free State. After getting all due clearances (ethical and institutional)<sup>11</sup>, individualized links to the survey were emailed to 24 396 students on the 29<sup>th</sup> of October 2013. The survey was perfectly anonymous; the links had personalized passwords which disabled students from completing the survey twice. To boost responses, the Centre for Research on Higher Education and Development, donated an iPad to a random respondent as an incentive. The survey was live for two weeks but most of the data was collected within the first week.

### **3.2.5 Data collection and handling**

1503 students completed the survey. This number is above the minimum sample size required for statistical inferences as calculated above.

The data was obtained at the close of the survey after the two weeks and it was obtained in two formats, in CSV format and SPSS formats.

The next subsection shall describe in detail the way in which the data was cleaned, coded and transformed in order for it to be analysed statistically.

---

<sup>10</sup> This is an online survey host

<sup>11</sup> Copies of these are in the Appendix

### 3.3 Synthesis

#### 3.3.1 Coding

As shown in the previous sections, most of the questions in the survey solicited an ordered response. The questions were mostly Likert scale questions coded as follows:

**Table 4: Likert\_scale**

<b>Disagree strongly</b>	<b>Disagree Moderately</b>	<b>Neutral</b>	<b>Agree moderately</b>	<b>Agree strongly</b>
<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
<b>(DS=1)</b>	<b>(D=2)</b>	<b>(N=3)</b>	<b>(A=4)</b>	<b>(AS=5)</b>

This was the coding used for most of the questions with the exception of a few questions which solicited continuous and other responses (e.g. Mark and all open questions).

The first step after collecting the data was to clean the data and remove some respondents who had completed the study but had not indicated explicit consent. This is because in the e-mail sent to students; they were informed that the survey was voluntary and participation was on explicit voluntary basis. Thus all those who indicated tacitly or explicitly they were not interested in the study were excluded from the analysis for ethical reasons. The copies of the ethical clearances obtained for this study are attached in the appendix.

After sieving out the unwilling students, there were 1 496 respondents remaining whose data we could use in the analysis. These responses were perfectly anonymous, further respondents were given numbers as identification from 1 to 1 496. A matrix of respondents together with their responses was created in Microsoft Excel and the responses and answers were coded.

The codes for the answers were simply Q1 for the first question in the questionnaire to Q87 which was the last question.

Of note, codes Q1 through to Q10 were demographic questions and Q11-Q65 were responses to the capability indicator questions ordered in sets of the capabilities they indicate. The rationale of this ordering will be discussed below. Finally, the last questions were basically summaries of how students ranked capabilities based on their perceptions and how they perceived the 'Wellbeing'.

A score for each capability was then formed by summing a set of responses to questions associated with the given capability. The next sub-section explains the statistical methods behind this transformation.

### **3.3.2 Threshold Analyses: Data Transformation**

The greatest statistical violations occur when researchers using regression or Structured Equation Modelling (SEM) fail to make necessary and accurate data to non-continuous data. These violations occur when numeric qualitative data is treated and handled as quantitative data. Scholars like K.A Bollen (1989) have been highlighting these violations but researchers still make them.

As said above, the primary data collected in this study is ordinal in scale as most of the questions were Likert-scale items. This means the data needs to be transformed to continuous data i.e. quantitative data. To do this, a statistical method proposed by McKelvey and Zavoina called Threshold Analyses will be employed (McKelvey & Zavoina, 1975). Most researchers capitalize on the fact that ordinal variables have metric properties similar to continuous variables as noted by Flora and Curran (2004) and thus work with ordinal as if it is continuous. This relationship is highly spurious on the grounds that ordinal variables have no units of measurement and are not continuous and thereby not normally distributed. This assumption leads to a superfluity of conundrums as errors associated with heteroscedasticity begin to emerge. The solution would be to transform the data using the Threshold analyses method in order to get accurate and informative covariance, mean matrices for the data and correlations (Joreskog, 2002).

The threshold analyses are founded on the postulation that for each ordinal variable T, there exists an underlying continuous variable,  $X^*$ , in which  $-\infty < X^* < \infty$ . The latent continuous variable  $X^*$  represents the affect underlying the ordered responses which solves the problem of unequal weights for all the questions (Perakis, et al., 2005). The underlying distribution can be parameterized in two ways, either by standard parameterization e.g. the Standard Normal distribution with a mean of zero and a variance of 1 or using an alternative threshold method.

The alternative parameterization method is most suitable when using fixed or equal threshold analyses. With standard parameterization, all underlying variables are standardized to a mean of zero and a variance of one. When the choices are similar across a number of questions, the differences in the distributions of these variables are reflected in the differences in the means and variances of the underlying variables. Alternative parameterization makes use of these differences. Joreskog indicates that alternative parameterization is equivalent to standard parameterization, in that there is a one-to-one correspondence between the parameters resulting from each type of parameterization (Joreskog, 2002). The difference in the two forms of parameterization as suggested by Joreskog is:

**Table 5 : Parameters resulting from Standard and Alternative Parameterization**

Parameterization	Mean	Standard deviation	Thresholds
Standard	0	1	$\tau_1, \tau_2, \tau_3 \dots \tau_{11}$
Alternative	$\mu^*$	$\sigma^*$	$0, 1, \tau_3 \dots \tau_{m-1}^*$
<b>Note:</b>	$\mu^* = -\tau_1/(\tau_2 - \tau_1),$ $\sigma^* = 1/(\tau_2 - \tau_1),$ $\tau^* = (\tau_i - \tau_1)/(\tau_2 - \tau_1) \quad \text{in which } i = 3, 4 \dots, m - 1$		

The above alternative parameterization method was operationalized in the study in the following manner:

Referring to the Likert scale given above, the possible response categories are ‘Disagree Strongly’ (DS), ‘Disagree’ (D), ‘Neutral (N), ‘Agree’ (A) and ‘Agree Strongly’ (AS). This ordinal variable X, is mapped onto a continuous variable,  $X^*$  which reflects the

study participant's degree of support for the target statement. In the research project, for the ordinal scale with five response choices, the observed  $X$  is related to  $X^*$  according to the following measurement model:

$$\mathbf{X} = \begin{cases} 1 \rightarrow \text{DS} & \text{if} & \tau_0 = -\infty \leq X^* < \tau_1 \\ 2 \rightarrow \text{D} & \text{if} & \tau_1 \leq X^* < \tau_2 \\ 3 \rightarrow \text{N} & \text{if} & \tau_2 \leq X^* < \tau_3 \\ 4 \rightarrow \text{A} & \text{if} & \tau_3 \leq X^* < \tau_4 \\ 5 \rightarrow \text{AS} & \text{if} & \tau_4 \leq X^* < \tau_5 = \infty \end{cases} \quad \dots \quad (3.4)$$

Where DS stands for Disagree strongly, D for Disagree, N for Neutral, A for Agree and AS for Agree Strongly.

The underlying continuous variables  $X^*$ , rather than the observed ordinal variables  $X$ , were thus used for the analyses in the next chapter.

Zuckerman argues that if ordinal variables are prime and irreducible then their natural sum is continuous<sup>12</sup> (Zuckerman, 1971). Thus integrating this corollary and the Threshold method described above the natural sums of the coded ordinal variables were calculated and mapped back to the original capabilities they represent/indicate.

Ineluctably, out of the 65  $X$  variables we ended with 9  $X^*$  variables which are continuous in nature. These were then coded according to the capability sets they represent: LEARNING, HEALTH, INTEGRITY, SENSES, EMOTIONS, REASON, AFFILIATION, LEISURE and ENVIRONMENT.

---

<sup>12</sup> Sum of ordinal numbers is continuous

### 3.4 Regression Parameter Estimation Methods

The regression estimation method of choice is the Maximum Likelihood Estimation (MLE) method. This section will prove that Ordinal Least Squares Regression (OLS) produces the same estimators as MLE.

#### 3.4.1 OLS Bivariate model

A brief description of the model is given below to inform the application. The bivariate model as given in chapter 2 is in the form

$$y_i = a + bx_i + e_i \quad \dots \quad (3.5)$$

This model can be rewritten as

$$y_i = a + bx_i + u_i \quad \dots \quad (3.6)$$

Where  $\hat{e}_i = \hat{u}_i = y_i - \hat{y}_i$  represents the residuals or the error term... The best regression model would be that with the Least Sum of Squares of the residuals.

$$SSE = \sum_{i=1}^n \hat{u}_i^2 = \sum_{i=1}^n (y_i - \hat{y}_i)^2 = \sum_{i=1}^n [y_i - (\hat{a} + \hat{b}x_i)]^2 = \sum_{i=1}^n (y_i - \hat{a} - \hat{b}x_i)^2 \quad \dots \quad (3.7)$$

The best model is:

$$\min SSE = \sum_{i=1}^n (y_i - \hat{a} - \hat{b}x_i)^2 \quad \dots \quad (3.8)$$

To find the estimates for a and b we minimize the SSE by i) taking the first order partial derivatives with respect to  $\hat{a}$  and  $\hat{b}$ , ii) setting the resulting equations equal to zero, iii) solving the first order conditions (FOC) for  $\hat{a}$  and  $\hat{b}$ , and iv) checking the second order conditions for a maximum or minimum. Taking the first order partial derivatives w.r.t.  $\hat{a}$  and  $\hat{b}$  and setting them equal to zero, the following two equations are obtained:

$$\frac{\partial SSR}{\partial \hat{a}} = \sum_{i=1}^n [2(y_i - \hat{a} - \hat{b}x_i)(-1)] = \sum_{i=1}^n -2(y_i - \hat{a} - \hat{b}x_i) = 0,$$

and

.. (3.9)

$$\frac{\partial SSR}{\partial \hat{b}} = \sum_{i=1}^n [2(y_i - \hat{a} - \hat{b}x_i)(-x_i)] = \sum_{i=1}^n -2x_i(y_i - \hat{a} - \hat{b}x_i) = 0.$$

The two equations above with two unknowns  $\hat{a}$  and  $\hat{b}$  are obtained from the first order conditions. To solve the two equations for the estimators the following steps are taken:

**Table 6: OLS\_ Solving for a**

Mathematical Deviation	Step involves
$\sum -2(y_i - \hat{a} - \hat{b}x_i) = 0$	Original FOC
$\sum (y_i - \hat{a} - \hat{b}x_i) = 0$	Divide both sides by -2
$\sum y_i - \sum \hat{a} - \sum \hat{b}x_i = 0$	Distribute the summation operator
$\sum y_i - n \hat{a} - \hat{b} \sum x_i = 0$	Summation over a constant
$n\hat{a} = \sum y_i - \hat{b} \sum x_i$	Subtraction
$\hat{a} = \frac{1}{n} \sum y_i - \frac{1}{n} \hat{b} \sum x_i$	Divide by n
$\hat{a} = \bar{y} - \hat{b}\bar{x}$	Definition of a mean

To derive the next estimate the following steps are followed:

Table 7: OLS\_ Solving for b

Mathematical Deviation	Step involves
$\sum -2x_i(y_i - \hat{a} - \hat{b}x_i) = 0$	Original FOC
$\sum x_i(y_i - \hat{a} - \hat{b}x_i) = 0$	Divide both sides by -2
$\sum x_i y_i - \sum \hat{a} x_i - \sum \hat{b} x_i x_i = 0$	Distribute the summation operator and $x_i$
$\sum x_i y_i - \hat{a} \sum x_i - \hat{b} \sum x_i^2 = 0$	Summation over a constant
$\sum x_i y_i - [\frac{1}{n} \sum y_i - \frac{1}{n} \hat{b} \sum x_i] \sum x_i - \hat{b} \sum x_i^2 = 0$	Substitute the definition for the $\hat{a}$
$\sum x_i y_i - \frac{1}{n} \sum y_i \sum x_i - \hat{b} [-\frac{1}{n} \sum x_i \sum x_i + \sum x_i^2] = 0$	Use the distributive law and then factor out $\hat{b}$ , careful with the negative and positive signs
$\hat{b} = \frac{\sum x_i y_i - \frac{1}{n} \sum y_i \sum x_i}{-\frac{1}{n} \sum x_i \sum x_i + \sum x_i^2}$	Solve for $\hat{b}$

The final estimators are:

$$\hat{a} = \bar{y} - \hat{b}\bar{x}$$

$$\hat{b} = \frac{n \sum_{i=1}^n x_i y_i - \sum_{i=1}^n x_i \sum_{i=1}^n y_i}{n \sum_{i=1}^n x_i^2 - (\sum_{i=1}^n x_i)^2} \quad \dots \quad (3.10)$$

### 3.4.2 OLS Multivariate Case

The multivariate form of the OLS is:

$$y_i = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \beta_3 x_{3i} + \dots + \beta_p x_{pi} + \varepsilon_i$$

Which in matrix notation can be written as:

$$\mathbf{Y} = \mathbf{XB} + \mathbf{e} \quad \dots \quad (3.11)$$

Where:

$$\mathbf{Y} = \begin{bmatrix} y_1 \\ y_2 \\ \cdot \\ \cdot \\ y_N \end{bmatrix}, \mathbf{B} = \begin{bmatrix} B_0 \\ B_1 \\ \cdot \\ \cdot \\ B_k \end{bmatrix}, \mathbf{e} = \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \cdot \\ \cdot \\ \varepsilon_N \end{bmatrix} \quad \text{and} \quad \mathbf{X} = \begin{bmatrix} 1 & x_{11} & x_{12} & \dots & x_{1k} \\ 1 & x_{21} & x_{22} & \dots & x_{2k} \\ \vdots & \vdots & \vdots & \dots & \vdots \\ 1 & x_{N1} & x_{N2} & \dots & x_{Nk} \end{bmatrix}$$

$\mathbf{Y}$  is an  $N \times 1$  column matrix of cases' scores,  $\mathbf{X}$  is an  $N \times (k + 1)$  matrix,  $\mathbf{B}$  is a  $(k + 1) \times 1$  column matrix containing the regression constant and coefficients, and  $\mathbf{e}$  is an  $N \times 1$  column matrix of cases' errors of prediction.

Like with the univariate case, the goal is to find the values of  $\mathbf{B}$  which minimizes the sum of squared errors. That is:

$$SSE = \mathbf{e}'\mathbf{e} \quad \dots \quad (3.12)$$

Where

$$\mathbf{e} = \mathbf{Y} - \mathbf{XB} \quad \dots \quad (3.13)$$

Substituting the expression on the right side into Equation (3.4.8), we get:

$$SSE = (\mathbf{Y} - \mathbf{XB})'(\mathbf{Y} - \mathbf{XB}) \quad \dots \quad (3.14)$$

Distributing the matrix above

$$SSE = \mathbf{Y}'\mathbf{Y} - \mathbf{Y}'\mathbf{XB} - \mathbf{B}'\mathbf{X}'\mathbf{Y} + \mathbf{B}'\mathbf{X}'\mathbf{XB} \quad \dots \quad (3.15)$$

If multiplied out, the two middle terms –  $\mathbf{Y'XB}$  and  $\mathbf{B'X'Y}$  -- are identical: they produce the same scalar value. As such, the equation can be further simplified to:

$$SSE = \mathbf{Y'Y} - 2\mathbf{Y'XB} + \mathbf{B'X'XB} \quad \dots \quad (3.16)$$

We now have an equation which expresses SSE in terms of  $\mathbf{Y}$ ,  $\mathbf{X}$ , and  $\mathbf{B}$ . The next step – as in the bivariate case – is to take the derivative of SSE with respect to the matrix  $\mathbf{B}$ . Since we're really dealing with a set of variables in this differentiation problem – we again use the partial derivative operator:

$$\frac{\partial SSE}{\partial \mathbf{B}} = \frac{\partial}{\partial \mathbf{B}} (\mathbf{Y'Y} - 2\mathbf{Y'XB} + \mathbf{B'X'XB}) \quad \dots \quad (3.17)$$

To solve the derivative above, we follow the following steps:

- i) All matrices besides  $\mathbf{B}$  are treated as equivalent of constants; the first term in brackets – based completely on the  $\mathbf{Y}$  matrix has a derivative of zero.
- ii) The middle term is the equivalent of a scalar term in which the variable we are differentiating with respect to is raised to the first power, which means we obtain the derivative by dropping the  $\mathbf{B}$  and taking the transpose of all the matrices in the expression which remain, giving us  $-\mathbf{2X'Y}$ .
- iii) The third term is the equivalent of a scalar term in which the variable we are differentiating with respect to is raised to the second power. This means we obtain the derivative by dropping the  $\mathbf{B'}$  from the term and multiplying by two, giving us  $\mathbf{2X'XB}$ . Thus, the full partial derivative is

$$\frac{\partial SSE}{\partial \mathbf{B}} = -\mathbf{2X'Y} + \mathbf{2X'XB} \quad \dots \quad (3.18)$$

Setting this partial derivative to zero and solve for the matrix  $\mathbf{B}$  will give us an expression for the matrix of estimates that minimize the sum of the squared errors of prediction.

$$0 = -\mathbf{2X'Y} + \mathbf{2X'XB} \quad \dots \quad (3.19)$$

Subtracting  $2\mathbf{X}'\mathbf{X}\mathbf{B}$  from each side of the equation yields:

$$-2\mathbf{X}'\mathbf{X}\mathbf{B} = -2\mathbf{X}'\mathbf{Y} \quad \dots \quad (3.20)$$

Multiplying each side of the equation by  $-\frac{1}{2}$ :

$$\mathbf{X}'\mathbf{X}\mathbf{B} = \mathbf{X}'\mathbf{Y} \quad \dots \quad (3.21)$$

Solving for B by pre-multiplying each side of the equation the inverse of  $(\mathbf{X}'\mathbf{X})$ , i.e.,  $(\mathbf{X}'\mathbf{X})^{-1}$  :

$$\mathbf{B} = (\mathbf{X}'\mathbf{X})^{-1} \mathbf{X}'\mathbf{Y} \quad \dots \quad (3.22)$$

Equation (3.4.19) is the OLS estimator.

This is like the bivariate case where  $\mathbf{X}'\mathbf{Y}$  gives the sum of the cross-products of  $\mathbf{X}$  and  $\mathbf{Y}$ ,  $\mathbf{X}'\mathbf{X}$  gives us the sum of squares for  $\mathbf{X}$ .

The next step is to compare this estimator to the Maximum Likelihood estimator:

### 3.4.3 Maximum Likelihood Estimator

For a Normal distribution with regression equation:

$$y_i = a + bx_i + e_i \quad \dots \quad (3.23)$$

Where  $e_i \sim N(0, \sigma^2)$  the term  $y_i \sim N(a + bx, \sigma^2)$

The likelihood function using MLE is:

$$L(a, b) = \prod \frac{1}{\sigma\sqrt{2\pi}} \exp\left\{-\frac{1}{2}\left(\frac{y_i - a - bx_i}{\sigma}\right)^2\right\} \quad \dots \quad (3.24)$$

$$\therefore \ln(L) = \text{constant} - \frac{1}{2} \sum \left(\frac{y_i - a - bx_i}{\sigma}\right)^2 \quad \dots \quad (3.25)$$

So maximizing L is equivalent to minimizing  $\sum (y_i - a - bx_i)^2$  which is SSE from (3.4.5).

That is:

$$\min SSE = \sum_{i=1}^n (y_i - a - bx_i)^2 \quad \dots \quad (3.26)$$

Thus:

$$\frac{\partial SSR}{\partial a} = \sum_{i=1}^n [2 (y_i - a - bx_i) (-1)] = \sum_{i=1}^n -2(y_i - a - bx_i) = 0,$$

and ... (3.27)

$$\frac{\partial SSR}{\partial b} = \sum_{i=1}^n [2 (y_i - a - bx_i) (-x_i)] = \sum_{i=1}^n -2x_i(y_i - a - bx_i) = 0.$$

Solving the two equations for a and b gives:

$$a = \bar{y} - b\bar{x}$$

$$b = \frac{n \sum_{i=1}^n x_i y_i - \sum_{i=1}^n x_i \sum_{i=1}^n y_i}{n \sum_{i=1}^n x_i^2 - \left(\sum_{i=1}^n x_i\right)^2} \quad \dots \quad (3.28)$$

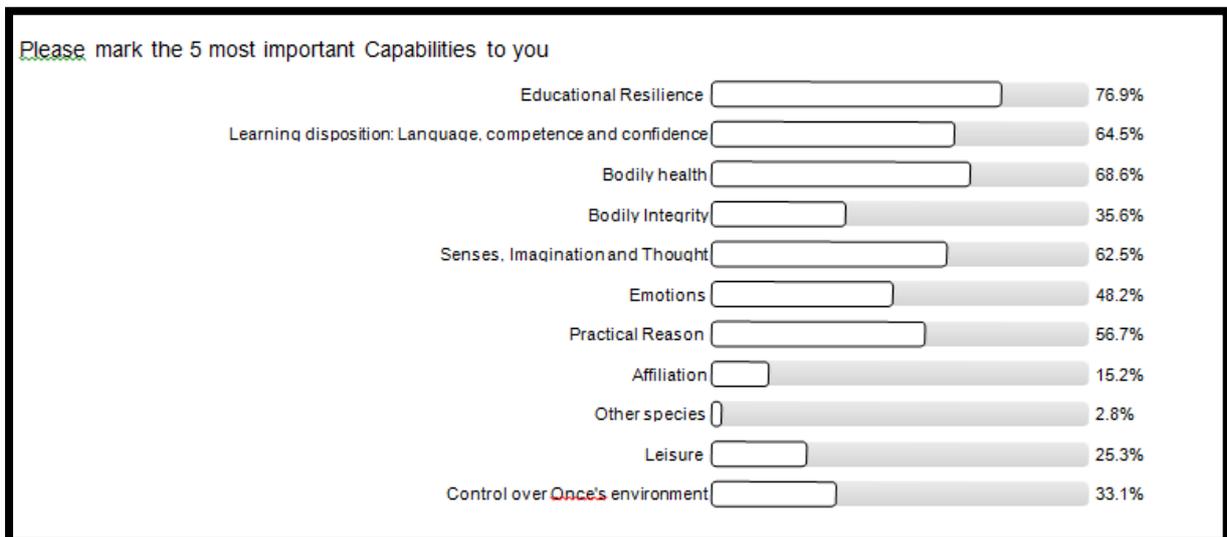
The above estimators are the same as the least squares estimators. A similar argument can be made for the multiple regression case.

## 4 Chi-squared tests: Contingency table analysis

The chapter shows the tests done to test the validity of the measuring instrument.

### 4.1 Introduction: Student perceptions

As mentioned in the previous chapter, the survey had a section where students could rank the capabilities according to the way they value them. **Figure 28** below shows the capabilities which students ranked as important based on their perceptions.



**Figure 5 :Well-being perception**

The above capabilities will be contrasted with the capabilities identified through Structural Equation Modelling to see if there is substantial value in student perceptions. This chapter uses contingency tables to perform Chi-squared tests and log-linear analysis to evaluate the relationship between student perception and the indicators of capabilities used in the measuring instrument. A conclusion of association between the two gives integrity to the instrument.

#### 4.2 Background: Contingency tables and Chi squared tests

Contingency tables describe the relationship between any two categorical variables. Chi squared tests are used to compare capability indicator responses and wellbeing score as shown below:

**Table 8: Chi-squared contingency table**

A (Capability variable score)	B (Wellbeing score)				Row total
	1 to 5	6	...	10	
Strongly disagree	$o_{11}$	$o_{12}$	...	$o_{1J}$	$R_1$
Disagree	$o_{21}$	$o_{22}$	...	$o_{2J}$	$R_2$
⋮	⋮	⋮	⋮	⋮	⋮
Strongly agree	$o_{I1}$	$o_{I2}$	...	$o_{IJ}$	$R_I$
<b>Column total</b>	$K_1$	$K_2$	...	$K_J$	<b>Grand total</b>

The chi-square test is used to determine whether or not the two categorical variables are statistically independent. If they are independent there is no association between them. For the joint distribution of the counts  $n_{ij}$  where  $i = 1, 2, \dots, I$  and  $j = 1, 2, \dots, J$ . Let marginal probabilities of an observation that will fall in row  $i$  and column  $j$  be denoted by:

$$\pi_{i.} = \sum_{j=1}^J \pi_{ij}$$

$$\pi_{.j} = \sum_{i=1}^I \pi_{ij}$$

If the row and column are independent:

$$\pi_{ij} = \pi_{i.} \pi_{.j}$$

We thus consider the following hypothesis

$$H_0: \pi_{ij} = \pi_i \cdot \pi_{.j}$$

vs.

$H_1$  that  $\pi_{ij}$  are free. Under  $H_0$ , the MLE of  $\pi_{ij}$  is

$$\begin{aligned}\hat{\pi}_{ij} &= \hat{\pi}_i \cdot \hat{\pi}_{.j} \\ &= \frac{n_i}{n} \times \frac{n_{.j}}{n}\end{aligned}$$

Under the alternative, the MLE of  $\pi_{ij}$  is

$$\tilde{\pi}_{ij} = \frac{n_{ij}}{n}$$

These estimates can be used to form a likelihood ratio test or an asymptotically equivalent Pearson Chi-squared test:

$$\chi^2 = \sum_{i=1}^I \sum_{j=1}^J \frac{(O_{ij} - E_{ij})^2}{E_{ij}} \quad \dots \quad (4.1)$$

Here the  $O_{ij}$  are the observed counts ( $n_{ij}$ ). The expected counts, the  $E_{ij}$ , are the fitted counts.

$$E_{ij} = n \hat{\pi}_{ij} = \frac{n_i \cdot n_{.j}}{n}$$

Pearson's Chi-square statistics is  $\therefore$

$$\chi^2 = \sum_{i=1}^I \sum_{j=1}^J \frac{(n_{ij} - \frac{n_i \cdot n_{.j}}{n})^2}{\frac{n_i \cdot n_{.j}}{n}} \quad \dots \quad (4.2)$$

Under the null hypothesis the marginal probabilities are estimated from the data and are specified by  $(I - 1) + (J - 1)$  independent parameters. Thus the degrees of freedom  $df$  are:

$$df = IJ - 1 - (I - 1) - (J - 1) = (I - 1)(J - 1) \quad \dots \quad (4.3)$$

By means of the above mentioned chi-square ( $\chi^2$ -test) it is possible to test the hypothesis that the two variables are independent. The steps for the test are listed below:

1.  $H_0$ : the two categorical variables are independent (no association).

versus

$H_1$ : the two categorical variables are dependent (association exists).

2.  $\alpha = 0.05$  is the significance level.
3. The test statistic is calculated as follows;

$$\chi^2 = \sum_{i=1}^I \sum_{j=1}^J \frac{(O_{ij} - E_{ij})^2}{E_{ij}}$$

with

$I$  = number of rows in a contingency table (number of groups for variable 1),

$J$  = number of columns in a contingency table (number of groups for variable 2),

Where

$$E_{ij} = \frac{(\text{row total in contingency table})(\text{column total in contingency table})}{n} = \frac{R_i \times K_j}{n}$$

= Expected value of the variable

and

$O_{ij}$  = observed frequency of the variable.

4. Calculate the p-value and compare with  $\alpha$  mentioned in step 2.

5. Reject  $H_0$  if statistical p value  $< \alpha$ .

6. A conclusion is then made as to the meaning of the statistical test.

Values of the calculated Chi-Squared ( $C$ ) close to 0 imply we cannot reject  $H_0$  and there is no association between the two variables. Values of the calculated Chi-Squared significantly greater than 0 imply an association between the Capability variable and the Wellbeing variable. The table below summarized these decision rules.

**Table 9: Chi- Squared decision table**

Test statistics	Distribution of Test statistics under $H_0$	Table with critical values
$C = \sum_{i=1}^I \sum_{j=1}^J \frac{(O_{ij} - E_{ij})^2}{E_{ij}}$ <p>With <math>E_{ij} = \frac{R_i K_j}{n}</math></p>	<p>Approximately <math>\chi^2\{(I - 1)(J - 1)\}</math></p> <p>If n is large</p> <p>and <math>E_{ij} &gt; 5</math> for all i and j</p>	<p>Critical values of the <math>\chi^2</math> – distribution</p>
<p><b>Hypotheses</b></p>	<p><b>Decision rule:</b></p> <p><b>Reject <math>H_0</math> if</b></p>	<p><b>P –value</b></p>
<p><math>H_0</math>: Row and column factors are independent</p> <p><math>H_1</math>: Row and column factors are dependent</p>	$C \geq \chi_{(i-1)(j-1),\alpha}^2$	$p = P(C \geq c)$ <p><math>c</math> is a critical value</p>

### 4.3 Contingency tables and Log-linear analysis

The log-linear analysis technique allows the analysis of the interaction structure between the factors of an observed two dimensional, three-dimensional or multi-dimensional contingency table.

For a general two-way table with a sample of  $n$  entities the ‘expected’ frequency  $v_{ij}$  of an  $(I \times J)$  contingency table can be drawn by:

$$v_{ij} = n X P$$

$$i = 1,2,3, \dots, I \text{ and } j = 1,2,3, \dots, J$$

The log linear model representation is now based on

$$\xi_{ij} = \ln(v_{ij}); \quad i = 1,2,3, \dots, I \text{ and } j = 1,2,3, \dots, J$$

(Steyn, Smit, du Toit, & Strasheim, 1994)

The logarithms of expected frequencies of the  $(I \times J)$  contingency table considered in this study are in the following fashion:

**Table 10: Logarithms of expected frequencies**

A (Capability variable score)	B (Wellbeing score)				Average
	1 – 5	6	...	10	
Strongly disagree	$\xi_{11}$	$\xi_{12}$	...	$\xi_{1J}$	$\bar{\xi}_{r1}$
Disagree	$\xi_{21}$	$\xi_{22}$	...	$\xi_{2J}$	$\bar{\xi}_{r2}$
⋮	⋮	⋮	⋮	⋮	⋮
Strongly agree	$\xi_{I1}$	$\xi_{I2}$	...	$\xi_{IJ}$	$\bar{\xi}_{rI}$
<b>Average</b>	$\bar{\xi}_{k1}$	$\bar{\xi}_{k2}$	...	$\bar{\xi}_{kJ}$	$\bar{\xi}$

If  $\bar{\xi}_{ri}$ ,  $\bar{\xi}_{kj}$  and  $\bar{\xi}$  respectively indicate the row, column and total means of the  $\xi$  values, it follows that  $\xi_{ij}$  can be expressed as follows:

$$\begin{aligned} \xi_{ij} &= \bar{\xi} + (\bar{\xi}_{ri} - \bar{\xi}) + (\bar{\xi}_{kj} - \bar{\xi}) + (\xi_{ij} - \bar{\xi}_{ri} - \bar{\xi}_{kj} + \bar{\xi}) \\ &= \mu + \lambda_i^A + \lambda_j^B + \lambda_{ij}^{AB} \quad , \quad i = 1,2, \dots, I \text{ and } j = 1,2,3, \dots, J \quad \dots \quad (4.4) \end{aligned}$$

Where:

$\mu = \bar{\xi}$  , the mean effect

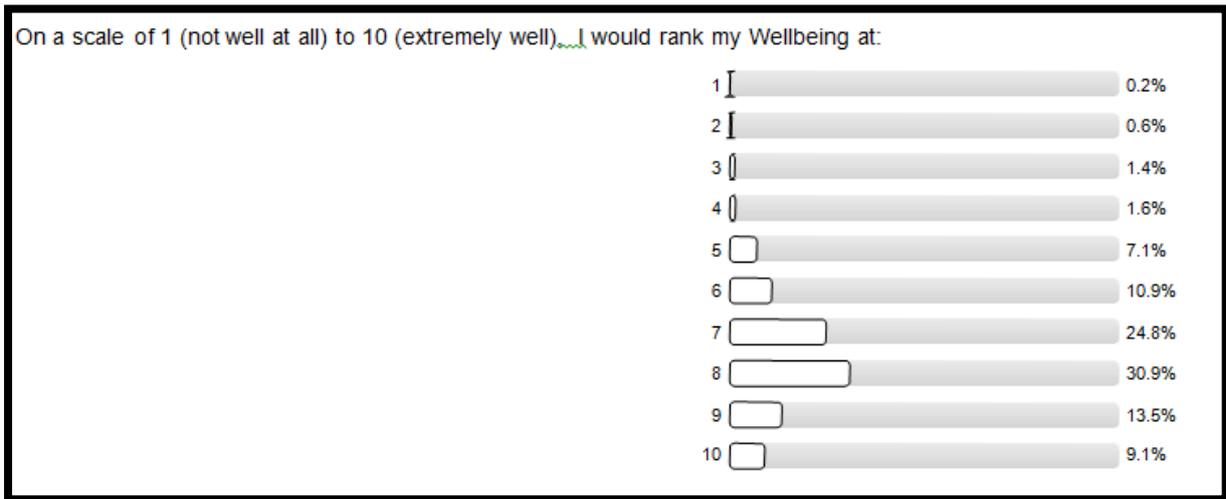
$\lambda_i^A = (\bar{\xi}_{ri} - \bar{\xi})$ , the effect of capability variable  $A_i$

$\lambda_j^B = (\bar{\xi}_{kj} - \bar{\xi})$ , the effect of wellbeing variable  $B_j$

$\lambda_{ij}^{AB} = (\xi_{ij} - \bar{\xi}_{ri} - \bar{\xi}_{kj} + \bar{\xi})$ , the interaction effect between  $A_i$  and  $B_j$

#### 4.4 Wellbeing Perceptions and Variables: A contingency table analysis

The relationship between the student perception of wellbeing and the variables used in the survey is important in validating the measuring instrument and concomitantly, the analysis. The figure below shows the student ranking of their wellbeing based on perception.



**Figure 6: Aggregate perceived Wellbeing**

Rankings 1 up to 5 were then combined to ensure expected values above 5 for each cell in a Contingency table. This is a key requirement for the log linear analysis to be applied.

Frequencies of the responses are presented in a tabular form. The rows represent the capability variable on a Likert scale (1 strongly disagree and 5 strongly agree) and the columns represent the Wellbeing variable (1-5(not so well) up to 10(extremely well)).

The following Hypothesis is then investigated.

$H_0$ : Self wellbeing ranking and variable are Independent

$H_1$ : There is association between self wellbeing ranking and variable

Using a strict criteria (significance level of 0.05), the tables below summaries the main conclusions with regard to association between the categorical variables. Values of the Likelihood Ratio/Chi-squared p-value close to 0 imply we cannot reject  $H_0$  and there is no association between the two variables. Values of the Likelihood Ratio/Chi-squared p-value significantly greater than 0 imply an association between the Capability variable and the Wellbeing variable. The results below show a summary of the tests.

**Table 11: Educational resilience indicators**

<b>Educational Resilience Capability</b>	<b>Pearson Chi-Square p-value</b>	<b>Reject Null Hypothesis?</b>	<b>Likelihood Ratio p-value</b>	<b>Reject Null Hypothesis?</b>
<b>I cope well with academic pressure and challenges.</b>	(457.88) 0.000	Yes	(213.68) 0.000	Yes
<b>I do not wish I was studying towards another degree.(i.e. I enjoy what the degree that I am registered for)</b>	(91.00) 0.000	Yes	(88.50) 0.000	Yes
<b>I am able to ‘bounce’ back from academic setbacks</b>	(409.10) 0.000	Yes	(179.19) 0.000	Yes
<b>I was able to deal with the transition from school to University</b>	(126.38) 0.000	Yes	(110.46) 0.000	Yes
<b>I aspire to succeed in my University degree</b>	(114.20) 0.000	Yes	(69.74) 0.001	Yes

All the variables under the Educational resilience capability are significant reflecting that there is an association between them and student's perception of wellbeing.

**Table 12: Learning Disposition and Bodily Health Capability Indicators**

<b>Learning Disposition Capability</b>	<b>Pearson Chi-Square p-value</b>	<b>Reject Null Hypothesis?</b>	<b>Likelihood Ratio p-value</b>	<b>Reject Null Hypothesis?</b>
<b>Learning new things is easy for me</b>	(241.28) 0.000	Yes	(130.58) 0.000	Yes
<b>High school equipped me with skills required for University study.</b>	(123.79) 0.000	Yes	(105.46) 0.000	Yes
<b>I am confident in my ability to learn.</b>	(332.41) 0.000	Yes	(188.59) 0.000	Yes
<b>I am fluent in my language of instruction indicated in Section 1.</b>	(127.25) 0.000	Yes	(87.23) 0.000	Yes
<b>I have access to all the study material I need.</b>	(165.32) 0.000	Yes	(131.45) 0.000	Yes
<b>I have my own laptop/computer to do my assignments.</b>	(92.31) 0.010	Yes	(79.97) 0.010	Yes
<b>I turn to my lecturers and/or use university academic support structures when I am facing academic challenges.</b>	(104.82) 0.000	Yes	(89.93) 0.000	Yes
<b>I feel confident to speak out and express my views in my classes</b>	(143.93) 0.000	Yes	(114.92) 0.000	Yes

There is a relationship with all the variables under the Learning disposition capability. The University of the Free state is equipped with state of the art computer laboratories.

**Table 12: (cont.) Bodily Health Capability**

<b>Bodily Health Capability</b>	<b>Pearson Chi-Square p-value</b>	<b>Reject Null Hypothesis?</b>	<b>Likelihood Ratio p-value</b>	<b>Reject Null Hypothesis?</b>
<b>My health does not in any way limit my daily activities compared with most people of my age</b>	(294.82) 0.000	Yes	(239.91) 0.000	Yes
<b>I have enough to eat every day</b>	(169.84) 0.000	Yes	(157.15) 0.000	Yes
<b>I live in adequate accommodation which is conducive for my studies</b>	(219.83) 0.000	Yes	(158.38) 0.000	Yes
<b>I can afford specialized or private medical care.</b>	(136.69) 0.000	Yes	(139.189) 0.000	Yes
<b>The university has facilities to cater for all my medical needs</b>	(94.09) 0.000	Yes	(90.45) 0.000	Yes

The variables considered under the Bodily health have a relationship with student ranking of wellbeing.

Table 13: Bodily Integrity Capability Indicators

<b>Bodily Integrity Capability</b>	<b>Pearson Chi-Square p-value</b>	<b>Reject Null Hypothesis?</b>	<b>Likelihood Ratio p-value</b>	<b>Reject Null Hypothesis?</b>
<b>I feel very safe walking alone in the area near my residence (on campus or off-campus) DURING THE DAY time</b>	(58.35) 0.011	Yes	(55.33) 0.021	Yes
<b>I feel very safe walking alone in the area near my residence (on campus or off-campus) AFTER DARK.</b>	(50.77) 0.052	No	(52.97) 0.034	Yes
<b>I can afford decent clothing</b>	(142.53) 0.000	Yes	(134.43) 0.000	Yes
<b>I am NOT likely to be a victim of sexual assault during the course of my studies</b>	(110.72) 0.000	Yes	(104.55) 0.000	Yes
<b>I have not been a victim of physical harassment during the course of my studies</b>	(152.65) 0.000	Yes	(135.85) 0.000	Yes

The students reviewed that they do not feel safe walking near their places of residence but there is no relationship between this perception and how they ranked their wellbeing under the chi-square test.

Table 14: Senses Imagination and Thought Capability Indicators

<b>Senses, Imagination, and Thought Capability</b>	<b>Pearson Chi-Square p-value</b>	<b>Reject Null Hypothesis?</b>	<b>Likelihood Ratio p-value</b>	<b>Reject Null Hypothesis?</b>
<b>I can use reasoning to reflect critically on my own beliefs and values</b>	(121.89) 0.000	Yes	(118.48) 0.000	Yes
<b>I can find evidence, examples and reasons to support my views.</b>	(122.60) 0.000	Yes	(111.45) 0.000	Yes
<b>I use my imagination and creativity in learning and thinking: To think of what might be, not just what is.</b>	(121.28) 0.000	Yes	(101.09) 0.000	Yes
<b>The knowledge I gain in my studies is extremely important for what I want to be someday</b>	(180.38) 0.000	Yes	(90.24) 0.050	No
<b>I am learning to think about the contents of my academic subjects critically</b>	(257.48) 0.000	Yes	(108.72) 0.000	Yes
<b>I find pleasure in what I am studying.</b>	(239.33) 0.000	Yes	(127.75) 0.000	Yes

Under the Senses, Imagination and thought capability, all the variables have an association with wellbeing.

**Table 15: Emotions Capability Indicators**

<b>Emotions Capability</b>	<b>Pearson Chi-Square p-value</b>	<b>Reject Null Hypothesis?</b>	<b>Likelihood Ratio p-value</b>	<b>Reject Null Hypothesis?</b>
<b>I value the social support structures that are at my disposal in the university</b>	(187.53) 0.000	Yes	(132.49) 0.000	Yes
<b>At present it is easy for me to enjoy the love care and support of my immediate family and friends</b>	(307.14) 0.000	Yes	(230.83) 0.000	Yes
<b>It is easy for me to express feelings of love, happiness and gratitude compared to other students</b>	(298.37) 0.000	Yes	(210.44) 0.000	Yes
<b>I usually do not express feelings of anger and hatred compared to other students</b>	(90.32) 0.000	Yes	(83.47) 0.000	Yes
<b>I am not fearful or anxious in learning situations</b>	(396.66) 0.000	Yes	(262.39) 0.000	Yes

All the variables under the Emotions capability have an association with the student's wellbeing ranking.

**Table 16: Practical reasoning Capability Indicators**

<b>Practical Reasoning Capability</b>	<b>Pearson Chi-Square p-value</b>	<b>Reject Null Hypothesis?</b>	<b>Likelihood Ratio p-value</b>	<b>Reject Null Hypothesis?</b>
<b>My idea of a good life is based on my own judgement.</b>	(79.71) 0.000	Yes	(73.26) 0.000	Yes
<b>I have a clear plan of how I would like my life to be.</b>	(126.52) 0.000	Yes	(94.83) 0.000	Yes
<b>I constantly evaluate how I lead my life and where I am going in life</b>	(110.03) 0.000	Yes	(93.00) 0.000	Yes
<b>I have been contributing positively to the community during my studies.</b>	(112.56) 0.000	Yes	(82.77) 0.000	Yes
<b>I find it easy to solve problems which I did not anticipate.</b>	(213.20) 0.000	Yes	(175.80) 0.000	Yes

All the variables under the Practical Reasoning capability have an association with the student's well-being ranking.

Table 17: Affiliation Capability Indicators

<b>Affiliation Capability</b>	<b>Pearson Chi-Square p-value</b>	<b>Reject Null Hypothesis?</b>	<b>Likelihood Ratio p-value</b>	<b>Reject Null Hypothesis?</b>
<b>I respect, value and appreciate other people.</b>	(87.49) 0.000	Yes	(73.96) 0.000	Yes
<b>I normally meet up with friends or family for a drink or a meal at least once a month.</b>	(120.78) 0.000	Yes	(89.68) 0.000	Yes
<b>I find it easy to imagine the situations of other people and to feel concern. (i.e. 'to put myself in others' shoes').</b>	(67.72) 0.001	Yes	(54.25) 0.050	Yes
<b>I find it easy to relate to my peers in the classroom.</b>	(148.98) 0.000	Yes	(110.74) 0.000	Yes
<b>I am able to participate successfully in groups for learning</b>	(155.75) 0.000	Yes	(116.08) 0.000	Yes

All the variables under the Affiliation capability have an association with the student's well-being ranking.

**Table 18: Leisure Capability Indicators**

<b>Leisure Capability</b>	<b>Pearson Chi-Square p-value</b>	<b>Reject Null Hypothesis?</b>	<b>Likelihood Ratio p-value</b>	<b>Reject Null Hypothesis?</b>
<b>I have recently been spending time in recreational activities.</b>	(63.74) 0.003	Yes	(66.65) 0.001	Yes
<b>I play sport at the university</b>	(48.07) 0.086	No	(53.49) 0.030	Yes
<b>I attend social functions on campus</b>	(61.85) 0.005	Yes	(63.22) 0.003	Yes
<b>I have time to participate in other things on campus besides school work</b>	(110.60) 0.000	Yes	(98.84) 0.000	Yes
<b>I belong to a social club/student association.</b>	(67.12) 0.001	Yes	(70.66) 0.010	Yes

Most of the variables under the Leisure do not have an association with how student's perceive their well-being.

Table 19: Control over one's environment

<b>Control over One's Environment Capability</b>	<b>Pearson Chi-Square p-value</b>	<b>Reject Null Hypothesis?</b>	<b>Likelihood Ratio p-value</b>	<b>Reject Null Hypothesis?</b>
<b>I am able to participate in the political activities that affect my life if I want to</b>	(64.31) 0.003	Yes	(65.63) 0.002	Yes
<b>My field of study makes use of my skills, abilities and talents</b>	(121.57) 0.000	Yes	(113.36) 0.000	Yes
<b>I find it easy to relate to my peers in the classroom</b>	(170.03) 0.000	Yes	(136.67) 0.000	Yes
<b>My fellow classmates and lecturers treat me with respect</b>	(232.63) 0.000	Yes	(130.36) 0.000	Yes
<b>I am free to express my political views on campus.</b>	(85.74) 0.000	Yes	(81.07) 0.000	Yes
<b>I am free to practice my religion as I want to on campus.</b>	(55.080) 0.010	Yes	(49.96) 0.061	No

There was no association between freedom to practice religion on campus and student wellbeing(likelihood ratio test). There is however association between how students perceive their wellbeing and the other variables.

#### 4.5 Conclusion

The above results show that the measuring instrument had reliable variables as they relate well to the students perception of wellbeing. This is a validation of processes following in modelling student capabilities and it shows that models fitted were fitted correctly and that there is an honourable degree of integrity in them.

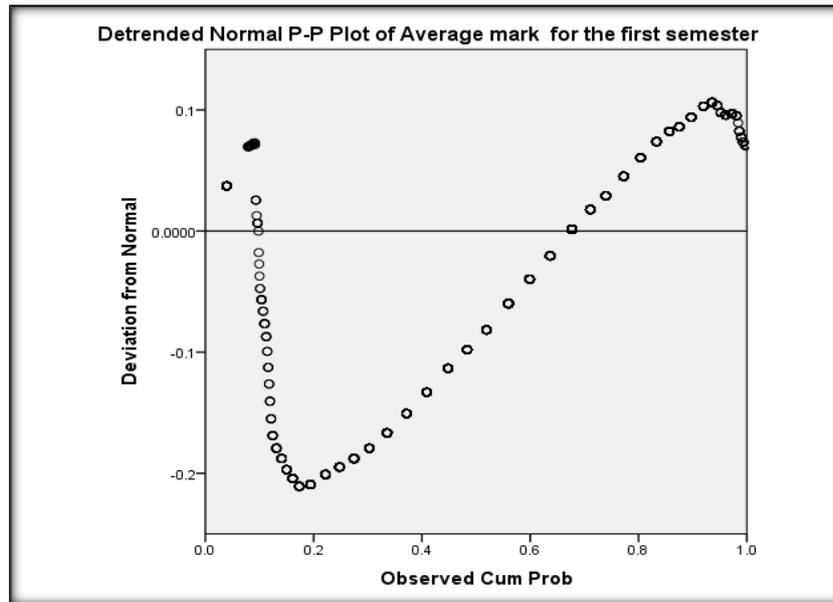
The study suggests that capabilities are good indicators of wellbeing which supports the initial hypothesis that Human Development approaches to education provide better indicators of wellbeing than Human Capital approaches.

## 5 Descriptive Statistics: Findings and results

The following chapters focus on the statistical methods used to analyse the data, together with discussions on the findings from the data analysis process. The first section will shed more details on the nature of the data using descriptive statistical methods. The next section will fit a conventional regression model, as has been used by other researchers in similar studies, and test this model to see how best it fits the data. The next section will focus on the creation of a new model which can better fit the data. The last section will compare the two models and provide limitations of each of them.

### 5.1 Variables

The previous chapter concluded by providing a condensed list of variables which should be analysed. These variables are of a mixed nature with continuous quantitative variables and nominal and ordinal qualitative data. In order for the data to be regressed, a student's average mark was identified as a proxy for wellbeing. Student marks can work well as a proxy because academic performance is the conventional universal indicator of a student's general aptitude. The P-P plot for the student marks given below shows that excluding a few outliers, the empirical distribution of Average marks and the theoretical distributions are comparable as the distribution follows the function  $y = x$ . Thus, statistically, I can use Mark (Average mark) as a viable dependent variable and assume that it is normally distributed.



**Figure 7: P-P plot of marks**

The general assumption in this study therefore is that a student’s academic performance can be explained through an analysis of the matrix of his/her conversion factors and his capabilities (opportunities to achieve what they value) and functionings.

The table below gives a summary of the variables used:

**Table 20: Variables**

Variable	Code in Analysis	Class	Nature
Outputs			
Gender of participants	Gender	Nominal	Demographics
Age range	Age	Ordinal	Demographics
Type of residence	Residence	Nominal	Demographics
Home language	Home_language	Nominal	Demographics
Language of instruction	Language_Instruction	Nominal	Demographics
Race	Race	Nominal	Demographics
Faculty	Faculty	Nominal	Demographics
Year of study	Academic_year	Ordinal	Demographics
Subjects failed in the previous	Subjects_failed	Ordinal	Demographics

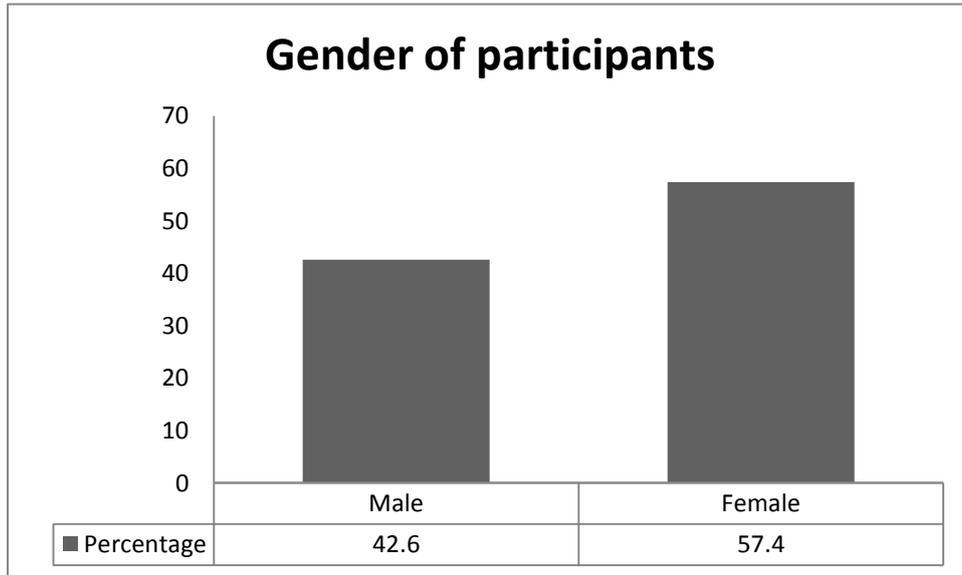
semester			
Average mark in the previous semester	Mark	Continuous	Proxy for well being
Educational resilience	EDUCATION	Continuous	Capability
Learning disposition, language and competence	LEARNING	Continuous	Capability
Bodily health	HEALTH	Continuous	Capability
Body integrity	INTEGRITY	Continuous	Capability
Senses imagination and thought	SENSES	Continuous	Capability
Emotions	EMOTIONS	Continuous	Capability
Practical reason	REASON	Continuous	Capability
Affiliation	AFFILIATION	Continuous	Capability
Leisure	LEISURE	Continuous	Capability
Control over one's environment	ENVIRONMENT	Continuous	Capability

## 5.2 Demographics

Before an exposition of the analytical methods and findings is given, it is imperative that a brief description of the data collected be given to set the context in which the analysis is done. This sub-section shall give visual summaries of the nature of participants in the study. As mentioned above, there were 1 496 participants from the University of the Free State South Africa. Most of the university statistics cited below are from the University's Strategic Plan 2012-2016<sup>13</sup>.

<sup>13</sup> This can be obtained from the university's website or using the following link [http://www.ufs.ac.za/dl/userfiles/Documents/00001/931\\_eng.pdf](http://www.ufs.ac.za/dl/userfiles/Documents/00001/931_eng.pdf) as accessed on 17 March 2014

### 5.2.1 Gender



**Figure 8: Gender**

The ratio of females to males who participated is similar to the University gender ratio which is 60:40 in favour of females.

### 5.2.2 Age

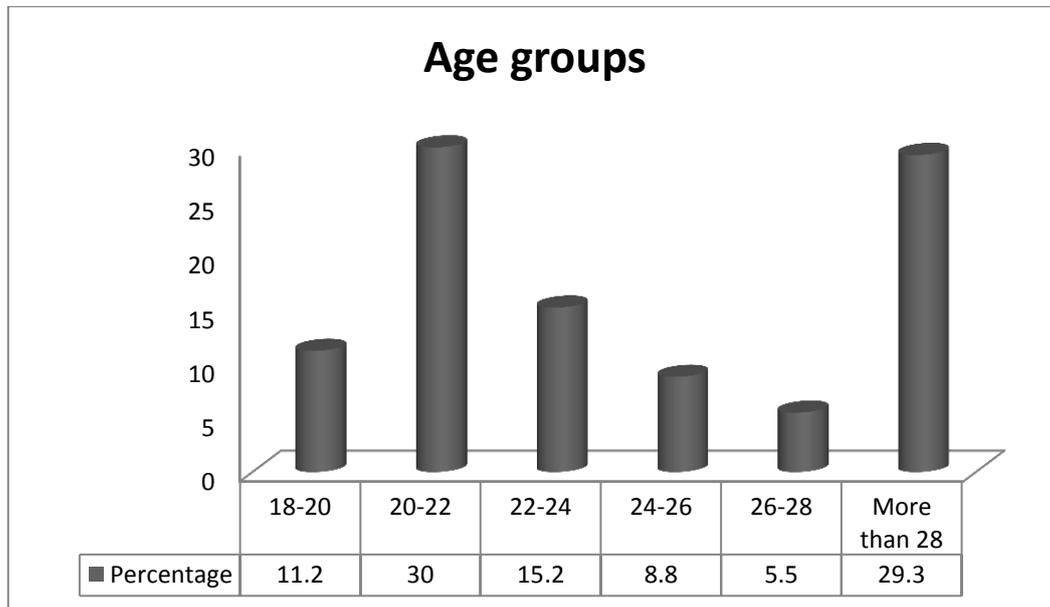
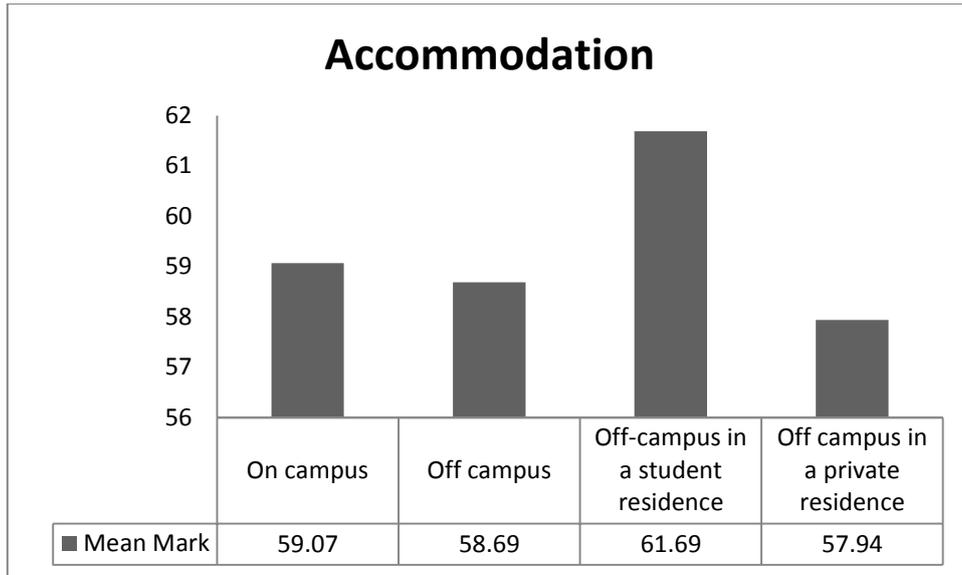


Figure 9: Age

The figure above shows that the sample was rich and diverse age wise. The majority of the participants were aged between 20 and 22 years, followed by the group above 28 years. This could be explained by the fact that most students leave the university around the ages of 23 and 24 and only come back for post-graduate studies when they are older, that is usually above 28 years of age.

### 5.2.3 Residential Profiles

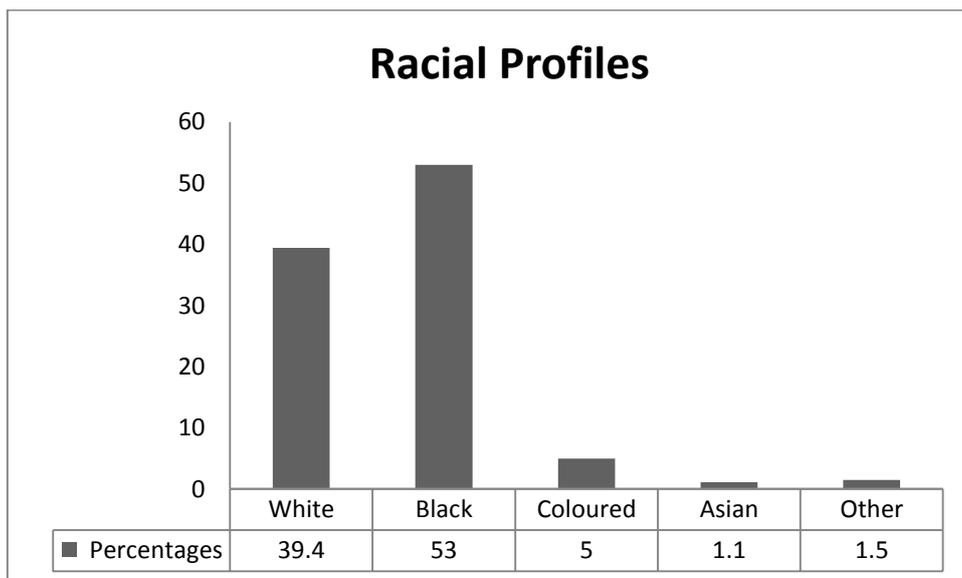
Another characteristic of note is where students reside. The analysis of where they reside is crucial in determining all the variables that affect students' capabilities. The figure below shows the residential statuses of the participants.



**Figure 10: Accommodation**

### 5.2.4 Racial profiles

The University of the Free State is a historically white Afrikaans university and has in recent years been affected by racial conflicts. Nonetheless the university is transforming slowly to reflect national racial proportions and currently the Black racial group is predominant. Given the history of the university and its current position, it is important for any study on students to represent views of all racial groups. The survey was sent to all students regardless of race and the figure below shows the racial profiles of the participants:



**Figure 11: Race**

This is comparable to the Universal statistics where (63%) are African, (30%) white, (5%) coloured and (2%) Indian.

### 5.2.5 Faculties

The university has numerous faculties and each of the 7 faculties was duly represented in the following proportions:

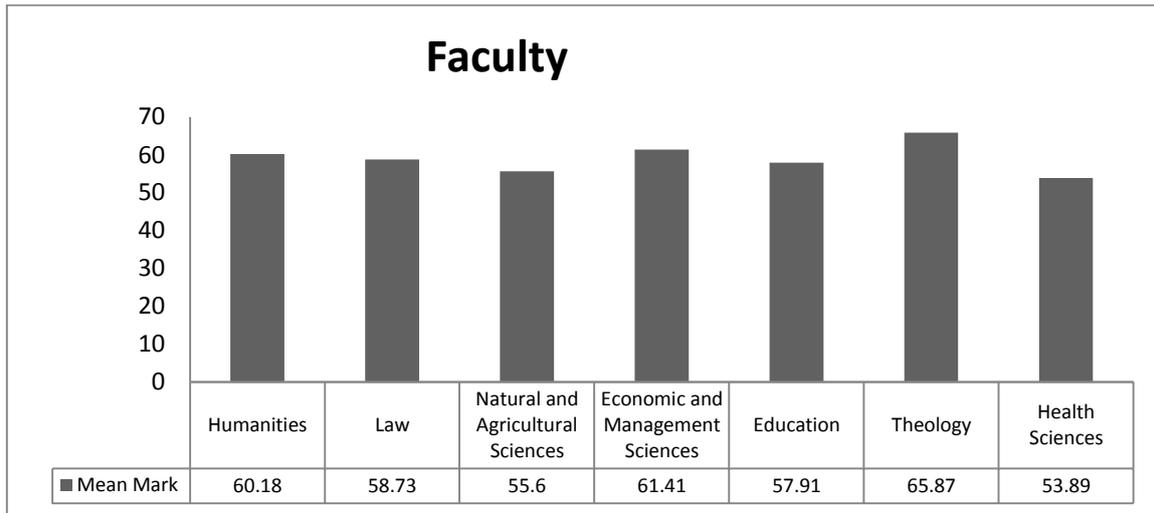


Figure 12: Faculties

This sub –section showed that the sample is indeed balanced and representative of all the sectors in the student populace. In the whole population, the largest faculty is Education with 7 642 students, followed by Humanities (7 515), EMS (6 488) and the Natural and Agricultural Sciences (5 952). The smaller faculties are Health Sciences (2 634), Law (2 605) and Theology (242).

### 5.3 General Statistics of the continuous variables

The thesis shall use Regression analysis and Structural Equation Modelling which requires continuous data. The statistics of the continuous variables used are as follows:

**Table 21: General Statistics**

	Mean of the scores	Std. Deviation	Kurtosis	Std. Error of Kurtosis
Mark	58	20.03245	3.05	0.126
EDUCATION	20.16578	3.568	9.585	0.126
LEARNING	31.07687	5.231	11.07	0.126
HEALTH	18.91979	4.105	4.021	0.126
INTEGRITY	18.24599	4.03	4.025	0.126
SENSES	25.46457	4.071	15.485	0.126
EMOTIONS	18.89639	3.76	6.795	0.126
REASON	19.8857	3.493	10.5	0.126
AFFILIATION	20.04144	3.631	10.087	0.126
LEISURE	12.76738	4.946	-0.201	0.126
ENVIRONMENT	22.33356	4.372	6.658	0.126

An assumption for the analysis method proposed in the next chapter is that of normality of the distributions of the variables. Normality has formal statistical tests but it can also be observed in two ways, firstly through the Skewness. Generally, if Skewness is between -1 and 1 then the data is likely distributed normally. Or it can be observed through the Kurtosis. If the kurtosis is negative then the distribution is flat and if the Kurtosis is positive then the distribution is narrow or sharp. The degree of flatness is directly proportional to the magnitude Kurtosis. The above figures show that in this case Normality cannot be concluded without an official test.

#### 5.4 Cross relationships

The relations between Mark (average mark), race and gender are important since academic performance will be used as proxy for wellbeing.

**Table 22: Race, gender and Average mark**

<b>Gender</b>	<b>Race</b>	<b>Mean % Mark</b>
<b>Females</b>	White	<b>60.65</b>
	Black	<b>59.45</b>
	Coloured	<b>59</b>
	Asian	<b>64.86</b>
	Other	<b>59.08</b>
<b>Male</b>	White	<b>58.92</b>
	Black	<b>55.42</b>
	Coloured	<b>61.85</b>
	Asian	<b>54</b>
	Other	<b>49.3</b>

The table above shows that Asian females have the highest average among the females, and Coloured males the highest among males. Further, along racial groups, the white students have the highest combined average.

The figure and tables below show the numbers of people in the different classes (English and Africans) and further illustrates that Afrikaans students across faculties have higher academic averages than English students except for the Law and Natural and Agricultural Sciences faculties. Whether this affects the capabilities they value or is because of the functions they have can only be ascertained after in later sections.

**Table 23: Language of instruction and faculty vs. Average mark**

Language of Instruction	Faculty	Mean Mark
<b>English</b>	Humanities	58.9
	Law	58.76
	Natural and Agricultural Sciences	55.36
	Economic and Management Sciences	60.99
	Education	55.5
	Theology	62.4
	Health Sciences	52.49
<b>Afrikaans</b>	Humanities	67.31
	Law	58.56
	Natural and Agricultural Sciences	56.28
	Economic and Management Sciences	64.42
	Education	65.22
	Theology	67.92
	Health Sciences	58.13

The table below shows that Venda speaking students perform better than any other group taught in English and also, English speaking students perform better than their counterparts in Afrikaans classes. Overall, students in Afrikaans classes<sup>14</sup> perform better than students in English classes as they have an average of 63% whereas the English classes have 58% average.

<sup>14</sup> The University of the Free State has a dual medium of instruction policy where most classes are offered both in English and Afrikaans classes.

**Table 24: Language of instruction vs. Home language**

<b>Language of Instruction</b>	<b>Home Language</b>	<b>Mean Mark</b>
<b>English</b>	Sesotho	<b>57.64</b>
	Afrikaans	<b>57.85</b>
	Tswana	<b>58.56</b>
	Xhosa	<b>59.22</b>
	IsiZulu	<b>58.54</b>
	Venda	<b>62.84</b>
	English	<b>58.12</b>
	Other	<b>53.41</b>
<b>Afrikaans</b>	Sesotho	<b>59</b>
	Afrikaans	<b>62.51</b>
	Tswana	<b>0</b>
	Xhosa	<b>0</b>
	IsiZulu	<b>0</b>
	Venda	<b>0</b>
	English	<b>74</b>
	Other	<b>67</b>

There are many other cross-relations that can be investigated but the above are the critical ones for the purposes of this study. The next sub section shall investigate the nature of the correlations between the variables.

### **5.5 Correlations**

There are numerous correlation tests, with most common being the Pearson test. The Pearson correlations test assumes among other things that the variables are linear and approximately normally distributed. These assumptions do not hold therefore a non-parametric correlations test which can find correlations between categorical and numerical data is most appropriate. Therefore the best test which is as effective as the Pearson test and is suitable for ordinal data is the Spearman test. The Spearman non-parametric correlations

test was used to find cross correlations between and among the variables. The full results of the program output of the test are in the Appendix. The hypotheses tested were:

$$H_0: \rho = 0$$

$$H_1: \rho \neq 0$$

The correlations were regarded significant at a 95% confidence level.

The average varies significantly across various demographical categories. The differences in the average Mark across gender, racial and residential lines shall be investigated below.

### 5.5.1 Analysis of Variance (ANOVA)

Running an analysis of variance type III to test for the strength of interactions among the significant background variables reveals that residential status when considered in a joint/mixed model has no effect on the student marks. The table below shows the summary.

**Table 25: Mixed Models - Type III Sum of Squares analysis**

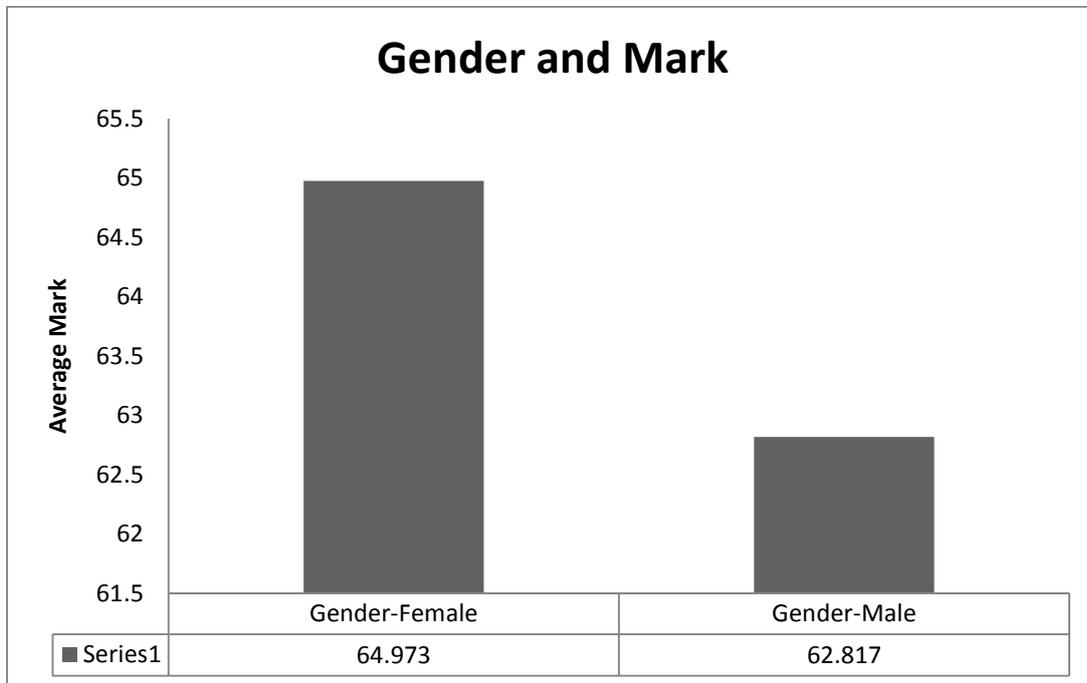
Source	Type	DF	Sum of squares	Mean squares	E(Mean squares)	F	Pr > F
Gender	Random	1	1567.231	1567.231	$\sigma^2 + 1938.57 * \sigma^2(\text{Gender})$	18.309	< 0.0001
Residential status	Random	1	60.746	60.746	$\sigma^2 + 1938.57 * \sigma^2(\text{Res\_status})$	0.710	0.400
Race	Random	4	6040.696	1510.174	$\sigma^2 + 775.429 * \sigma^2(\text{Race})$	17.643	< 0.0001
Error		1350	115556.958	85.598	$\sigma^2$		

The test shows that there are significant differences in the Marks between the variables Gender, Residential status and Race. Analysing the individual variables reviews the following:

## 5.6 Statistical tests for differences in Marks

### 5.6.1 Gender

793 of the participants were females and 709 were male and the average marks were approximately 65% and 63% respectively. The graph below summarizes the differences.



**Figure 13: Gender and Mark**

Testing the differences using Dunn-Sidak Multiple comparison test reveals the following:

Testing the hypotheses-

$H_0$ : There is no difference in the average Mark between different genders

$H_1$ : There is a difference in the average Mark between different genders

The following results are observed.

**Table 26:** Gender / Dunn-Sidak / Analysis of the differences between the categories with a confidence interval of 95%:

Contrast	Difference	Standardized difference	Critical value	Pr > Diff	Significant
Male vs. Female	0.094	2.048	1.962	0.041	Yes
Modified significance level:			0.05		

Thus the null hypothesis is rejected at a significance level of 5% and it is concluded that there is a significant difference between the marks scored by females and those scored by males. The result implies female students generally performed slightly better than male students in this population.

### 5.6.2 Residential status

The effect of a student accommodation on the mark is important in identifying a comprehensive model. From the study 20.71% of the students who participated stay on-campus. The differences in the mark between on and off campus students are shown below:

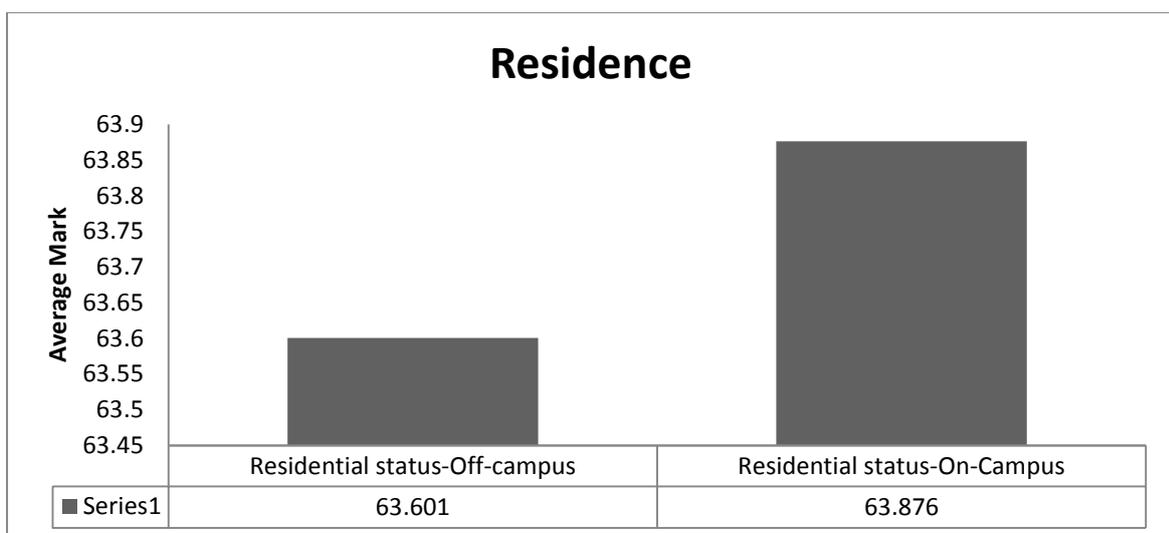


Figure 14: Marks by residential status

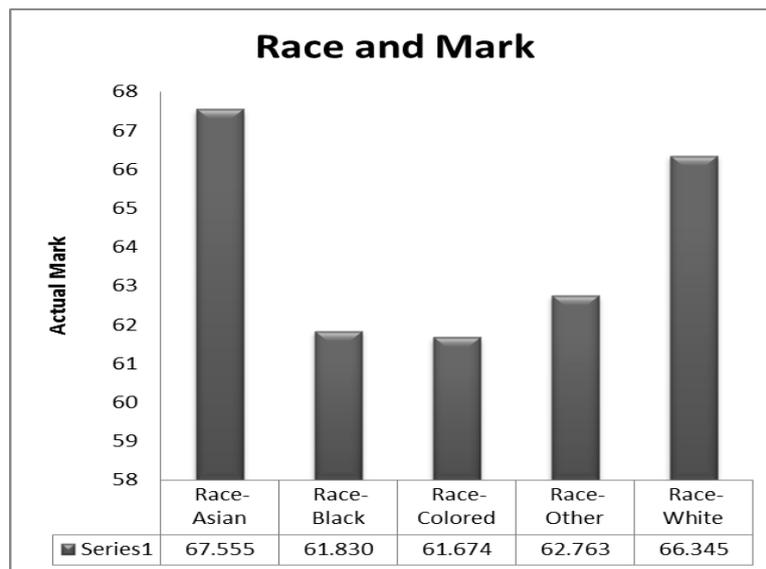
There appears to be a slight and negligible difference in the marks between on and off-campus students but the Dunn-Sidak test below shows that there is a significant difference between the marks and the residential status. Thus staying on-campus has a slight positive effect on academic performance. The large sample size makes a small difference (in absolute marks) significant as the variances are very small.

**Table 27:** Residential status / Dunn-Sidak / Analysis of the differences between the categories with a confidence interval of 95%

Contrast	Difference	Standardized difference	Critical value	Pr > Diff	Significant
Off-campus vs. On-Campus	1.744	30.165	1.962	< 0.0001	Yes
Modified significance level:			0.05		

### 5.6.3 Race

The marks according to the different races are as follows:



**Figure 15:** Test for race vs. Mark

This shows that Asian students perform better than all other races followed by white students and the black and coloured students perform slightly lower than all the other categories.

Using the Fisher (LSD) Comparison test the following results are obtained:

**Table 28:** Pair wise comparisons\_\_\_\_Race / Fisher (LSD) / Analysis of the differences between the categories with a confidence interval of 95%

Contrast	Difference	Standardized difference	Critical value	Pr > Diff	Significant
Asian vs. Colored	5.845	2.159	1.962	0.031	Yes
Asian vs. Black	5.654	2.260	1.962	0.024	Yes
Asian vs. Other	5.292	1.725	1.962	0.085	No
Asian vs. White	1.200	0.479	1.962	0.632	No
White vs. Colored	4.645	3.962	1.962	< 0.0001	Yes
White vs. Black	4.454	8.067	1.962	< 0.0001	Yes
White vs. Other	4.092	2.200	1.962	0.028	Yes
Other vs. Colored	0.553	0.261	1.962	0.794	No
Other vs. Black	0.363	0.196	1.962	0.844	No
Black vs. Colored	0.191	0.166	1.962	0.868	No

The pairwise comparison above shows that there are five racial groups which have significant differences in academic performance. The Asian and Coloured students have the biggest difference in performance followed by Asian and Black students. The difference between the performances of Asian students is significant when compared to Black and Coloured students but non-significant elsewhere. The same is true for the white students against the Black, Coloured and Other categories. This test shows us that the performance of Black students is comparable to Coloured students but not with Asian and White students. Though the Asian students have the highest marks the test reviews that their marks are comparable with the White category and also with the ‘Other’ category thus making the White category the only one with a unitary comparative. These differences can be attributed to the inherent real opportunities and freedoms the categories have, that is their capabilities.

The following chapter shall look at the regression models considered in this study.

## 6 Modelling –Results and discussions

The chapter shall try different regression models to see which best models the data and gives the best prediction for student marks.

### 6.1 Ordinary Least squares regression

#### 6.1.1 Basic model and assumptions

The Ordinary Least Squares regression method is the most conventional method used to analyse relationship between variables (Corpening, et al., 2004). The model has a univariate structure and a multivariate extension. Given the number of the independent variables used in this study, the multivariate form of the Ordinary Least Squares regression will be fit. The model form is:

$$y_i = \beta_0 + \beta_1 x_{1,i} + \beta_2 x_{2,i} + \dots + \beta_m x_{m,i} + \varepsilon_i \quad \dots \quad (6.1)$$

Where:

$x_{m,i}$  Is an observation of capability index  $m$  for student  $i$  and  $\beta_m$  is a scalar valued regression coefficient associated with explanatory (capability) variable  $m$  and  $y_i$  is the average mark for individual  $i$ .

The method of least squares however does not provide unbiased and consistent parameter estimates when its underlying assumptions are violated. The assumptions of this model are as follows (Farland, 2013):

#### i. **Linearity:**

The specified population regression function is the true data generating process and is linear in its parameters.

$$y_i = \beta_0 + \beta_1 x_{1,i} + \beta_2 x_{2,i} + \dots + \beta_m x_{m,i} + \varepsilon_i \quad \dots \quad (6.2)$$

None of the parameters is raised to a power or multiplied by another parameter.

**ii. Constant Variance (Homoscedasticity):**

The variance of the stochastic disturbances is a constant over all observations.

$$E[\varepsilon_i^2 | x_i] = \sigma^2 \quad \dots \quad (6.3)$$

Non constant variance results in heteroscedasticity. Its negative consequence is to bias the standard errors on the regression coefficients.

**iii. No serial correlation among the disturbances:**

$$E[\varepsilon_i \varepsilon_j | x_i] = 0, \quad \forall i \neq j \quad \dots \quad (6.4)$$

Correlation of the disturbances is known as autocorrelation. Its negative consequence is to bias the standard errors on the regression coefficients.

**iv. No Multicollinearity:**

This requires that there is no perfect linear correlation among explanatory variables in the design model. If this assumption is violated, multicollinearity (or just collinearity) is the result. It leads to inflated standard errors on the regression coefficients. This has a negative effect on hypothesis tests and confidence interval precision.

**v. Strict Exogeneity of the Explanatory Variables:**

Strict exogeneity requires that the predictor variables are non-random and are uncorrelated with the disturbances at any time period. In other words:

$$E[E[\varepsilon_i|x_i, \dots, x_n]] = E[\varepsilon_i] = 0 \quad \dots \quad (6.5)$$

$$cov(\varepsilon_i x_i) = 0, \forall i = 1, \dots, n \quad \dots \quad (6.6)$$

### 6.1.2 Model fitting

The Ordinary least squares model was fitted as follows:

$$y_i = \beta_0 + \beta_1 x_{1,i} + \beta_2 x_{2,i} + \dots + \beta_m x_{m,i} + \varepsilon_i \quad \dots \quad (6.7)$$

Where:

$y_i$  is the mark of student  $i$

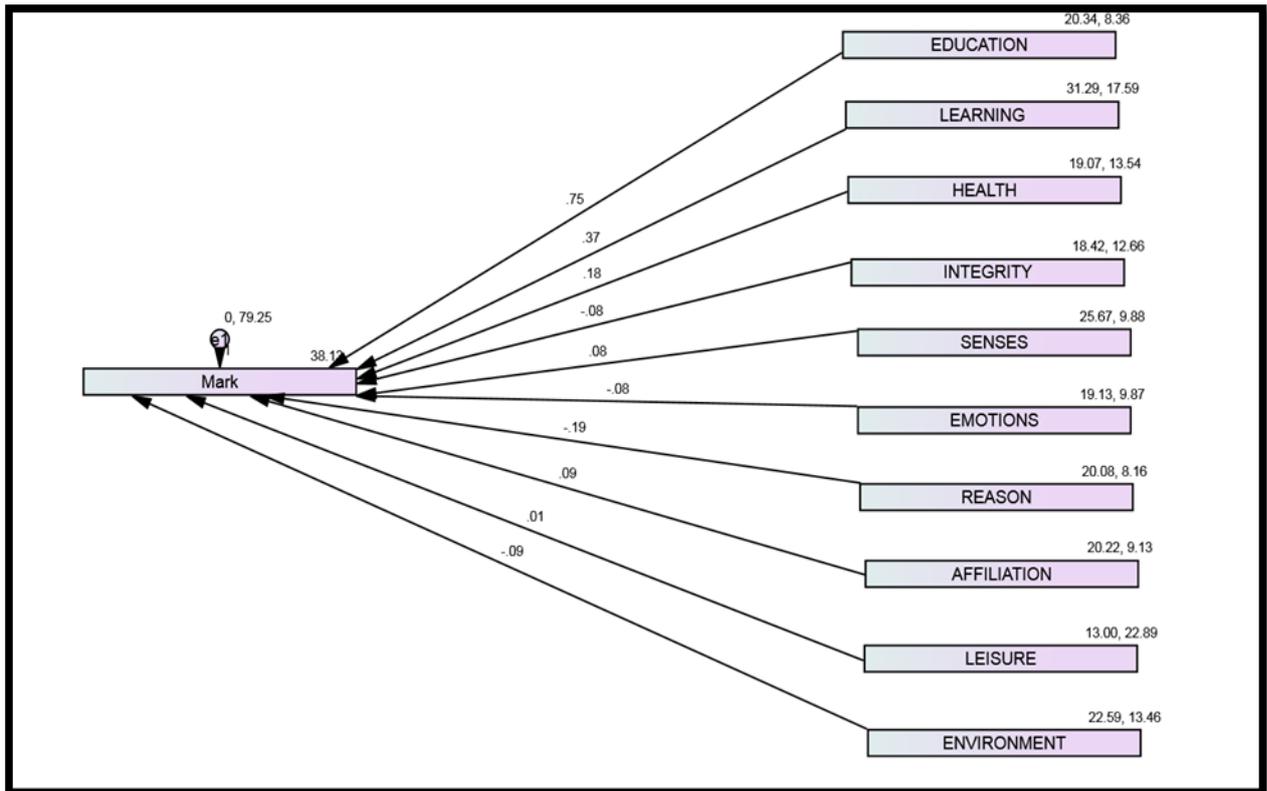
$x_{p,i}$  is student  $i$ 's indicator of capability  $x_p$

$\beta_0$  is the student's mark which is independent of his capabilities

$\beta_i$  is the coefficient of capability  $i$  in the model

The results from E-views7, SPSS-22, AMOS21 and Excel2010 using Maximum Likelihood Estimates and unstandardized estimates are as follows:

**Table 29: Ordinary least squares Regression (The Independence model)**



Variable	Coefficient	Std. Error	t-Statistic	Prob.
<b>C-constant</b>	38.13273	2.471135	15.43126	0
<b>Affiliation</b>	0.085507	0.103165	0.82884	0.4073
<b>Educational Resilience</b>	0.748266	0.109792	6.815303	0
<b>Emotions</b>	-0.077199	0.100843	-0.765541	0.4441
<b>Control over one's Environment</b>	-0.088997	0.089168	-0.998085	0.3184
<b>Bodily Health</b>	0.184931	0.0811	2.280281	0.0227
<b>Bodily Integrity</b>	-0.082315	0.079425	-1.036388	0.3002
<b>Learning disposition: Language and confidence</b>	0.3739	0.080813	4.626739	0
<b>Leisure</b>	0.006336	0.053346	0.118764	0.9055
<b>Practical reasoning</b>	-0.193325	0.101657	-1.901738	0.0574
<b>Senses and Imagination</b>	0.080288	0.100777	0.796687	0.4258

The test was conducted at a 5% significance level thus all  $p$  values greater than 0.05 represent non-significant variables. From the table above, the only significant variables are EDUCATION with a  $p$  value of 0, HEALTH with a  $p$  value of 0.0227 and LEARNING with a  $p$  value of 0. This means that according to this model, the only capabilities which directly affect a student's academic performance are Educational resilience, Bodily Health and Learning disposition, language and confidence.

In other terms the above model is:

$$\begin{aligned}
 MARK = & 38.1327324079 + 0.0855074120159 * AFFILIATION + 0.748265980157 * EDUCATION \\
 & - 0.0771994483719 * EMOTIONS - 0.0889967815347 * ENVIRONMENT \\
 & + 0.184931457063 * HEALTH - 0.0823154286937 * INTEGRITY \\
 & + 0.373899760507 * LEARNING + 0.00633560408418 * LEISURE \\
 & - 0.193325064941 * REASON + 0.08028793994 * SENSES
 \end{aligned}$$

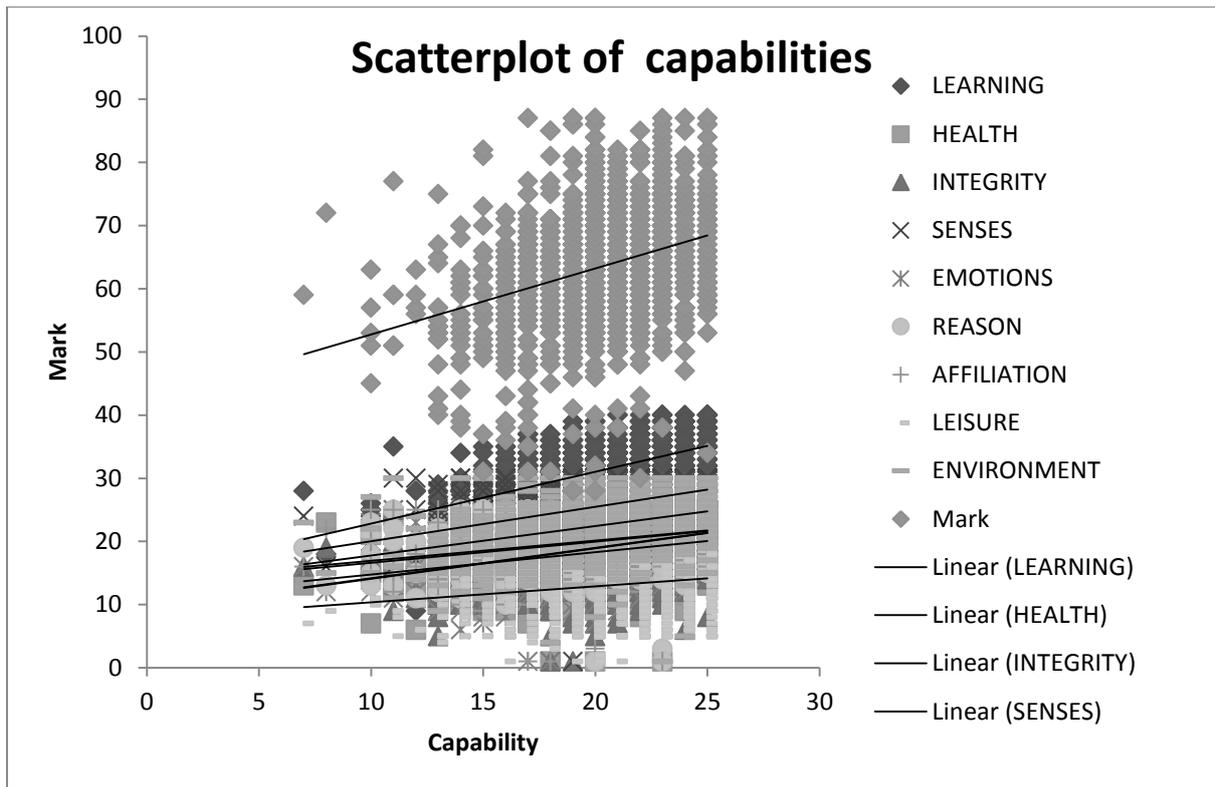
... (6.8)

According to the capabilities theory and the works of Alkire, Anand, Nussbaum, Walker etc. cited in Chapter 2, the capabilities used in this study are core capabilities to students and they should improve the student's wellbeing which is roughly represented by the student's academic mark. This theoretical positive correlation between the marks and the significant capabilities is confirmed by the model.

### 6.1.3 Model testing

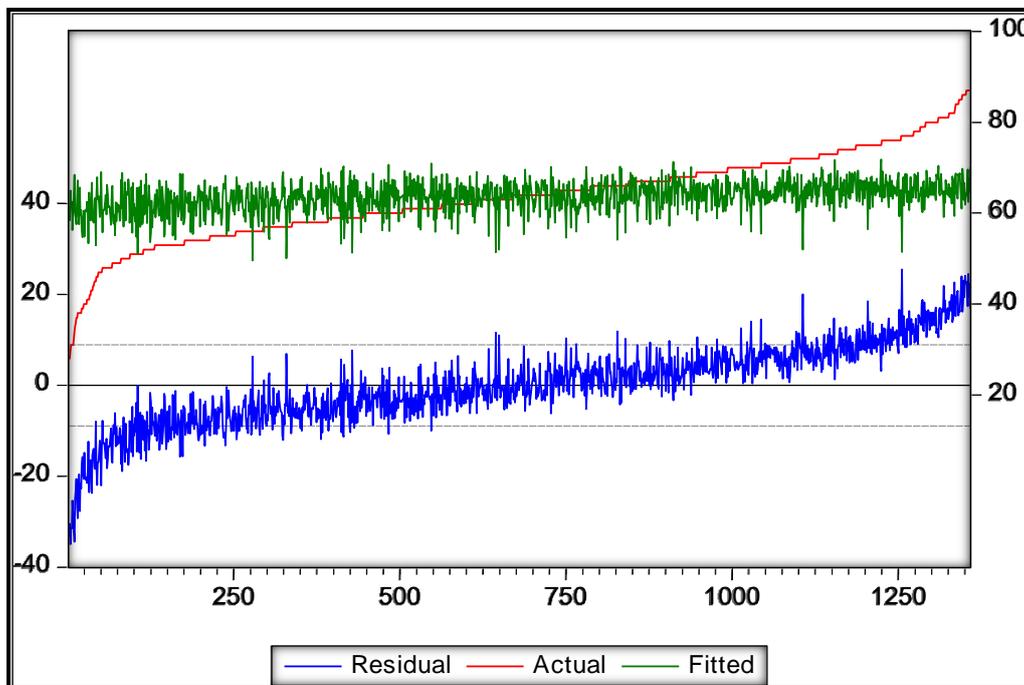
#### 6.1.3.1 Scatter plots, residuals and $R^2$

The  $R^2$  value is a statistical measure of how close the data are to the fitted regression line. It is also known as the coefficient of determination, or the coefficient of multiple determinations for multiple regression. The graph below illustrates how closely the model fitted simple linear univariate model regression lines for each capability. This gives an indication of how the overall model will fit:



**Figure 16: Scatterplot of Mark vs. individual capabilities**

The overall representation of the fitting of the model is given below:



**Figure 17 : Residual Plot** (Bottom series are the residuals, the thin line is the actual and the flat is the fitted model)

This shows that most of the capabilities have a positive correlation with the Mark, which is a good sign since it is consistent with the literature as reviewed in chapter 2.

The  $R^2$  value is low which means that there are other factors which explain the students' average mark.

### 6.1.3.2 Overall F-Test for Regression

The F-Test tests how well all the independent variables together affect the dependent variable.

The hypotheses are as follows:

$$H_0: \beta_1 = \beta_2 = \dots = \beta_{(p-1)} = 0$$

$$H_1: \beta_j \neq 0, \text{ for at least one value of } j$$

The F-statistic from the regression is 19.592 and the  $p$  – value is approximately 0.0000 thus the test is significant at 5% level of significance. Meaning we reject the null hypothesis and conclude that the variables jointly influence the dependent variable.

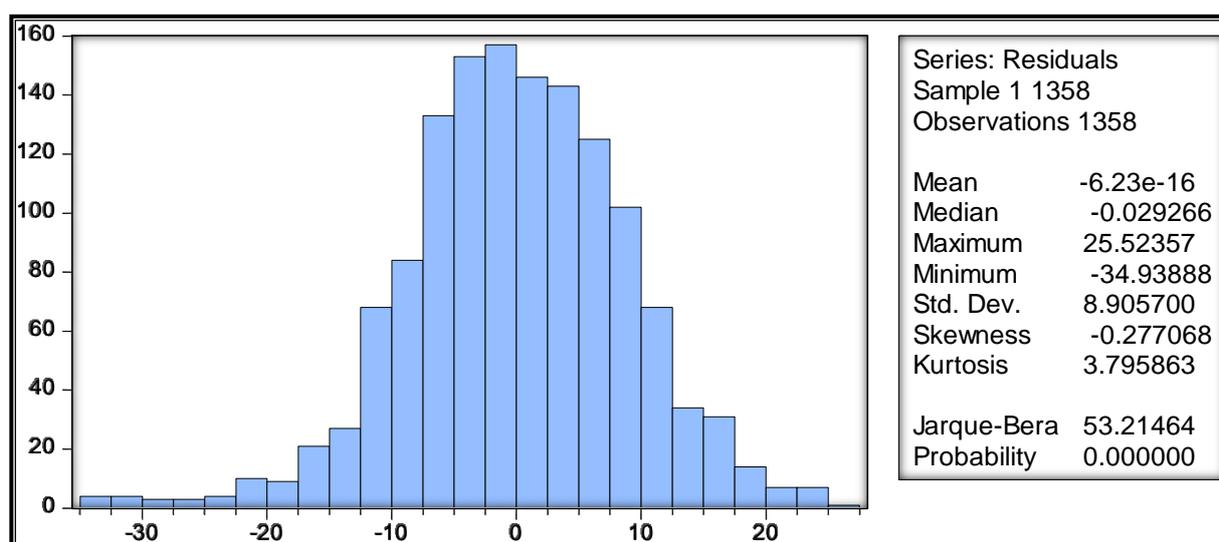
To get further clarity on the goodness of fit of the model, it is important to verify that the model does not violate three main assumptions of the model which are the normality of residuals, absence of serial correlation of the residuals and Homoscedasticity.

### 6.1.4 Testing of assumptions

The above tests suggest that the model does fit the data well but the low  $R^2$  value indicates that the model can still be improved. Before attempting to prove the model, it is important to test if the regression model fit was appropriate, that is if the fault was a result of a violation of fundamental rules. The following headings give a few of the key assumptions.

### 6.1.4.1 Normality

One of the biggest assumptions of the Ordinary Least squares regression model is that the residuals are normally distributed. A histogram of the residuals from the OLS model is given below:



**Figure 18: Test for normality of residuals**

The graph looks fairly normal. The skewness is close to 0 and the Kurtosis is also close to 3 which implies the graph is slightly skewed and a bit narrow shaped .To officially test for Normality, I will use the Jarque –Bera test<sup>15</sup> (JB).

The hypotheses are as follows:

$$H_0: \text{The residuals are normally distributed}$$

$$H_1: H_0 \text{ not true}$$

The Critical value is 53.21464 and the  $p$  – value is 0.0000 therefore we reject the null hypothesis and conclude that the residuals are not normally distributed.

Thus the first assumption of Normality has been violated. The next assumption to be tested is collinearity.

<sup>15</sup> The Jarque–Bera test is a goodness-of-fit test of whether sample data have the skewness and kurtosis matching a normal distribution.

### 6.1.4.2 Serial Correlation

Serial correlation occurs when the error terms are not independently distributed across the observations and are not *strictly* random. The desirable outcome of the test is that there should not be any serial correlation.

The Breusch-Godfrey Serial Correlations test was used to test for serial correlations.

The hypotheses for this test are:

$H_0$ : Residuals not serially correlated

$H_1$ : There is serial correlation

The result of this test is given below:

**Table 30 : Breusch-Godfrey Serial Correlation LM Test:**

F-statistic	6828.968		Prob. F(2,1345)	0
Obs*R-squared	1236.256		Prob. Chi-Square(2)	0
R-squared	0.910351		Mean dependent var	-6.23E-16
Adjusted R-squared	0.909551		S.D. dependent var	8.9057
S.E. of regression	2.678366		Akaike info criterion	4.817817
Sum squared resid	9648.549		Schwarz criterion	4.867728
Log likelihood	-3258.298		Hannan-Quinn criter.	4.836504
F-statistic	1138.161		Durbin-Watson stat	0.991513
Prob(F-statistic)	0			

The Critical value is the Observed  $R^2$ . The critical value thus is 1236.256 and the p value is 0.0000.

Therefore we reject the null hypothesis and conclude that the residuals are serially correlated.

The second assumption is also violated. To further test the assumption, one more test was done; it was the test for heteroscedasticity.

### **6.1.4.3 Heteroscedasticity**

If the error terms of the model have a constant variance then they are homoscedastic. This is a key assumption of the Ordinary Least Squares regression model.

To test for Heteroscedasticity, the Breusch-Pagan-Godfrey test was used. The hypotheses for this test are:

$H_0$ : *Not heteroskedastic this is Homoscedastic*

$H_1$ : *Heteroskedastic*

The critical value is 35.98287 and the p value is 0.001. Thus we reject the null hypothesis at 5% significance level and conclude that there is heteroscedasticity.

### **6.1.4.4 Conclusion of assumption tests and data transformations**

The Ordinary Least Squares regression model can be improved by transforming the data. This is important because for the model to work all the assumptions should be met and then, and only then, can a model be tested accurately. Kenneth Benoit (2011) advocates for a very common transformation of the data in order to make its residuals normal and eliminate heteroscedasticity and collinearity. This transformation is the Logarithmic transformation. The next sub-section will analyse the results from an OLS regression model fitted on transformed data.

### 6.1.5 Logarithmic transformation

Logarithms of all the variables were taken and the resulting was of the form below:

Estimation Equation:

$$\begin{aligned} \text{LOG}(\text{MARK}) = & C(1) + C(2) * \text{LOG}(\text{AFFILIATION}) + C(3) * \text{LOG}(\text{EDUCATION}) + C(4) * \\ & \text{LOG}(\text{EMOTIONS}) + C(5) * \text{LOG}(\text{ENVIRONMENT}) + C(6) * \text{LOG}(\text{HEALTH}) + C(7) * \\ & \text{LOG}(\text{INTEGRITY}) + C(8) * \text{LOG}(\text{LEARNING}) + C(9) * \text{LOG}(\text{LEISURE}) + C(10) * \\ & \text{LOG}(\text{REASON}) + C(11) * \text{LOG}(\text{SENSES}) \quad \dots \quad (6.9) \end{aligned}$$

The model was run and the following was the result:

**Table 31: Transformed OLS**

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.910273	0.114525	25.41169	0
LOG(AFFILIATION)	0.025383	0.021229	1.195692	0.232
LOG(EDUCATION)	0.224494	0.033082	6.786002	0
LOG(EMOTIONS)	0.013005	0.023449	0.554609	0.5793
LOG(ENVIRONMENT)	-0.019478	0.026448	-0.736436	0.4616
LOG(HEALTH)	0.028285	0.0191	1.48088	0.1389
LOG(INTEGRITY)	-0.017971	0.018642	-0.964	0.3352
LOG(LEARNING)	0.16744	0.038055	4.399959	0
LOG(LEISURE)	-0.001078	0.010021	-0.107616	0.9143
LOG(REASON)	-0.052857	0.024006	-2.201796	0.0278
LOG(SENSES)	0.01765	0.026648	0.662333	0.5079

The transformation did not improve the model<sup>16</sup> as only 3 variables are significant and the  $R^2$  for this model is lower than the one for the untransformed model.

Looking at the Breusch-Godfrey Serial Correlation LM Test, the p-value is 0.0000 meaning there is still serial correlation.

The Heteroskedasticity Test: Breusch-Pagan-Godfrey also has an observed  $R^2$  is 31.79513 and the p-value is 0.0004 therefore there is still heteroskedasticity.

<sup>16</sup> Full print-outs are provided in the appendix

### **6.1.6 OLS Conclusion**

Section 6.1 showed that the conventional Ordinary Least Squares regression model can still be improved. Alternative regression models are considered below.

## 6.2 Other Regression Models: Model selection

To determine if a proposed model is better than the Ordinary Least Squares regression model which was fit and discussed in the previous section, a few criterion will be used. This criterion includes:

- a) The  $R^2$  value which measures how much of the Variability in the dependent variable is due to the independent variables in the model.
- b) The Akaike Information Criterion (AIC) which is a measure of relative quality of a statistical model given the data
- c) The Schwarz Information Criterion or Bayesian Information Criterion (BIC) is a criterion for model selection among a finite set of models
- d) Hannan-Quinn information Criterion (HIC) is also a criterion to select a model

The Ordinary Least Squares Model had the following values which will be compared against the other proposed models:

The OLS had the following results:

**Table 32 : Model selection OLS**

<b>Criterion</b>	<b>Value</b>
<b>AIC</b>	7.2267
<b>BIC</b>	7.268956
<b>HIC</b>	7.242535

For a model to be better than the Ordinary least squares model, then the following should be true:

**Table 33 : Model selection rules**

Criterion	Value
$R^2$	Should be higher than for OLS
AIC	Should be lower than 7.2267
BIC	Should be lower than 7.268956
HIC	Should be lower than 7.242535

Various Regression models were fit on the data and results thereof are presented below

### 6.2.1 Quantile Regression

One reason the OLS regression yielded less than perfect results could be because of too many outliers in the data and to curb this quantile regression can be used since the quantile regression estimates are more robust against outliers in the response measurements. The result of the fitted model is:

**Table 34 : Quantile regression**

Pseudo R-squared	0.068795	Mean dependent var	63.56333
Adjusted R-squared	0.061882	S.D. dependent var	9.531009
S.E. of regression	8.962145	Objective	4717.02
Quantile dependent	64	Restr. objective	5065.5
Sparsity	22.00408	Quasi-LR statistic	126.6964
Prob(Quasi-LR stat)	0		

Quantile regression divides the data set in categories or quartiles thus the output has a Pseudo  $R^2$  value not a normal  $R^2$  value. The Pseudo  $R^2$  is about 6% which is lower than the 12% for the OLS model thus quantile regression does not yield better predictors than Ordinary least squares regression.

### 6.2.2 ML - ARCH (Marquardt) - Normal distribution

The next model to be fit is the E-Garch model. The results are as follows:

**Table 35: ML - ARCH (Marquardt) - Normal distribution**

R-squared	0.004725	Mean dependent var	63.56333
Adjusted R-squared	-0.00266	S.D. dependent var	9.531009
S.E. of regression	9.543694	Akaike info criterion	6.068793
Sum squared resid	122687.6	Schwarz criterion	6.126382
Log likelihood	-4105.71	Hannan-Quinn criter.	6.090354
Durbin-Watson stat	0.000767		

Though the AIC, HIC and BIC values are lower than for the OLS regression model, the  $R^2$  is less than 1% which makes this a terrible model.

### **6.2.3 Step-wise regression model**

Since the previous models fitted have yielded poor results, a step-wise regression model was fitted to determine the best predictive model.

Stepwise regression shows that the linear regression model or the Ordinary Least squares regression model is actually the best predictive model for the data.

The OLS regression method still gives better results than the models tried above. The other regression model that can still be fit on the data is Ordinal Logistic regression.

### **6.2.4 Regression Conclusion**

The tests done above show that there is no one regression model which bests fit the data. The Ordinal regression model is better than all the models tried but it is not perfect though it provides valuable insights which will be discussed in the next chapter. The next chapter will look at an alternative model which can be fit on the data. The model suggested is still part of Structural Equation Modelling.

## 7 Path Modelling – Final Results and Discussions

### 7.1 Introduction-Path modelling

Regression Analysis showed the relationship between the various explanatory variables and the depended variables but it did not show numerous relationships between variables themselves simultaneously. A technique which settles this problem is Path Modelling.

Path Modelling is a statistical technique used to examine causal relationships between two or more variables. It is an extension of regression modelling in that it gives the extra flexibility of quantifying indirect and total causal effects (Bollen, 1989). That is, Path modelling allows the predictor variables to influence the outcome variable directly (as in the case with regression analysis) as well as indirectly through mediating variables.

The other characteristics of Path modelling are:

- i. The direction of influence in the relationship of variables should be specified from the theory behind the investigation.
- ii. Explanatory or Predictor variables are assumed to be measured without error.
- iii. The relationship between target variables is linear.
- iv. Any outcome variable in the system of equations under investigation has an error term attached to it.

Path analysis uses path diagrams to show hypothesized causal relationships between variables and thus in essence is an extension of regression analysis (Garson, 2004). The three main features of path modelling as stated by Bollen (1989) are:

- i. The translation of a conceptual problem into a pictorial presentation, which shows the network of relationships. This is regarded as the best way to represent causal relationships (Wright, 1920).
- ii. Obtaining systems of equations that relate observed correlation and covariance to parameters (Wright, 1923).

- iii. Decomposition of effects of one variable on another from the correlation of measured variables (Wright, 1921).

Amos21 was used to create path diagrams of the different relationships.

## 7.2 Limits of Regression Analysis

The Ordinal Least Squares Regression model or the Independence model explained in the previous chapter above is of the nature given below:

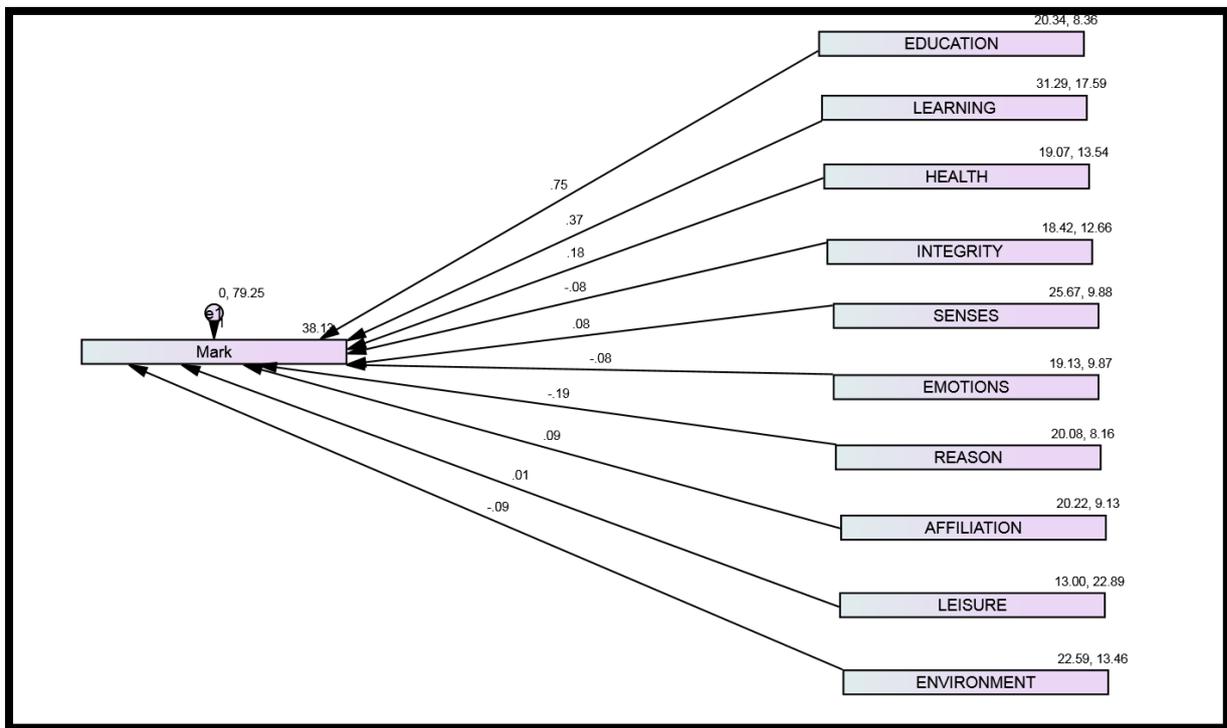


Figure 19: Independence model Amos

The regression analysis shows that there are three important capabilities at 95% confidence level. These Capabilities are Bodily health, Educational Resilience, and Learning disposition: Language and confidence. All three capabilities have positive co-efficiencies meaning they improve student marks. At a more relaxed significance level of 10% the capability Practical reasoning also becomes significant. One interesting fact though is that the Practical reason has a negative coefficient. This implies that, if one possesses this capability, their academic performance will slightly dampen. This could be because of the educational system which does not leave room for creativity and thorough pedagogical and epistemological contestations at undergraduate level

The revised model at 10% level of significance would be:

$$Mark_i = \beta_o + \beta_1 Educational\_resilience_{1,i} + \beta_2 Learning\_Disposition_{2,i} + \beta_3 Bodily\_health_{3,i} + \beta_4 Practical\_reasoning + \varepsilon_i \quad \dots \quad (7.1)$$

Running this model yields the following estimates:

**Table 36: Significant capabilities**

	<b>Coefficients</b>	<b>Standard Error</b>	<b>t Stat</b>	<b>P-value</b>
<b>C</b>	38.31622	2.252066	17.01381	5.63E-59
<b>Educational Resilience</b>	0.743241	0.104194	7.133238	1.59E-12
<b>Bodily Health</b>	0.36063	0.076284	4.72746	2.51E-06
<b>Learning disposition: Language and confidence</b>	0.151803	0.075014	2.023655	0.043202
<b>Practical Reasoning</b>	-0.20156	0.092719	-2.17391	0.029885

Thus the shown capabilities are statistically significant and are deemed the most important capabilities in order to improve academic performance and they are summed up in the regression model below:

$$Mark_i = 38.31622 - 0.202Practical\ Reasoning + 0.743Educational\ Resilience_i + 0.152Learning\_Disposition_i + 0.361Bodily\_health_i + \varepsilon_i \quad \dots \quad (7.2)$$

All the coefficients to the selected capabilities, except practical reason due to the reason expressed above, have the expected positive sign. We therefore conclude that, in this population of University students, out of a total of 10 human capabilities considered, the following capabilities were found to be critical for the wellbeing (academic achievement) of students: educational resilience, learning disposition, bodily health and practical reasoning. The model has a low  $R^2$  value indicating that there are other factors besides the selected capabilities which affect the academic performance of students.

### 7.3 Multicollinearity

The regression model above assumed that the explanatory variables are independent and are not inter-correlated. This is a fundamental assumption of the regression model which needs to be tested. Looking at the Correlation Matrix below, it can be seen that there is moderate positive correlation between the explanatory variables.

Table 37: Correlation Matrix

	INTEGRITY	EMOTIONS	REASON	SENSES	ENVIRONMENT	LEARNING	LEISURE	AFFILIATION	HEALTH	EDUCATION	Mark
INTEGRITY	1										
EMOTIONS	0.334	1									
REASON	0.171	0.404	1								
SENSES	0.285	0.396	0.43	1							
ENVIRONMENT	0.304	<b>0.501</b>	0.425	0.453	1						
LEARNING	0.334	0.487	0.386	0.495	0.466	1					
LEISURE	0.149	0.206	0.17	0.065	0.245	0.147	1				
AFFILIATION	0.239	0.466	0.391	0.414	<b>0.551</b>	0.424	0.219	1			
HEALTH	0.457	0.367	0.196	0.329	0.29	0.463	0.092	0.291	1		
EDUCATION	0.287	0.44	0.338	<b>0.501</b>	0.366	<b>0.565</b>	0.153	0.306	0.379	1	
Mark	0.108	0.154	0.089	0.197	0.127	0.29	0.048	0.138	0.206	0.317	1

From the matrix alone we cannot conclude on the absence of multicollinearity. Multicollinearity inflates standard error. To test for it Tolerance and Variance Inflation Factors (VIF) are considered. The VIF measures how much the variance of the estimated coefficients is increased over the case of no correlation among the explanatory variables. A tolerance close to 0 suggests there might be serious multicollinearity and VIF close to 1 suggests no multicollinearity.

The hypotheses for this test are:

$H_0$ : There is perfect independence, that is there is no multicollinearity (VIF = 1)

$H_1$ : The null hypothesis is false

The table below gives the results of the multicollinearity test is SPSS:

**Table 38 : Multicollinearity test**

Model		Unstandardized		Standardized			Collinearity Statistics	
		Coefficients		Coefficients			Tolerance	VIF
		B	Std. Error	Beta	T	Sig.		
1	(Constant)	20.768	3.559		5.835	.000		
	EDUCATION	.734	.217	.131	3.387	.001	.414	2.413
	LEARNING	.017	.165	.004	.103	.918	.333	3.007
	HEALTH	.143	.168	.029	.850	.396	.520	1.925
	INTEGRITY	.039	.162	.008	.243	.808	.583	1.714
	SENSES	.108	.200	.022	.540	.589	.373	2.684
	EMOTIONS	.417	.200	.078	2.090	.037	.439	2.280
	REASON	-.031	.203	-.005	-.151	.880	.493	2.027
	AFFILIATION	-.026	.206	-.005	-.127	.899	.440	2.272
	LEISURE	.271	.110	.067	2.472	.014	.841	1.190
	ENVIRONMENT	.242	.173	.053	1.399	.162	.431	2.318

a. Dependent Variable: Average mark for the first semester

The VIF values are all more than 1 hence we reject  $H_0$  since there is no perfect independence between and among the explanatory variables. One of the assumptions of the regression model is that there is no multicollinearity and the test above has shown that that assumption is violated along with the ones identified in the previous chapter.

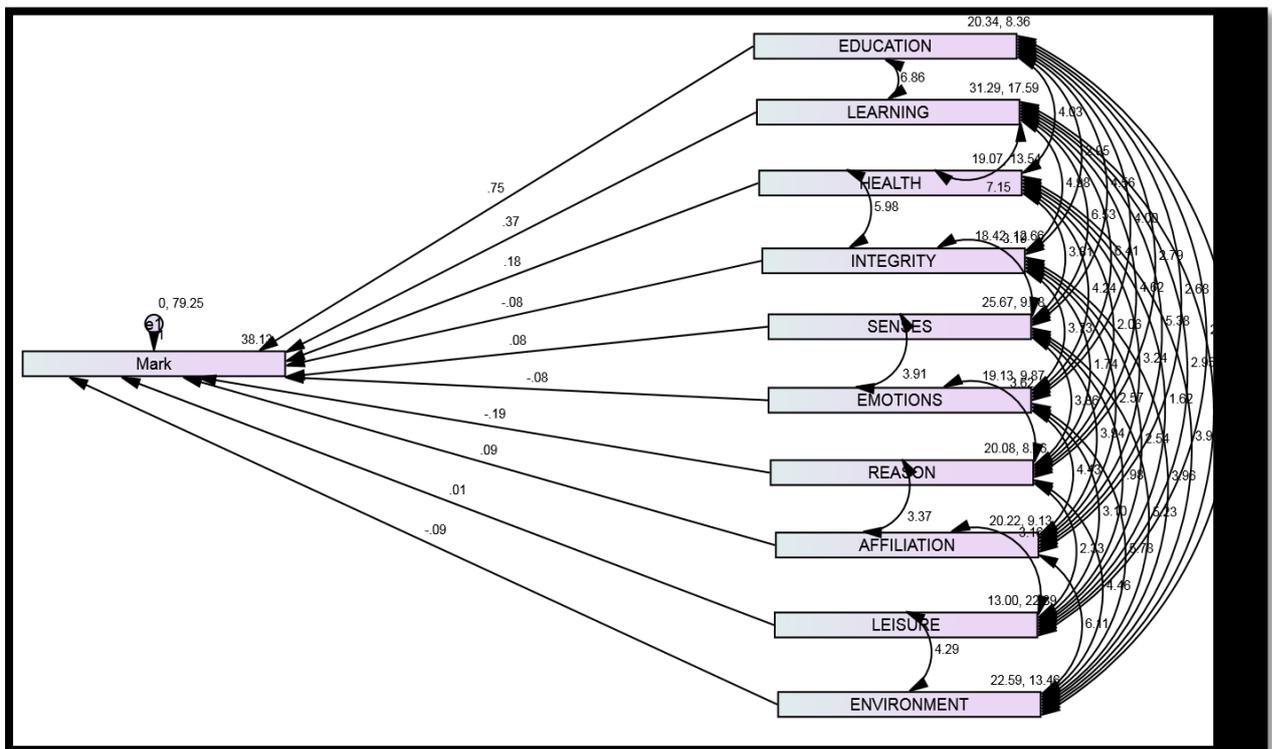
To improve the model, we need to use a model which allows for multi relationships to be modeled simultaneously which brings us to Path modelling.

## 7.4 Model fit: Path Modelling

The creation of Path diagrams allows us to model relationships without assuming absence of multicollinearity. It allows us to model the interrelationships between the explanatory variables as well as with the independent variable. In-order to study the influence of capabilities on student academic performance a few models need to be interrogated. The estimation method of choice is the Maximum Likelihood Estimate method and the estimates are unstandardized.

### 7.4.1 Saturated model

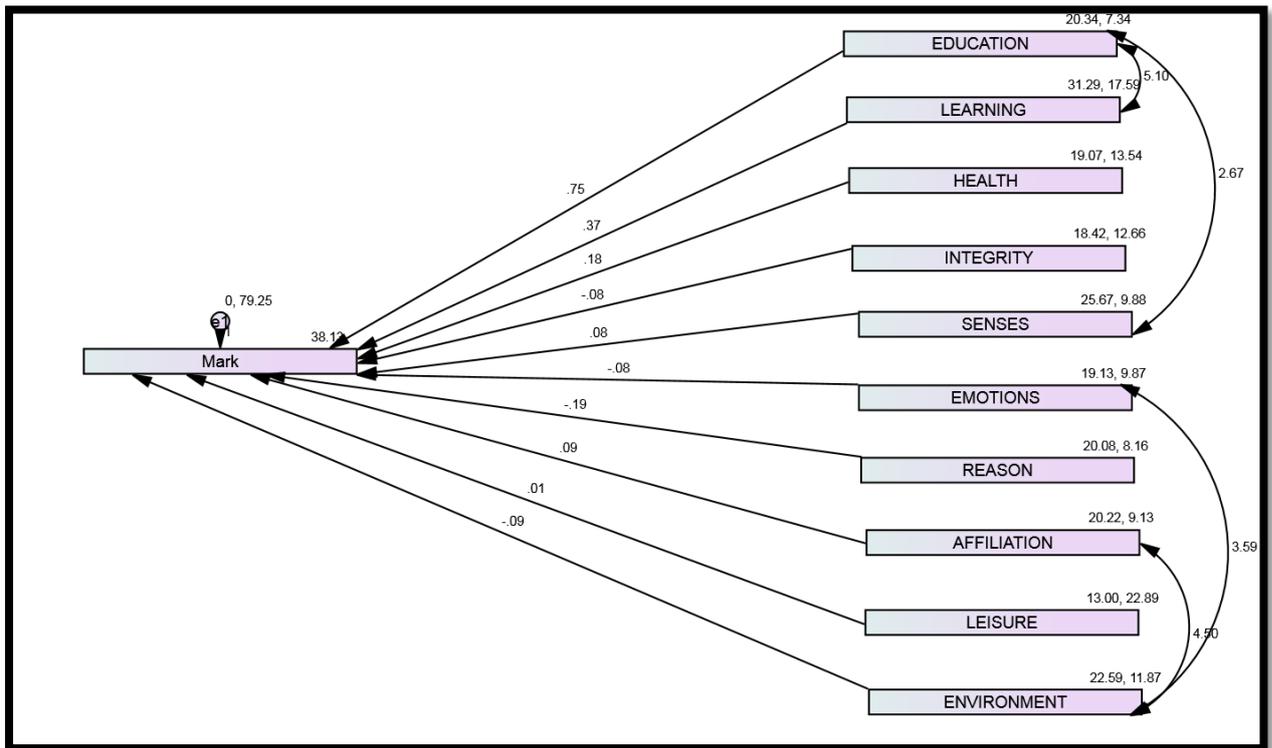
The saturated model assuming all the explanatory variables are interrelated would be:



**Figure 20: Saturated model**

This model can be simplified by using the correlation matrix given above to identify significant correlations.

The following relationships were suspected in the dependence model (see Figure 21)



**Figure 21: Dependence model with statistically significant covariances only**

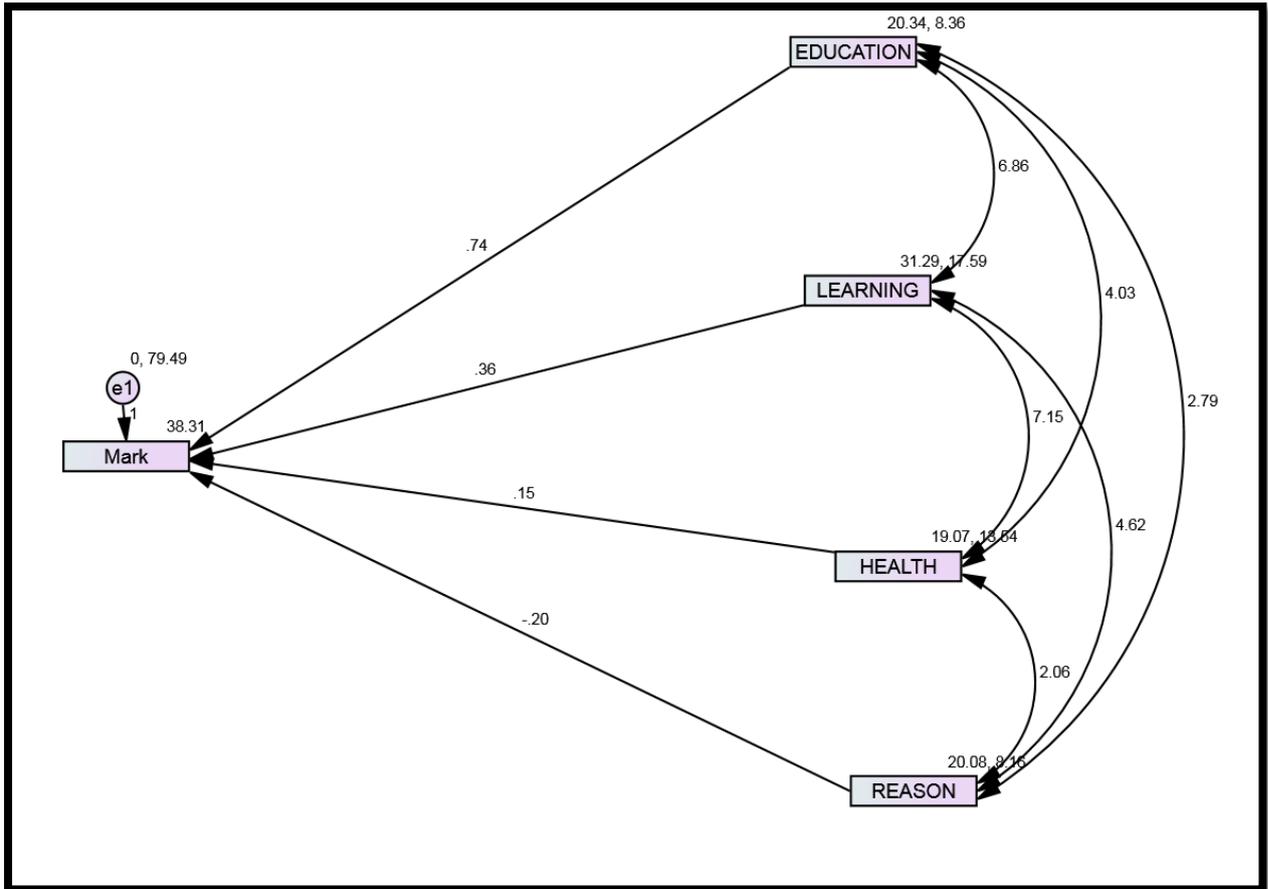
The values of the arrows represent the parameter estimates, the value on the Mark variable is the intercept of the model and the values on the boxes are the variables of the explanatory variables. The covariances indicated in the independence model are consistent with arguments from educational capability operationalization researchers like Walker (2006) and Wilson-Strydom (2010). The diagram shows that most of the explanatory variables/capabilities have positive co-efficiencies which show that capabilities increase students' marks and it also shows that certain capabilities are indeed correlated. The table below shows the regression weights from Path Analysis for the Path diagram above.

**Table 39: Regression weights**

			<b>Maximum Likelihood Estimate</b>	<b>Standard Error</b>	<b>Critical Ratio</b>	<b>P- Value</b>
Mark	<---	EDUCATION	.748	.084	8.954	.000
Mark	<---	HEALTH	.185	.066	2.816	.005
Mark	<---	AFFILIATION	.086	.080	1.069	.285
Mark	<---	LEISURE	.006	.051	.125	.900
Mark	<---	LEARNING	.374	.058	6.488	.000
Mark	<---	ENVIRONMENT	-.089	.066	-1.351	.177
Mark	<---	SENSES	.080	.077	1.044	.296
Mark	<---	REASON	-.193	.085	-2.285	.022
Mark	<---	EMOTIONS	-.077	.077	-1.003	.316
Mark	<---	INTEGRITY	-.082	.068	-1.212	.226

#### 7.4.2 Reduced model

Reducing the dependence model by removing all the statistically insignificant variables yields and incorporating all possible covariances produces the following reduced model:



**Figure 22: Reduced model with statistically significant capabilities only and all possible covariances**

The graph above showing covariances reveals that, like regression analysis, the capabilities selected improve student marks, except for the Practical reasoning capability which lowers the marks as explained in the regression analysis section. The table below shows that indeed all the variables are significant at 5% level of significance meaning the listed capabilities indeed affect the academic performance of the students.

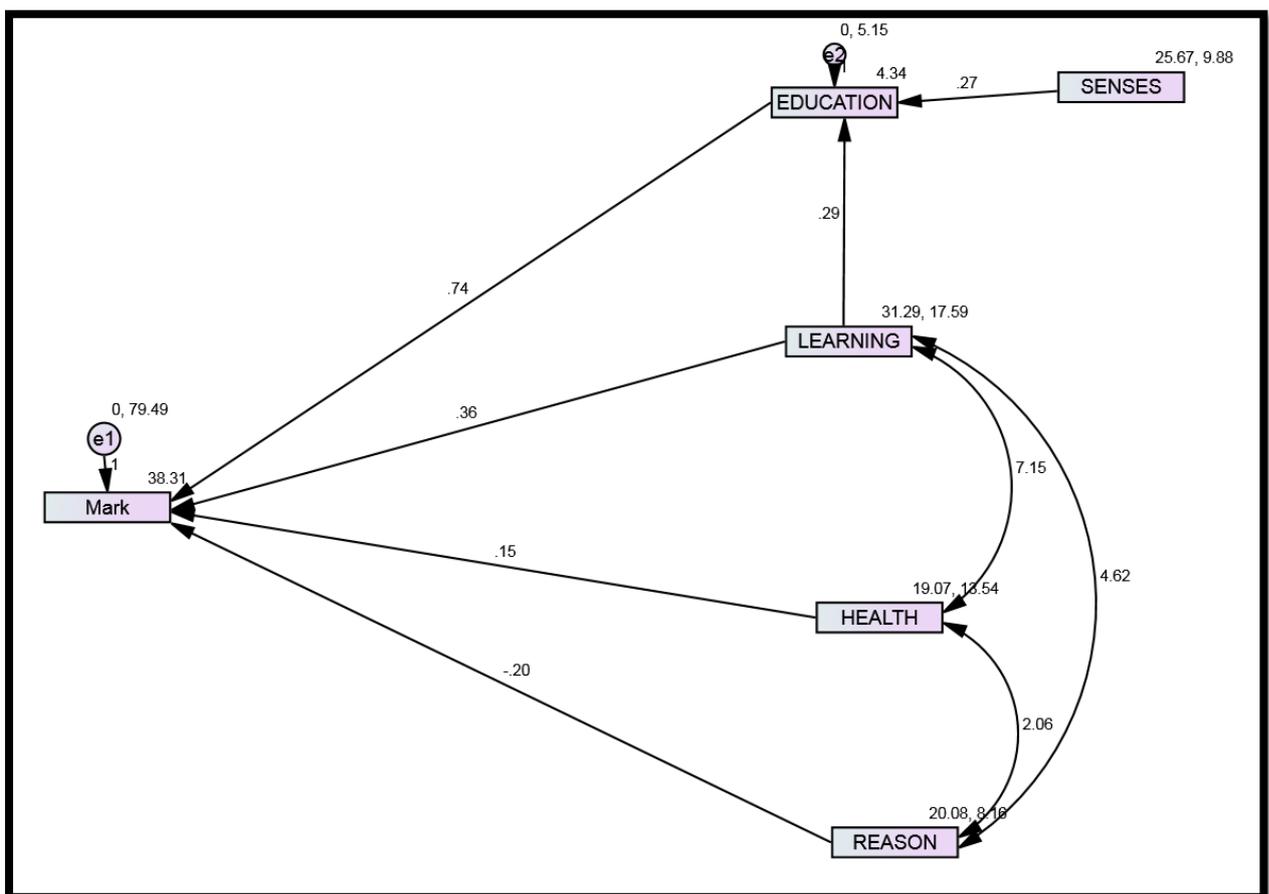
**Table 40: Weights of the reduced model**

			Maximum Likelihood Estimate	Standard Error	Critical Ratio	P-Value
Mark	<---	REASON	-.201	.093	-2.161	.031
Mark	<---	EDUCATION	.743	.104	7.139	.000
Mark	<---	LEARNING	.361	.076	4.730	.000
Mark	<---	HEALTH	.152	.075	2.025	.043

The greatest advantage of Path Modelling is that it allows for multiple relationships to be modelled simultaneously. Thus instead of looking at just the influence the capabilities on the marks we can look at the factors which influence the capabilities as well. These are referred to in literature as conversion factors (Robeyns, 2012).

### 7.4.3 Final Model

The correlation matrix shows that Environment and Emotions are highly correlated as well as Affiliation and Environment. The only variable of concern which is highly correlated to other explanatory variables in the reduced model is Education which is correlated with Learning and Senses.



**Figure 23: Final model with statistically significant capabilities and statistically significant covariances**

This model is an improvement of the reduced one and as shown in the table below, all the capabilities/explanatory variables are significant at 5% as shown below

**Table 41: Regression Weights of the final model**

			Maximum Likelihood Estimate	Standard Error	Critical Ratio	P- Value
EDUCATION	<---	SENSES	.270	.020	13.766	.000
EDUCATION	<---	LEARNING	.290	.015	19.736	.000
Mark	<---	REASON	-.201	.092	-2.188	.029
Mark	<---	EDUCATION	.743	.100	7.435	.000
Mark	<---	LEARNING	.361	.075	4.805	.000
Mark	<---	HEALTH	.152	.074	2.051	.040

In other notation, the final model thus is given by:

$$Average\_Mark_i = 0.743Educational\_resilience_i + 0.361Learning\_Disposition_i + 0.152Bodily\_health_i - 0.201Practical\_reasoning_i + \varepsilon_i \quad \dots (7.3)$$

Where:

i. The  $i$  refers to the  $i^{th}$  student

ii.  $Educational\_resilience_i = 0.27 * Senses_i + 0.27 * Learning\_disposition_i \dots(7.4)$

The model shows that a student's academic performance is influenced by the student's practical reasoning skills, bodily health, learning disposition and Educational resilience. It also shows that Educational resilience depends on a student's Learning disposition or preparedness as well as the student's Senses, Imagination and thoughts.

Further, the model reviews that there are significant correlations between Learning disposition, bodily health and practical reasoning skills which means that a student needs to be balanced in all the listed capabilities in order for him/her to perform well.

### 7.5 The effect of background variables on the valued student capabilities

There are salient factors which affect student capabilities. This section shall investigate the effects of some of these factors on the four main valuable capabilities.

One of the core concepts in the Human Capability theory is the concept of conversion factors which was explained in Chapter 2. Conversion factors are the background factors which assist in the transformation of a functioning into a capability. This section will explore the effect of the following background factors; Race, Gender, Home Language, Language of Instruction, Residence, Academic year and Faculty on the capabilities which were observed above as valuable for student academic achievement .

To achieve this, the background variables were collapsed into dichotomous variables which were then regressed against the capabilities.

The factors observed were:

#### Gender

$$GenderM = \begin{cases} 1 & \text{if } Male \\ 0 & \text{Female (as basis of comparison)} \end{cases}$$

#### Residence

$$Res\_Family = \begin{cases} 1 & \text{if } Family \\ 0 & \text{otherwise} \end{cases}$$

$$Res\_StudentAccommodation = \begin{cases} 1 & \text{if } StudentAccommodation \\ 0 & \text{otherwise} \end{cases}$$

$$Res\_Private = \begin{cases} 1 & \text{if } Private \\ 0 & \text{otherwise} \end{cases}$$

On-Campus residence will be used as basis of comparison.

#### Home Language

$$Lang\_Sesotho = \begin{cases} 1 & \text{if } Sesotho \\ 0 & \text{otherwise} \end{cases}$$

$$Lang\_Afrikaans = \begin{cases} 1 & \text{if Afrikaans} \\ 0 & \text{otherwise} \end{cases}$$

$$Lang\_Tswana = \begin{cases} 1 & \text{if Tswana} \\ 0 & \text{otherwise} \end{cases}$$

$$Lang\_Xhosa = \begin{cases} 1 & \text{if Xhosa} \\ 0 & \text{otherwise} \end{cases}$$

$$Lang\_IsiZulu = \begin{cases} 1 & \text{if IsiZulu} \\ 0 & \text{otherwise} \end{cases}$$

$$Lang\_Venda = \begin{cases} 1 & \text{if Venda} \\ 0 & \text{otherwise} \end{cases}$$

English Home Language is used as a basis of comparison.

### Language of instruction

$$LangInstructionEng = \begin{cases} 1 & \text{if English} \\ 0 & \text{if Afrikaans (as basis of comparison)} \end{cases}$$

### Race

$$Race\_Black = \begin{cases} 1 & \text{if Black} \\ 0 & \text{otherwise} \end{cases}$$

$$Race\_Coloured = \begin{cases} 1 & \text{if Coloured} \\ 0 & \text{otherwise} \end{cases}$$

$$Race\_Asian = \begin{cases} 1 & \text{if Asian} \\ 0 & \text{otherwise} \end{cases}$$

The White race will be used as basis of comparison.

### Faculty

$$Facult\_NAS = \begin{cases} 1 & \text{if NAS} \\ 0 & \text{otherwise} \end{cases}$$

$$Facult\_Law = \begin{cases} 1 & \text{if Law} \\ 0 & \text{otherwise} \end{cases}$$

$$Facult\_Theo = \begin{cases} 1 & \text{if Theo} \\ 0 & \text{otherwise} \end{cases}$$

$$Facult\_Hum = \begin{cases} 1 & \text{if Hum} \\ 0 & \text{otherwise} \end{cases}$$

$$Facult\_EDU = \begin{cases} 1 & \text{if EDU} \\ 0 & \text{otherwise} \end{cases}$$

$$Facult\_Health = \begin{cases} 1 & \text{if } Health \\ 0 & \text{otherwise} \end{cases}$$

The faculty of Commerce, Economic and Management Sciences, will be used as basis of comparison.

### Year or Study

$$Year\_2 = \begin{cases} 1 & \text{if } is\ 2^{nd} \\ 0 & \text{otherwise} \end{cases}$$

$$Year\_3 = \begin{cases} 1 & \text{if } 3^{rd} \\ 0 & \text{otherwise} \end{cases}$$

$$Year\_4^+ = \begin{cases} 1 & \text{if } 4^+ \\ 0 & \text{otherwise} \end{cases}$$

The first year of study will be used as the baseline.

### 7.5.1 Educational Resilience- background factors

The effects of the background factors on the educational resilience capability are summarized in the table below:

**Table 42: Effect of Conversion factors on Educational Resilience**

			Estimate	S.E.	C.R.	P
EDUCATION	<---	Lang_Sesotho	-0.441	0.216	-2.039	0.041
EDUCATION	<---	Lang_Afrikaans	2.291	0.183	12.538	***
EDUCATION	<---	Lang_Tswana	-1.194	0.305	-3.913	***
EDUCATION	<---	Lang_Xhosa	-0.018	0.361	-0.05	0.96
EDUCATION	<---	Lang_IsiZulu	-1.074	0.349	-3.08	0.002
EDUCATION	<---	Lang_Venda	1.171	0.673	1.74	0.082
EDUCATION	<---	LangInstructionEng	1.596	0.229	6.968	***
EDUCATION	<---	Race_Black	1.883	0.173	10.901	***
EDUCATION	<---	Race_Coloured	0.135	0.401	0.337	0.736
EDUCATION	<---	Race_Asian	1.448	0.839	1.726	0.084
EDUCATION	<---	Facult_Hum	1.002	0.203	4.935	***
EDUCATION	<---	Facult_Law	0.967	0.273	3.539	***
EDUCATION	<---	Facult_NAS	0.813	0.201	4.046	***
EDUCATION	<---	Facult_Edu	1.246	0.288	4.325	***
EDUCATION	<---	Facult_Theo	1.713	0.701	2.443	0.015
EDUCATION	<---	Facult_Health	1.591	0.375	4.245	***
EDUCATION	<---	Year_3	0.585	0.218	2.685	0.007
EDUCATION	<---	Year_4	0.627	0.188	3.331	***
EDUCATION	<---	Year_2	1.239	0.203	6.11	***
EDUCATION	<---	GenderM	0.461	0.175	2.635	0.008
EDUCATION	<---	Res_StudentAccommodation	0.934	0.335	2.79	0.005

<b>EDUCATION</b>	<---	Res_Private	1.501	0.188	7.974	***
<b>EDUCATION</b>	<---	Res_Family	0.916	0.177	5.179	***

The table above shows that the following home languages; Sesotho, Tswana and IsiZulu have statistically significant and lower effects on Educational resilience than English language. Conversely, Afrikaans as a home language has a larger effect on the development of Educational resilience than English as a home language of the students.

Race also has a positive effect on the development of Education resilience. Black ethnicity has a larger effect on educational resilience than white.

Gender has a statistically significant positive effect on educational resilience in favour of male students.

The table shows that the effect of the 2<sup>nd</sup> year of study on Educational resilience is higher than any other year as well as the effects of the various years of study increases after 1<sup>st</sup> year. This implies senior students have more educational resilience than junior students with the exception of 2<sup>nd</sup> year students who have the highest effect.

The table suggests that Health students have the greatest educational resilience followed by Education, Humanities, Law, Science and Commerce students.

The language of instruction also has a very significant effect on educational resilience with English enhancing the capability almost twice as much as Afrikaans.

Off campus residences have a higher effect on educational resilience than on campus residence.

The following figure shows the magnitude of the effects (as indicated by the numbers on the arrows).

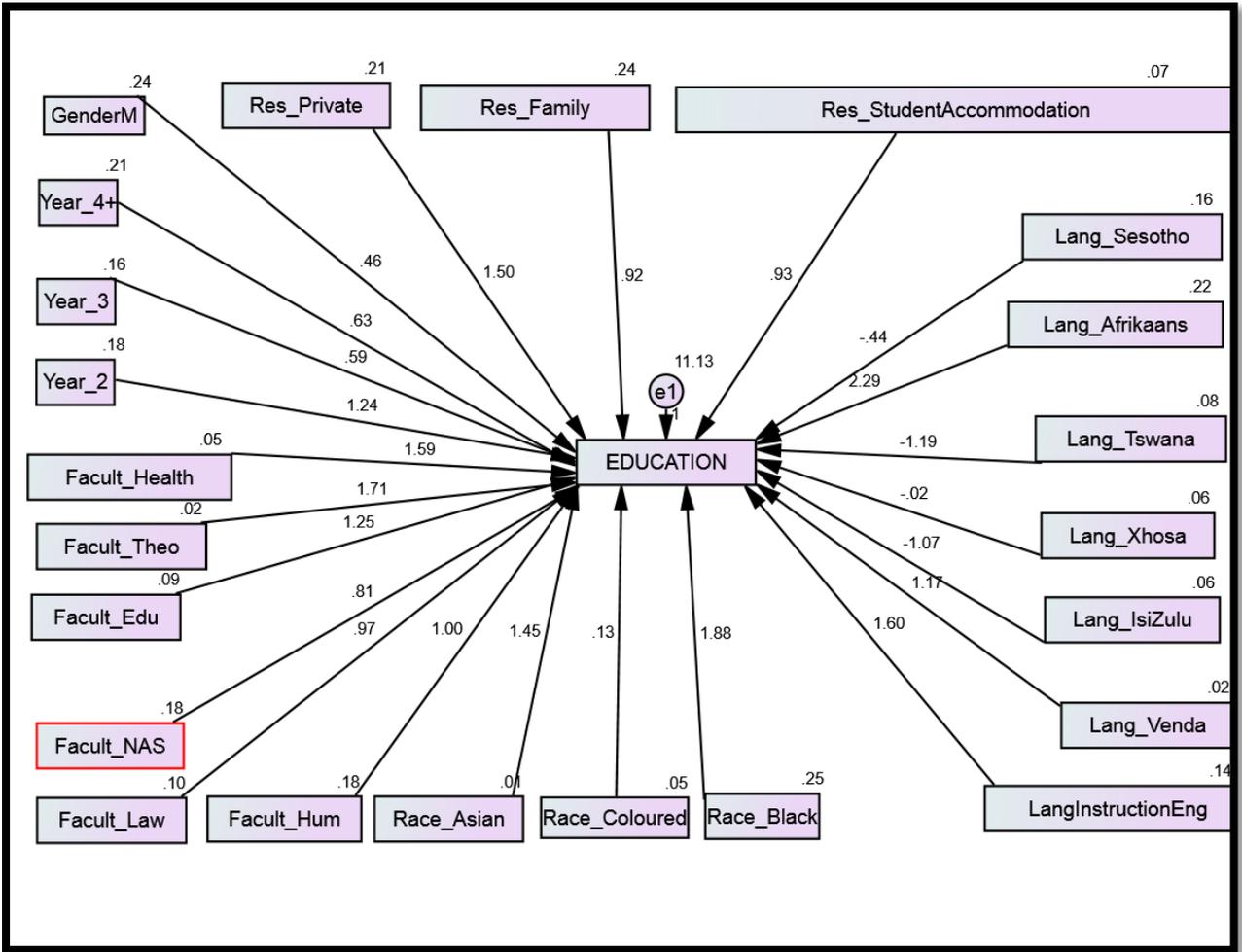


Figure 24: Effects of background factors on the Educational resilience capability

## 7.5.2 Learning disposition

The effects of the background factors on the Learning disposition capabilities are summarized in the table below:

**Table 43: Learning disposition background factors**

			Estimate	S.E.	C.R.	P
<b>LEARNING</b>	<---	Lang_Sesotho	-0.968	0.321	-3.014	0.003
<b>LEARNING</b>	<---	Lang_Afrikaans	2.576	0.271	9.491	***
<b>LEARNING</b>	<---	Lang_Tswana	-1.954	0.453	-4.311	***
<b>LEARNING</b>	<---	Lang_Xhosa	-1.034	0.536	-1.929	0.054
<b>LEARNING</b>	<---	Lang_IsiZulu	-1.716	0.518	-3.313	***
<b>LEARNING</b>	<---	Lang_Venda	0.306	1	0.306	0.759
<b>LEARNING</b>	<---	LangInstructionEng	2.265	0.34	6.655	***
<b>LEARNING</b>	<---	Race_Black	2.15	0.256	8.383	***
<b>LEARNING</b>	<---	Race_Coloured	0.252	0.595	0.424	0.671
<b>LEARNING</b>	<---	Race_Asian	1.82	1.246	1.461	0.144
<b>LEARNING</b>	<---	Facult_Hum	1.357	0.302	4.5	***
<b>LEARNING</b>	<---	Facult_Law	1.389	0.406	3.423	***
<b>LEARNING</b>	<---	Facult_NAS	1.221	0.298	4.092	***
<b>LEARNING</b>	<---	Facult_Edu	2.077	0.428	4.853	***
<b>LEARNING</b>	<---	Facult_Theo	2.455	1.042	2.357	0.018
<b>LEARNING</b>	<---	Facult_Health	1.53	0.557	2.749	0.006
<b>LEARNING</b>	<---	Year_3	1.028	0.324	3.175	0.001
<b>LEARNING</b>	<---	Year_4	1.557	0.28	5.569	***
<b>LEARNING</b>	<---	GenderM	0.477	0.26	1.836	0.066
<b>LEARNING</b>	<---	Res_StudentAccommodation	0.85	0.497	1.708	0.088
<b>LEARNING</b>	<---	Res_Private	1.88	0.28	6.725	***
<b>LEARNING</b>	<---	Res_Family	1.206	0.263	4.591	***
<b>LEARNING</b>	<---	Year_2	1.546	0.301	5.132	***

Staying in a student accommodation has an insignificant effect on Learning disposition compared to staying on campus. The table above shows that the following home languages; Sesotho, Tswana and IsiZulu have statistically significant and lower effects on learning disposition than English language. Also, Afrikaans as a home language has a larger effect on learning disposition than English as a home language of the students.

Race also has a positive effect on the learning disposition of the students. Black ethnicity has a larger effect on learning disposition than white.

Gender does not have a statistically significant effect on learning disposition.

The table shows that the effects of the various years of study on learning disposition increases after 1st year.

The table suggests that the effects of learning disposition are highest in Health students followed by Education, Law, Humanities, Science and Commerce students.

The language of instruction also has a very significant effect on learning disposition in favour of Afrikaans over English.

The effects are summarized below:

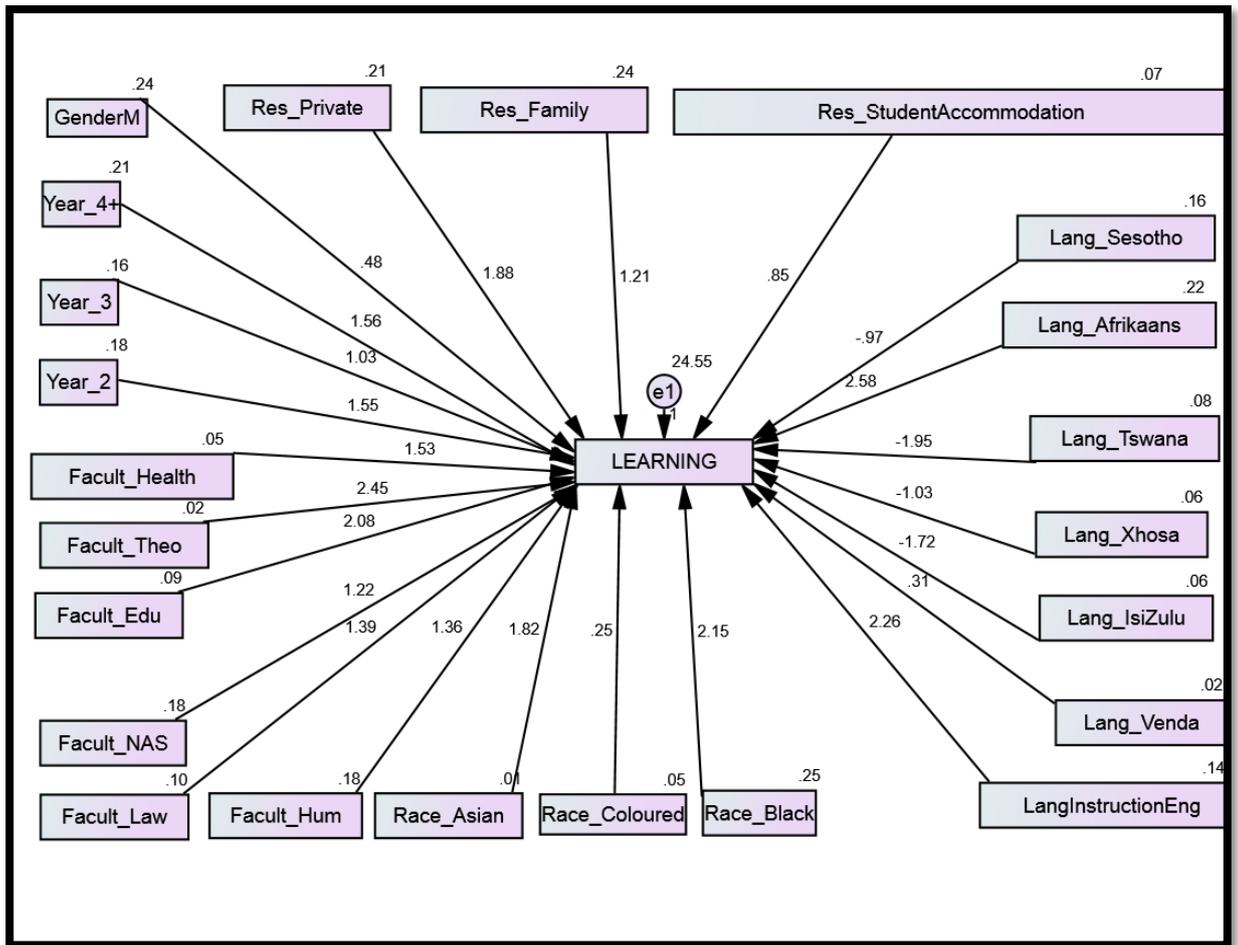


Figure 25: Effects of background factors on Learning disposition

### 7.5.3 Bodily Health

The effects of the background factors on the Bodily Health capability are as follows:

Table 44: Bodily Health background factors

			Estimate	S.E.	C.R.	P
HEALTH	<---	Lang_Sesotho	-1.172	0.251	-	***
					4.673	
HEALTH	<---	Lang_Afrikaans	2.229	0.212	10.52	***
					2	
HEALTH	<---	Lang_Tswana	-1.014	0.354	-	0.004
					2.865	
HEALTH	<---	Lang_Xhosa	-0.086	0.419	-	0.836
					0.207	
HEALTH	<---	Lang_IsiZulu	-1.528	0.404	-3.78	***
HEALTH	<---	Lang_Venda	-0.609	0.78	-0.78	0.436
HEALTH	<---	LangInstructionEng	1.038	0.266	3.908	***
HEALTH	<---	Race_Black	0.649	0.2	3.241	0.001
HEALTH	<---	Race_Coloured	-0.732	0.464	-	0.115
					1.576	
HEALTH	<---	Race_Asian	-0.283	0.973	-	0.771
					0.291	
HEALTH	<---	Facult_Hum	-0.029	0.235	-	0.901
					0.124	
HEALTH	<---	Facult_Law	0.872	0.317	2.753	0.006
HEALTH	<---	Facult_NAS	0.243	0.233	1.042	0.298
HEALTH	<---	Facult_Edu	-0.386	0.334	-	0.248
					1.156	
HEALTH	<---	Facult_Theo	1.162	0.813	1.429	0.153
HEALTH	<---	Facult_Health	0.862	0.435	1.983	0.047
HEALTH	<---	Year_3	0.308	0.253	1.219	0.223
HEALTH	<---	Year_4	0.75	0.218	3.437	***
HEALTH	<---	GenderM	-0.026	0.203	-0.13	0.897
HEALTH	<---	Res_StudentAccommodation	0.93	0.388	2.395	0.017
HEALTH	<---	Res_Private	1.204	0.218	5.515	***
HEALTH	<---	Res_Family	0.788	0.205	3.846	***
HEALTH	<---	Year_2	0.778	0.235	3.308	***

The table above shows that the following home languages; Sesotho, Tswana and IsiZulu have statistically significant and lower effects on Bodily Health than English

language. Afrikaans as a home language has a larger effect on the appreciation of Bodily Health than English as a home language of the students.

Race also has an effect on the development of Bodily Health. Black ethnicity has a larger effect on Bodily health than white.

Gender does not have a statistically significant effect on educational resilience in favour of male students.

The table shows that the effect of the 2nd year of study on Bodily Health is higher than any other year

The table suggests that Law students have the greatest appreciation of the Bodily health.

The language of instruction also has a very significant effect on Bodily health with English students being affected almost twice as much as Afrikaans.

The effect of staying off campus on the Bodily Health capability is positive and statistically significant.

The following figure shows the magnitude of the effects (as indicated by the numbers on the arrows).

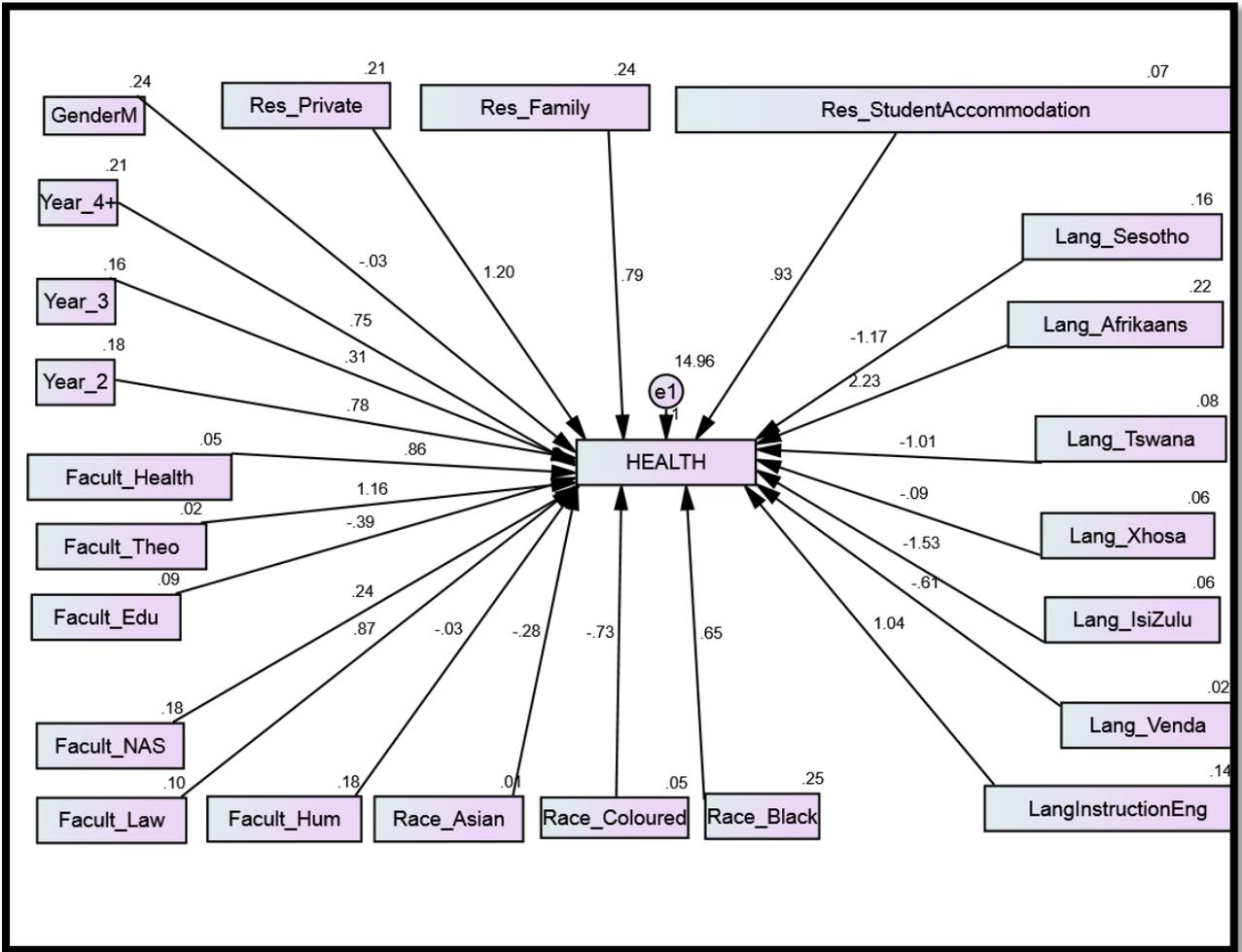


Figure 26: Background factors and Bodily Health

### 7.5.4 Practical reasoning

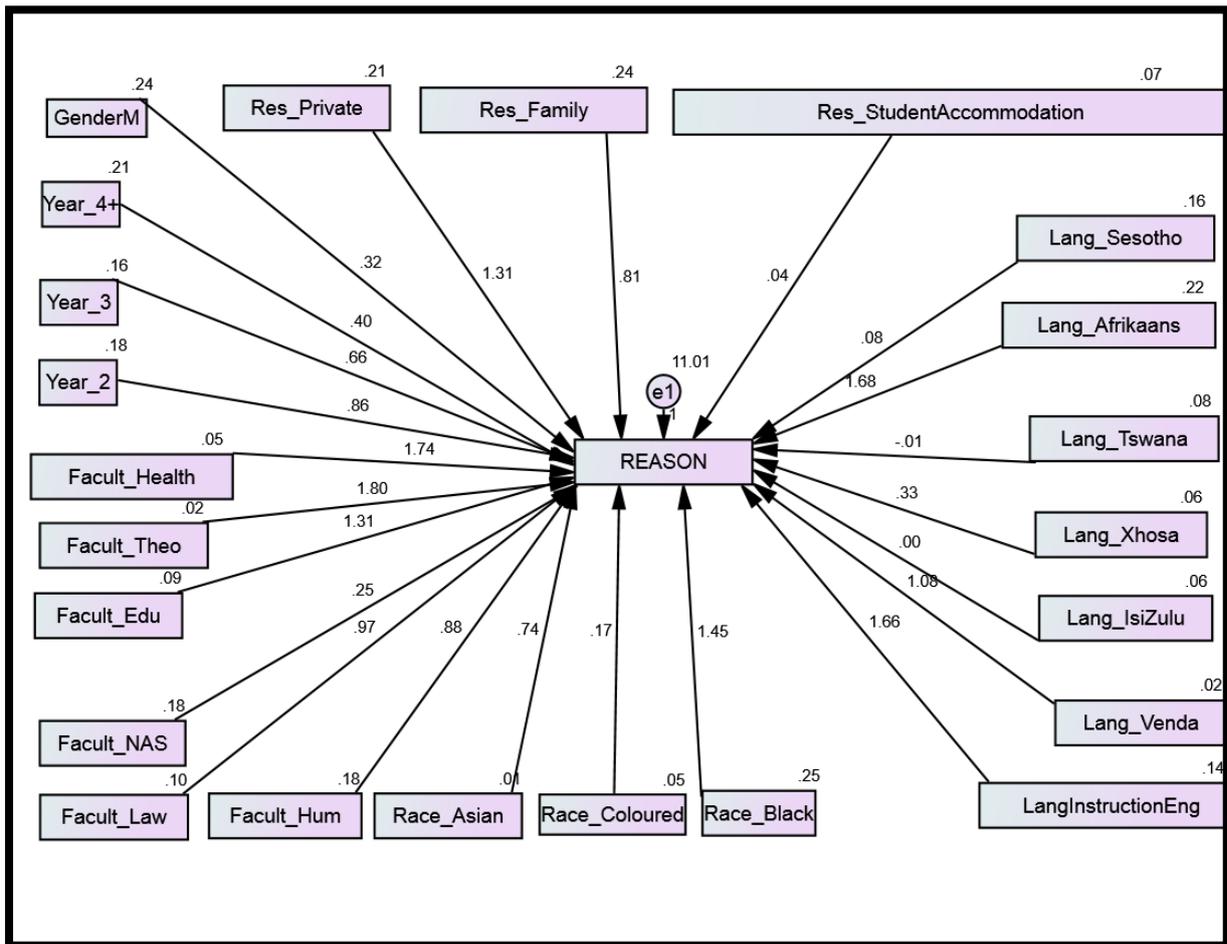


Figure 27: Practical reasoning and background factors

The figure above shows the effects of the various conversion factors on the Practical reasoning capability.

The figure above and the table below show that Afrikaans is the only home language that has an effect which is statistically significant on practical reason. This effect is more than English home language.

The Language of Instruction has a huge effect on Practical reasoning . Also, residing with family and residing in private accommodation has a positive effect on practical reasoning compared to residing on campus.

All the faculties except the Natural and Agricultural faculty have effects on practical reasoning.

**Table 45: Practical reasoning background factors**

REASON	<---	Lang_Sesotho	0.077	0.215	0.359	0.72
REASON	<---	Lang_Afrikaans	1.675	0.182	9.219	***
REASON	<---	Lang_Tswana	-0.012	0.304	-0.04	0.968
REASON	<---	Lang_Xhosa	0.329	0.359	0.916	0.36
REASON	<---	Lang_IsiZulu	0.002	0.347	0.007	0.994
REASON	<---	Lang_Venda	1.083	0.669	1.618	0.106
REASON	<---	LangInstructionEng	1.663	0.228	7.298	***
REASON	<---	Race_Black	1.452	0.172	8.457	***
REASON	<---	Race_Coloured	0.168	0.398	0.422	0.673
REASON	<---	Race_Asian	0.739	0.834	0.886	0.376
REASON	<---	Facult_Hum	0.876	0.202	4.341	***
REASON	<---	Facult_Law	0.969	0.272	3.567	***
REASON	<---	Facult_NAS	0.251	0.2	1.258	0.209
REASON	<---	Facult_Edu	1.306	0.287	4.559	***
REASON	<---	Facult_Theo	1.798	0.697	2.578	0.01
REASON	<---	Facult_Health	1.744	0.373	4.679	***
REASON	<---	Year_3	0.655	0.217	3.024	0.002
REASON	<---	Year_4	0.405	0.187	2.162	0.031
REASON	<---	GenderM	0.318	0.174	1.825	0.068
REASON	<---	Res_StudentAccommodation	0.043	0.333	0.129	0.898
REASON	<---	Res_Private	1.309	0.187	6.994	***
REASON	<---	Res_Family	0.81	0.176	4.606	***
REASON	<---	Year_2	0.859	0.202	4.257	***

## 7.6 Path Modelling Conclusion

The study showed that Path modelling is a better option in modelling student capabilities since it is flexible enough to cater for inter-relationships of the variables. Further the study identified that the following capabilities are important in the Higher Education context: Educational resilience which is influenced by the Learning disposition, Bodily health and Practical reasoning. These findings also validate Ingrid Robeyns (2000) claim that Nussbaum's list of core capabilities is not exhaustive since in this study the Educational resilience capability suggested by Melanie Walker (2006) and the Learning disposition capability modified by Merridy Wilson-Strydom were found to be relevant capabilities in Higher Education though they are not part of the Nussbaum's list. The chapter also showed the effect of conversion factors on the capabilities.

## 8 Conclusions and recommendations

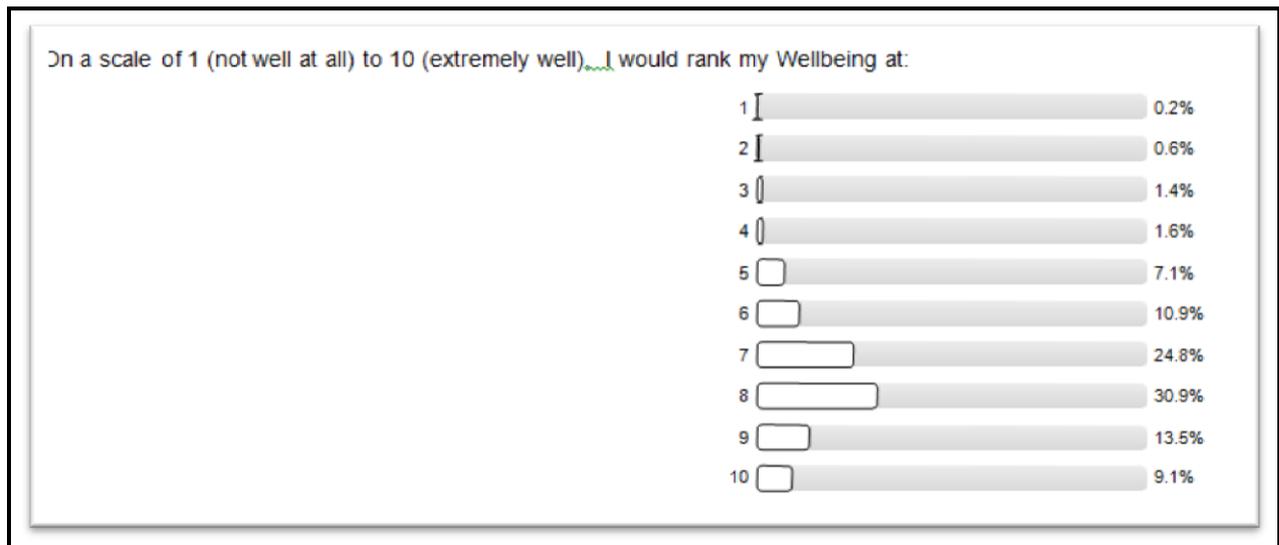
The title of the study is “The Human Capabilities Approach and Measurement: Operationalizing Human Capability Indicators in Education.” The aim of the study was to identify valuable capability indicators in Higher Education, as well as to create or identify a model to measure these capabilities. This chapter will discuss the effectiveness of this study in achieving this goal, together with justifications and elucidations on the results obtained from the empirical study.

### 8.1 Analysis and results

The last two chapters focused primarily on looking at the predictive models that can be used to develop a prediction estimates for a model to measure student wellbeing in Higher Education. The initial model proposed was the Ordinary Least squares regression model with student marks as a proxy for wellbeing.

The limitations of using student marks as a proxy for wellbeing are that student marks are affected by an infinitely larger number of variables than just capabilities. These variables may include quality of the lecturing they receive and the availability of productive and conducive academic spaces. These variables were not included in the model because indicators are not easy to develop and test. Another key variable which could affect student marks is their state of health and in this study this was not evaluated medically. The academic marks can be affected by a superfluity of factors which cannot be exhausted.

Limited as student marks are as a proxy for student wellbeing, they are the best easily accessible and quantifiable indicators of wellbeing that could have been identified at this level. A follow up study on this one can attempt to find an alternative single indicator for a student’s capability set. The average academic mark for students as shown in the previous chapters is comparable with their overall perception of their wellbeing shown in the figure below which makes student marks a reasonable proxy.



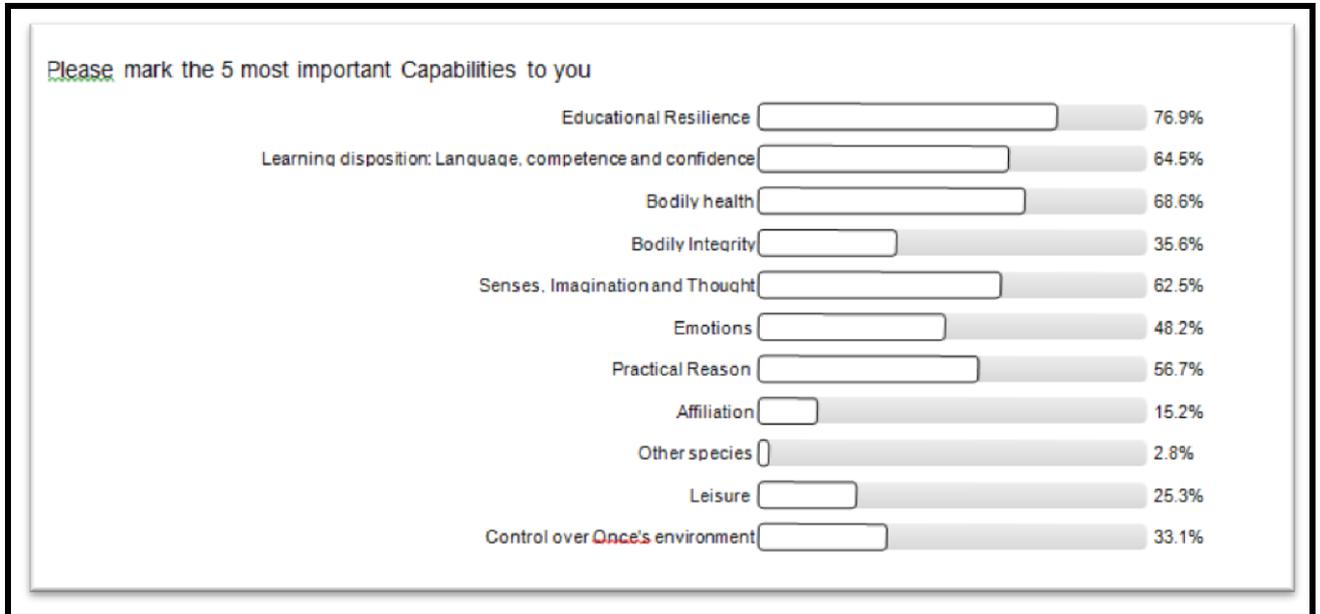
**Figure 28 : Aggregate perceived wellbeing**

The fact that student marks are affected by a seemingly large number of variables other than the capabilities a student has therefore means that the capabilities identified in this study cannot fully explain the variation in the marks. Thus the model proposed cannot and theoretically should not fully explain all the variation in student marks. From the Ordinary Least Squares Regression model a  $R^2$  value of 12% was obtained meaning the capabilities caused 12% of the variation in student marks which indicates that that the capabilities a student has contribute significantly to the student's academic performance as all other unidentified variables contribute 88%. The case is even better for the Ordinal Logistic regression model which has a Pseud R-squared value of approximately 28%. As said above the 28% R-squared value though is falls short of explaining all the variation in student marks is quite high showing that the capabilities a student has do affect student marks and that the Ordinal Logistic regression model is an improvement on the Ordinary Least squares model.

The shortcomings of the Ordinal Logistic Regression model explained in the previous chapter make it a less robust model than the final model fitted on the data-the Path Model.

Path modelling identified Educational resilience, Bodily integrity, Learning disposition: Language, competence and confidence, Practical reasoning and Senses Imagination and Thought as the key capabilities which students value. Comparing these capabilities with the responses of the students on the question which asked them to rank their

capabilities Figure 29 shows that the top four capabilities which students ranked as important based on the perceptions are indeed the capabilities which the model identified as important based on Path Modelling of their indicators.



**Figure 29 : Aggregate Ranking of capabilities**

This is a validation of processes following in modelling student capabilities and it shows that models fitted were fitted correctly and that there is an honourable degree of integrity in them.

The study thus met its objective of creating a statistical model to measure student capabilities.

## 8.2 Methodological discussions

The methodology used in this study has a plethora of advantages over the other alternative methods as discussed in Chapter 3. The method has yielded a great deal of success in answering the research questions. However, there are a number of limitations/shortcomings of the research methodology which will be discussed below.

The first limitation is the choice of indicators of capabilities. The capability set used for the study was obtained from literature as explicated in Chapter 2 and chapter 3. The set was a triangulation of various capability lists. This method provided a pragmatic and realistic solution, given the circumstances, to the problem of identification of a capability set. The

greatest weakness of this method however, is that some key capabilities which are context specific could have been left out of the model and some irrelevant capabilities have been added. An alternative method to the creation of the capabilities method used is to use in-depth individual interviews or focus group discussions to ascertain exactly what students have reason to value. This was not done given the scope and nature of the study. There were time constraints on the Masters project and theoretical lists were considered a practical option.

The models could not explain most of the variation in student marks, meaning there were some vital capabilities which needed to be added to the model. This short-coming is not necessarily a total negative because it contributes to the literature on the measurement of capabilities, proposing that the lists are not necessarily the best way to identify valuable capabilities. Further, this resonates well with Sen (1989) who advocates for deliberative democracy in identifying relevant corporate capabilities.

As part of the methodology, indicators of valuable student capabilities were created via processes of consultations with experts and through robust engagement with literature on similar studies. The indicators of capabilities seemed to capture the essence of the capabilities but there was no way to thoroughly test their effectiveness. This ambiguity in the method which was adopted from Anand (2013) could have affected the results of the study had there been a rogue or flat indicator. The indicators though appraised by most experts could still have added a degree of error. The solution to this in possible future similar studies could be to have a more rigorous interrogation. The indicators used in this study were interrogated through iterative diligent consultative processes so they were as suitable as could be given the circumstances.

After the indicators were developed, a measuring instrument was then developed. The measuring instrument of choice was a survey which can capture primarily quantitative data. The questionnaire, as can be seen in the appendix, had all relevant demographic information and questions which were indicators of probabilities. The instrument was piloted and redrafted and the version which was sent out was thoroughly probed for all possible loopholes. The advantage of using the questionnaire included the fact that we could get the views of many people on many different indicators. This added a dimension of validity to the methodology.

A very good response rate was achieved on the questionnaire, one thousand five hundred and three (1 503) students completed the questionnaire. This response rate speaks to the credibility of the instrument and the relevance thereof. The measuring instrument used was the best in obtaining primary quantitative data which can be analysed statistically.

The results of the survey were expansive and they cover many aspects which are beyond the scope of this study. These results can be used in further studies in the capabilities approach or in Higher Education studies. The fact that the instrument generated multi-commutable results shows that the instrument was robust. The results obtained can be analysed on three fronts.

Firstly, the demographical information can be used in any other study on the university. To date, the sample for this study is the biggest and most diversified group of students ever researched on for any academic study at the university thus the data can explain a lot of relationships and cross relationships between different demographical groups. The second tier is the results from the open ended questions that were asked. The extensive and elaborate qualitative string responses obtained can be analysed qualitatively to obtain vital insight on the well-being of students. There are over 1 460 direct students' opinions on their wellbeing which can be used by policy makers at the university when they formulate policies which deal with student life and student affairs. Thus, from the methodology of this study the emerged valuable information and data not only for my purposes but for the good of the general research community. The last tier is the capabilities section. This section comprises the ordinal responses to the various indicators of the capabilities. The responses given can be analysed and tested to find the strength of each indicator.

The final section of the methodology section focused on coding and transformation of some of the ordinal variables to continuous. The mathematical tractability of the transformation makes this study the first in the capabilities measurement literature to do that critical transformation. Most other studies make the mistake of working with categorical data as numerical data thereby obtaining spurious conclusions. The study provided a novel step to the capability measurement methodological pool.

The research was located in a post-positivist research paradigm and the results attest to that fact. The above methodological process was unique and useful in answering the research questions.

### 8.3 Literature discussion

The results obtained in this study are not at a tangent to the results from other researchers in measurement literature like Paul Anand. The study concurred with previously published literature on numerous points like the measurement instrument of choice for the quantitative study, the type of models best suited for this kind of research and on the limitations of the capabilities approach in providing a single measurable and exhaustive indicator of wellbeing.

However, the study found a couple of blank and blind spots in the measurement literature. The first short-coming is the use of predetermined lists in identifying valuable capabilities. This study showed that in a post-positivist or positivism research paradigm it is prudent to stick to theories by researchers in the positivism paradigm as well rather than borrowing methodological aspects from works in the Naturalist or other non-positivism paradigm. For instance, using Martha Nussbaum's (Naturalist paradigm) capabilities list in a quantitative study shows that there are gaps and missing information. It may be more effective to stick to Amartya Sen's notion of democratic deliberation.

The study highlighted that most 'quantitative' research uses continuous and categorical data wrongly in the analysis stage and thus through the detailed analysis steps given, the study provided guidelines on how best to do the analysis and the kind of transformation that are necessary. This lucidness in the methodology and analysis stages of the research met the research aim of creating a blueprint which can be used to measure capabilities.

The study is a first step in the creation of a model which can be used widely to identify valuable student capabilities in Higher Education. Recommendations can be tabled on the kind of methodology to be followed to achieve the goal and on the kind of analysis which can be done. This contribution is significant in that future studies in this field will have a foundation from which to build further.

Further, the study proved the importance of finding a measure for student Wellbeing which could enable policy makers to compare students and be able to address issues around inequality and equity. The need of this measure in Higher Education has never been highlighted in Higher Education. Finally, the research places a quantitative voice on the debate on student wellness. In short, the study has provided some valuable answers and questions in both fields of capabilities and Higher Education using statistical methods.

#### **8.4 Conclusion**

The study managed to meet all its objectives and answered all the research questions posed. The study has, as the title says, operationalized Human Capability indicators in Higher Education.

## 9 Bibliography

- Addabbo, T., Tommaso, M. L., & Facchinetti, G. (2004). To what extent fuzzy set theory and structural equation modelling can. *Materiali di Discussione del Dipartimento di Economia Politica n.468*.
- Alkire, S. (2002). Dimensions of Human Development . *World development*, 30, 119-205.
- Anand, P., Hunter, G., & Smith, R. (2005b). Capabilities and well-being: evidence based on. *Social Indicators Research*, 74:9-55.
- Anand, P., Hunter, G., Carter, I., Dowding, K., Guala, F., & Hees, M. v. (2013). The Measurement of Capabilities. Paris, France: New Directions in Welfare conference proceedings.
- Barro, R. J., & Lee, J.-W. (2001). International data on educational attainment: updates and implications. *Oxford Economic Papers* 3, 541-563.
- Basu, K. (1987). Achievements, capabilities and the concept of well-being. *Social Choice and Welfare*, 4:69-76.
- Beck, R. B. (2013). *The history of south Africa: The Second Edition* (2 ed.). United Kingdom: Greenwood Publishing Group.
- Benoit, K. (2011). Linear Regression Models with Logarithmic Transformations. *Methodology Institute, London School of Economics*.
- Bera, C. J. (1987). A test of normality of observations and regression. *International Statistics review*.
- Berridge, K. (2000). *The Psychology of Economic Decision. Volume 1: Rationality and wellbeing*. New York: Oxford University Press.
- Blalock, H. (1972). *Causal inferences in non-experiemnta research*. New York: Norton .
- Bollen, K. (1989). *Structural Equations with Latent variables* . New York: Wiley.
- Bollen, K. (1989). *Structural Equations with Latent Variables*. New York: Wiley .
- Bollerslev, T. (1987). A Conditionally Heteroskedastic Time Series for Speculative Prices and Rates of Return . *The Review of Economics and Statistics*, 542-547.
- Brandolini, A., & D'Alessio, G. (1998). Measuring Well-being in the functioning space. *Nazionale 91, 000184 Roma, Italy*.
- Carroll, R. J. (1988). *Transformation and Weighting in Regression*. . New York: Chapman and Hall.
- Ceroli, A., & Zani, S. (1990). *A Fuzzy Approach to the Measuremnet of Poverty*. Berlin: Springer-Verlag.
- Chambers, J. W. (1983). *Graphical Methods for Data Analysis*. New York: Wadsworth.
- Cheli, B., & Lemmi, A. (1995). A totally fuzzy and relative approach to the multidimensional analysis of poverty. *Economic Notes*, 1, 115-134.
- Cheli, B., & Lemmi, A. (1995). A 'Totally' Fuzzy and Relative Approach to the Multidimensional Analysis of Poverty. *Economic Notes*, 24, 115-134.

- Cheli, B., Lemmi, A., & Pannuzi, N. (1994). Measuring Poverty in the Countries in transition via TFR Method: The case of Poland in 1990-1991. *Statistics in Transition*, 1, 585-636.
- Chiappero, M. E. (2000). A Multidimensional Assessment of Wellbeing Based on Sen's Functioning approach. *Rivista Internazionale di Scienze Sociali* 108, 207-39.
- Chiappero-Martinetti, E. (2000). A multidimensional assessment of well-being based on Sen's functioning approach. *Rivista Internazionale di Scienze Sociali* 58, 207-239.
- Comim, F. (2001). Operationalizing Sen's Capability Approach. *Justice and Poverty: examining Sen's Capability Approach*. Cambridge: Cambridge press.
- Comim, F., Qizibash, M., & Alkire, S. (2008). *The Capability Approach: Concepts, Measures and Applications*. Cambridge : Cambridge University Press.
- Corpening, S., Reppen, N., & Ringlee., R. (2004). Restricted Likelihood Ratio Tests in Nonparametric Longitudinal Modles. *Statistica Sinica*, 713-729.
- Deneulin, S., Nebel, M., & Sagovsky, N. (2006). Transforming Unjust Structures. The Capability Approach. *Library of Ethics and Applied Philosophy. Vol 19*.
- Department of Higher Education. (1997, July 27). *Council on Higher Education*. Retrieved February 13, 2014, from [http://www.che.ac.za/sites/default/files/publications/White\\_Paper3.pdf](http://www.che.ac.za/sites/default/files/publications/White_Paper3.pdf)
- Desai, M., & Shah, A. (1988). An Econometric Approach to the Measurement of Poverty. *Oxford Economic Papers*, 40, 505-522.
- Dielman, T. E. (1991). *Applied Regression Analysis for Business and Economics*. PWS-KENT.
- Dodhia, R. (2007). *Raven Analytics*. Retrieved February 13, 2014, from <http://www.ravenanalytics.com/Articles/Misuse%20of%20statistics.pdf>
- Enders, W. (2010). *Applied Econometric Time series*. New York: Wiley.
- Engle, & F, R. (1982). A general approach to lagrange multiplier model diagnostics. *Journal of econometrics*, 83-104.
- Farland, J. (2013). *Zonal load forecasting in the New england wholesale electricity market: a semiparametric regression approach*. Retrieved September 16, 2013, from Dissertations and Theses at ScholarWorks@UMass Amherst.: <http://scholarworks.umass.edu/theses/1120>
- Federman, M., Garner, T. I., Short, K., W B Cutter(IV), J. K., Levine, D., McGough, D., et al. (1996). What does it mean to be poor in America. *Monthly labor review*, 119,5, 3-17.
- Ferrer-i-Carbonell, A., & Frjters, P. (2004). How important is methodology for the estimates of the determinants of happiness. *Economic Journal*, 641-659.
- Filippone, A., Cheli, B., & D'Agostino, A. (2001). *Adressing the interpretation and the*. University of Pisa.
- Flora, D., & Curran, P. (2004). An evaluation of alternative methods for confirmatory factor analysis with ordinal data. *Psychological Methods*, 9, 466-491.
- Garson, G. (2004, May 3). *Path Analysis*. Retrieved July 7, 2014, from <http://faculty.chass.ncsu.edu/garson/pa765/path.htm>
- Gujarati, D. (1995). *Basic Econometrics 4th.Edition*. Boston: McGraw-Hil.

- Guttman, L. (1954). A new approach to factor analysis: the Radex. In P. F. Lazarsfeld, *Mathematical thinking in the social sciences* (pp. 258-3478). New York: Free Press.
- Hirschberg, J., Maasoumi, E., & Slottje, D. (1991). Cluster Analysis for Measuring Welfare and Quality of Life Across Countries. *Journal of Econometrics*, 50, 131-150.
- Joreskog, K. G. (2002). *Structural Equation Modeling with Ordinal Variables using LISREL*. Retrieved January 6, 2014, from <http://www.ssicentral.com/lisrel/ordinal.html>
- Joreskog, K. G., & Goldberger, A. S. (1975). Estimation of a Model with Multiple Indicators and Multiple Causes of a Single Latent Variable. *Journal of the American Statistical Association*, 631-639.
- Lanzi, D. (2007). Capabilities, human capital and education. *The Journal of Socio-Economics* 36, 424-435.
- Lelli, S. (2001). Factor Analysis vs Fuzzy Sets Theory: Assessing the Influence of sen's functioning Approach. Leuven: Katholieke Universiteit Leuven.
- Lelli, S. (2001). Factor Analysis vs. Fuzzy Sets Theory: Assessing the Influence of Different Techniques on Sen's Functioning Approach". *CES Discussion Paper Series, 01.21, Katholieke Universiteit. Leuven* .
- Lemmi, A., Cheli, B., & Mazzolli, B. (1996). *La misura multidimensionale della poverta in Italia nella prima meta degli anni 90*. Mineo.Siena: Cenro di Ricerca Interdipartimentale sulla Distribuzione del Reddito.
- Lovell K, R. S. (1994). Resources and functionings - a. In E. W, *Models and measurement of* (pp. 787-807). Berlin .
- M.Alexande, J. (2008). *Capabilities and Social Justice: The Political Philosophy of Amartya Sen and Martha Nussbaum*. Leuven, Belgium: Katholieke Universiteit Leuven.
- MacDonald, G. M., & MacKinnon, J. G. (1985). Convenient methods for estimation of linear regression modles with MA(1) errors. *Canadian Journal of Economics* 17 No.1, 106-116.
- MacGregor, K. (2008). *SOUTH AFRICA: Universities taking financial knocks*. Retrieved February 2, 2014, from <http://www.universityworldnews.com/article.php?story=20081031100406466>
- Mack, J., & Lansley, S. (1985). *Poor Britain*. London: Allen Unwin.
- Martinetti. (2000). A multidimensional assessment of well-being based on Sen's functioning approach. *Internazionale di Scienze Sociali*.
- Mayer, S. E., & Jenks, C. (1989). Poverty and the Distribution of Material Hardship. *Journal of Human Resources*,21, 88-113.
- McKelvey, R., & Zavoina, W. (1975). A statistical model for the analysis of ordinal level dependent variables. *Journal o f mathematical Sociology*, 4 , 103-120.
- McLeod, A. I., & Bellhouse, D. R. (1983). A Convenient Algorithm for Drawing a Simple Random Sample. *Applied statistics*, 32, No. 2, 182-184.
- Mendenhall, W. a. (1989). *.A second course in business statistics: Regression*. London: Collier Mcmillan.

- Nissani, M. (1997). Ten Cheers for Interdisciplinarity: The Case for Interdisciplinary Knowledge and Research. *The Social Science Journal* , 34(2), 201-216.
- Nolan, M., & Whelan, C. (1996). The relationship Between Income and deprivation: A Dynamic Perspective. *Revue economique*, 3, 709-717.
- Nussbaum, M. (1988). Nature, functioning and capability. *Oxford studies in Ancient Philosophy* , Supplementary volume, 145-184.
- Nussbaum, M. (2000). *Women and Human Development. The Capabilities Approach*. Cambridge: Cambridge university Press.
- Nussbaum, M. (2003). Capabilities as Fundamental Entitlements: Sen and Social Justice. *Feminist Economics*, 9(2-3), 33-59.
- Nussbaum, M. (2011). *Creating Capabilities. The Human Development Approach*. Cambridge: Cambridge University Press.
- Nzimande, B. (2010). Keynote Address by Minister of Higher Education and Training Dr Blade Nzimande to the Stakeholder Summit on Higher Education Transformation. Cape Peninsula University of Technology: Stakeholder Summit on Higher Education Transformation.
- P.Burnham, K., & R.Anderson, D. (2002). *Model selection and multimodel inference: a practical information-thoretic approach*. Springer.
- Perakis, M., Maravelakis, P. E., Perakis, S., & Xekalaki, E. (2005). On certain indices for ordinal data with unequally weighted classes. *Quality and Quantity*, 39,, 515-539.
- Qiziffar, M. (2008). Amarta Sen's capability view: insightful sketch or distorted picture? . In S. Alkire, *Using the Capability Approach: prospctive and evaluative analyses* (p. 55). Cambridge: Cambridge University Press.
- Qizilbash, M. (1996). Capabilities, Wellbeing and Human Development. *Journal of Development Studies*, 36, 143-62.
- Robeyns, I. (2000). An unworkable Idea or a promising Alternative? Sen's capability Approach revisited. *Centre for economics Studies discussion paper 00.30*. Leuven.
- Robeyns, I. (2003). Sen's Capability Approach and Gender Inequality: Selecting Relevant. In I. Robeyns, *Feminist Economics*, (pp. 9(2-3), 61–92.).
- Robeyns, I. (2003). Sen's Capability Approach and Gender Inequality: Selecting Relevant Capabilities. *Feminist Economics*, 9(2-3), 61-92.
- Robeyns, I. (2005). The Capability Approach: A Theoretical Survey. *Journal of Human Development*, 6(1), 93-114.
- Robeyns, I. (2006). Three models of education Rights, capabilities and human capital. *Theory and Research in Education*, 4:69.
- Robeyns, I. (2009). The Capability Approach: An Interdisciplinary Introduction. *3rd International conference on the Capability Approach*. Pavia, Italy.
- Robeyns, I. (2011). *The Capability Approach*. The Stanford Encyclopedia of Philosophy.
- Robeyns, I. (2012). THE CAPABILITY APPROACH IN PRACTICE. *Human Development & Capability Association*, 7-10.

- Roemer, J. (1998). *Equality of opportunity*. Cambridge, Mass: Harvard University Press.
- Schokkaert, E., & Van Ootegem, L. (1990). Sen's concept of the living standard applied to. *Recherches Economiques de Louvain* 56(3-4); 429-450.
- Seber, G. A., & Lee, A. J. (2003). *Linear Regression Analysis: Second Edition*. New Jersey: John Wiley .
- Sen, A. (1979). Personal Utilities and Public judgements: Or whats wrong with welfare economics . *The Economic Journal* , 537-558.
- Sen, A. (1985). *Commodities and capabilities*. Amsterdam: North Holland.
- Sen, A. (1985). *Commodities and Capabilities*. Holland.
- Sen, A. (1985). *Commodities and capabilities*. Amsterdam: North\_Holland.
- Sen, A. (1985). Well-being, Agency & Freedom: The Dewey Lectures 1984. *The Journal of Philosophy*, 169-121.
- Sen, A. (1992). *Inequality Re-examined*. Oxford: Oxford University Press.
- Sen, A. (1999). *Development as Freedom*. London: Oxford University Press.
- Sen, A. (1999). *Development as freedom* . Oxford: Oxford University Press.
- Sen, A., & Nussbaum, M. (1993). *Capabilities and Wellbeing* . *In the Quality of life*. London: Oxford: Clarendon Press.
- Steyn, A., Smit, C., du Toit, S., & Strasheim, C. (1994). *Modern Statistics in practise*. Cape Town: Cape and Transvaal Book Printers.
- Tanaka, J. (1987). "How Big Is Big Enough?": Sample Size and Goodness of Fit in Structural Equation Models with Latent Variables. *Child Development*, Vol 58, No. 1, 134-146.
- Thadewalda, T., & Büninga, H. (2007). Jarque–Bera Test and its Competitors for Testing Normality – A Power Comparison. *Journal of Applied Statistics*, 85-105.
- Townsend, P. (1979). *Poverty in the United Kingdom: A survey of household resources and Standards of Living*. Harmondsworth: Penguin.
- Tsay, R. S. (2002). *Analysis of Financial Time Series*. New York: Wiley.
- Von Altrock, C. (1997). *Fuzzy logic and Neurofuzzy applications in Business*. Prentice-Hall, Inc.
- Walker, M. (2006). *Higher Education Pedagogies*. Berkshire, England: Society for Research into Higher Education & Open University Press.
- Walker, M. (2006). *Higher Education Pedagogies*. Berkshire, England: Society for Research into Higher Education & Open University Press.
- Walker, M., & Unterhalter, E. (2007). The Capability Approach: Its Potential for Work in Education. In: M Walker & E Unterhalter (eds). In *Amartya Sen's Capability Approach and Social Justice in Education*. New York : Palgrave Macmillan Ltd.
- Watson, G. S. (1964). Smooth Regression Analysis. *The Indian Journal of Statistics, Series A (1961-2002)* , Vol. 26, No. 4, 359-372.

- Wells, T. (2012). *Internet Encyclopedia of Philosophy* .
- White, S. (2010). Analysing wellbeing: a framework for. *Development in Practice, Volume 20, Number 2*.
- Wildemuth, B. M. (1993). Post-Positivist Research: Two Examples of Methodological Pluralism. *The Library Quarterly: Information, Community, Policy: Symposium on Qualitative Research: Theory, Methods, and Applications, 63(4)*, 450-468.
- Wilson-Strydom, M. (2012). FRAMEWORK FOR FACILITATING THE TRANSITION FROM SCHOOL TO UNIVERSITY IN SOUTH AFRICA: A CAPABILITIES APPROACH. Bloemfontein, Free State, South Africa: Faculty of education, University of the Free State.
- Wilson-Strydom, M. G. (2010). Traversing the Chasm from School to University in South Africa: A Student Perspective. *Tertiary Education and Management, 16(4)*, 313-325.
- Wolff, J., & de-Shalit, A. (2007). *Disadvantage*. London: Oxford University Press .
- Wright, S. (1920). The relative importance of heredity and environment in determining the piebald pattern of guinea pigs. *Proceedings of the National Academy of sciences 6*, 320-332.
- Wright, S. (1921). Correlation and Causation. Part 1: methods of path co-efficients. *Journal of Agricultural Research, 20*, 557-585.
- Wright, S. (1923). The theory of path coefficients. A replay to Niles' criticism. *Genetics, 8(3)*, 239-255.
- Yates, F. (1949). *Sampling methods for censuses and surveys*. London: Charles Griffin & Co. Ltd., London.
- Zadeh, L. (1965). Fuzzy sets. *Information and Control. Vol 8*, 338-353.
- Zellner, A. (1970). Estimation of Regression Relationships Containing Unobservable Variables. *International Economic Review, 11*, 441-454.
- Zuckerman, M. (1971). Natural Sum of ordinals. *Recu par Redaction, 14*, 289-294.

# 10 Appendixes

## 10.1 The questionnaire

Capabilities and measurement: operationalizing Capability Indicators in Higher Education

---

### Introduction

My name is Anesu Ruswa. I am studying with the Centre for Higher Education and capabilities Research (CHECaR). I have prepared this questionnaire to gather data to investigate general student wellbeing. Your participation is highly appreciated.

All your responses will immediately be entered into a database and treated confidentially. All information reported will be on an anonymous form and will not disclose your identity.

Participation in this research is completely on a voluntary basis.

If you have any questions regarding to this research please feel free to email:

[ruswaas@ufs.ac.za](mailto:ruswaas@ufs.ac.za)

### Section 1: Demographics

#### Instructions

Mark with an X the option which applies to you

1. Gender:

1) Male

2) Female

1
2

2. Indicate your age:

1
---

3. Residential status:

- 1) On campus
- 2) Off campus with family
- 3) Off-campus in a student residence
- 4) Off-campus in a private residence

1
2
3
4

**4. Home language -**

- Sesotho
- Afrikaans
- Tswana
- Xhosa
- IsiZulu
- Venda
- English
- Other (specify)

1
2
3
4
5
6
7

**5. Language of instruction**

- 1) English
- 2) Afrikaans

1
2

**6. Race**

- 1) White
- 2) Black
- 3) Coloured
- 4) Asian
- 5) Other

1
2
3
4

**7. Faculty**

- 1) Humanities
- 2) Law
- 3) Natural and Agricultural Sciences
- 4) Economic and Management Sciences
- 5) Education
- 6) Theology
- 7) Health Sciences

1
2
3
4
5
6
7

**8. Indicate your Academic Year:**

- 1) 1<sup>st</sup>
- 2) 2<sup>nd</sup>
- 3) 3<sup>rd</sup>
- 4) 4<sup>th</sup>
- 5) Other (specify)

1
2
3
4

**9. In my first semester of year 2013**

		<i>Please check the applicable row</i>
1	I failed 5 or more courses	
2	I failed 4 courses only	
3	I failed 3 courses only	
4	I failed 2 courses only	
5	I failed 1 course only	

6	I passed all my courses	
---	-------------------------	--

(If registered for year courses, Tests are used as final marks)

10. In my first semester of year 2013 my average mark for all the courses is

## Section 2: Capability Indicators

### Instructions

For the questions below, mark your choice with an X

<i>Disagree strongly</i> <b>1</b>  (DS=1)	<i>Disagree Moderately</i> <b>2</b>  (D=2)	<i>Neutral</i> <b>3</b>  (N=3)	<i>Agree moderately</i> <b>4</b>  (A=4)	<i>Agree strongly</i> <b>5</b>  (AS=5)
--	---	---	--	---

### Educational Resilience

	<i>DS</i> <b>1</b>	<i>D</i> <b>2</b>	<i>N</i> <b>3</b>	<i>A</i> <b>4</b>	<i>AS</i> <b>5</b>
. I cope well with academic pressure and challenges.					
. I do not wish I was studying towards another degree.(i.e. I enjoy what the degree that I am registered for)					
. I am able to 'bounce' back from academic setbacks					
. I was able to deal with the transition from school to University					
. I aspire to succeed in my University degree					

--	--	--	--	--	--

**Learning Disposition: Language, competence and confidence**

	<i>DS</i>	<i>D</i>	<i>N</i>	<i>A</i>	<i>AS</i>
	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>
. Learning new things is easy for me					
. High school equipped me with skills required for University study.					
. I am confident in my ability to learn.					
. I am fluent in my language of instruction indicated in Section 1.					
. I have access to all the study material I need.					
. I have my own laptop/computer to do my assignments.					
. I turn to my lecturers and/or use university academic support structures when I am facing academic challenges.					
. I feel confident to speak out and express my views in my classes					

**Bodily Health**

	<i>DS</i>	<i>D</i>	<i>N</i>	<i>A</i>	<i>AS</i>
	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>
. My health does not in any way limit my daily activities compared with most people of my age					
. I have enough to eat every day					

. I live in adequate accommodation which is conducive for my studies					
. I can afford specialized or private medical care.					
. The university has facilities to cater for all my medical needs					

### Bodily Integrity

	<i>DS</i>	<i>D</i>	<i>N</i>	<i>A</i>	<i>AS</i>
	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>
. I feel very safe walking alone in the area near my residence (on campus or off-campus) DURING THE DAY time					
. I feel very safe walking alone in the area near my residence (on campus or off-campus) AFTER DARK.					
. I can afford decent clothing					
. I am NOT likely to be a victim of sexual assault during the course of my studies					
. I have not been a victim of physical harassment during the course of my studies					

### Senses, Imagination, and Thought

	<i>DS</i>	<i>D</i>	<i>N</i>	<i>A</i>	<i>AS</i>
	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>
. I can use reasoning to reflect critically on my own beliefs and values					
. I can find evidence, examples and reasons to support my views.					

. I use my imagination and creativity in learning and thinking: To think of what might be, not just what is.					
. The knowledge I gain in my studies is extremely important for my for what I want to be someday					
. I am learning to think about the contents of my academic subjects critically					
. I find pleasure in what I am studying.					

### Emotions

	<i>DS</i>	<i>D</i>	<i>N</i>	<i>A</i>	<i>AS</i>
	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>
. I value the social support structures that are at my disposal in the university					
. At present it is easy for me to enjoy the love care and support of my immediate family and friends					
. It is easy for me to express feelings of love, happiness and gratitude compared to other students					
. I usually do not express feelings of anger and hatred compared to other students					
. I am not fearful or anxious in learning situations					

### Practical Reason

	<i>DS</i>	<i>D</i>	<i>N</i>	<i>A</i>	<i>AS</i>
	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>
. My idea of a good life is based on my own judgement.					
. I have a clear plan of how I would like my life to be.					
. I constantly evaluate how I lead my life and where I am going in life					
. I have been contributing positively to the community during my studies.					
. I find it easy to solve problems which I did not anticipate.					

### Affiliation

	<i>DS</i>	<i>D</i>	<i>N</i>	<i>A</i>	<i>AS</i>
	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>
. I respect, value and appreciate other people.					
. I normally meet up with friends or family for a drink or a meal at least once a month.					
. I find it easy to imagine the situations of other people and to feel concern. (i.e. 'to put myself in others' shoes').					
. I find it easy to relate to my peers in the classroom.					
. I am able to participate successfully in groups for learning					

### Other Species

	<i>DS</i>	<i>D</i>	<i>N</i>	<i>A</i>	<i>AS</i>
	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>
. I appreciate and value plants, animals and the world of nature					
. I am responsible for the environment					
. I enjoy visiting zoos and animal reserve parks.					
. I have a pet at home					
. I have grown some plants/planted a tree					

### Leisure

	<i>DS</i>	<i>D</i>	<i>N</i>	<i>A</i>	<i>AS</i>
	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>
. I have recently been spending time in recreational activities.					
. I play sport at the university					
. I attend social functions on campus					
. I have time to participate in other things on campus besides school work					
. I belong to a social club/student association.					

### Control over One's Environment

	<i>DS</i>	<i>D</i>	<i>N</i>	<i>A</i>	<i>AS</i>
	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>
. I am able to participate in the political activities that affect my life if I want to					
. My field of study makes use of my skills, abilities and talents					
. I find it easy to relate to my peers in the classroom					
. My fellow classmates and lecturers treat me with respect					
. I am free to express my political views on campus.					
. I am free to practice my religion as I want to on campus.					

### Well-Being

Please rank the following headings according to how important they are to your Wellbeing.

<i>Extremely unimportant</i> <i>1</i>	<i>Unimportant</i>  <i>2</i>	<i>Neutral</i>  <i>3</i>	<i>Important</i>  <i>4</i>	<i>Extremely important</i> <i>5</i>
--	------------------------------------	--------------------------------	----------------------------------	--

Use the following scale:

	1	2	3	4	5
Educational Resilience					
Learning Disposition: Language, competence and confidence					
Bodily Health					
Bodily Integrity					
Senses, Imagination, and Thought					
Emotions					
Practical Reason					
Affiliation					
Other Species					
Leisure					
Control over One's Environment					

On a scale of 1 (not well at all) to 10 (extremely well), here is how I would rank myself in terms of Wellbeing.

*(Wellbeing is defined as: A good or satisfactory condition of existence; a state characterized by health, happiness, and prosperity; welfare.)*

Please indicate with an X	
	1
	2
	3
	4
	5
	6
	7
	8
	9
	10

Any other comments on your Wellbeing

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

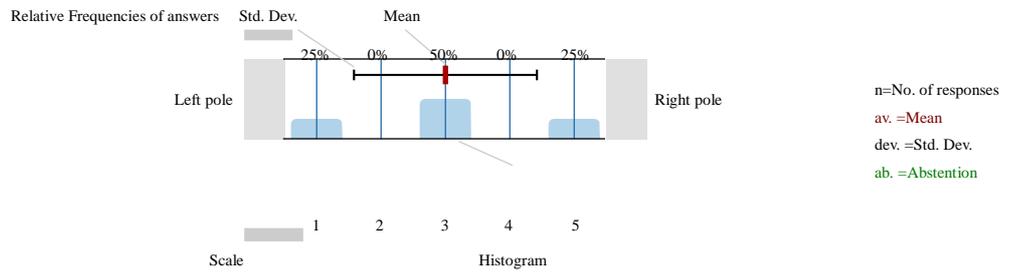
.....

.....

## 10.2 Survey Demographics Results

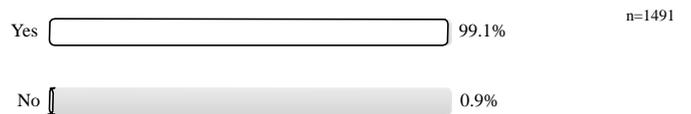
### Legend

Question text



### 1. Informed consent

1.1) Do you want to complete the questionnaire?

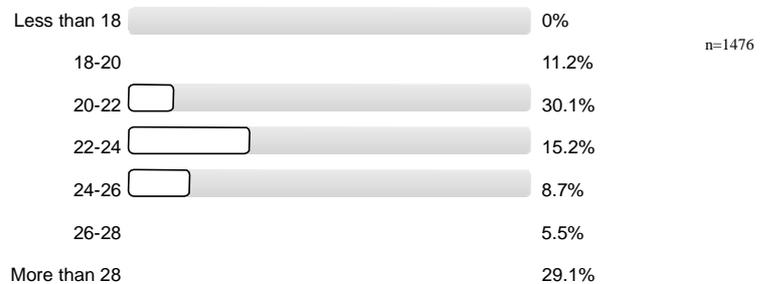


### 2. Demographics

2.1) Gender



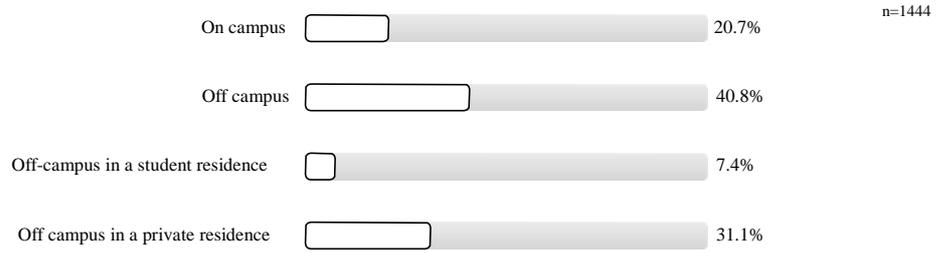
2.2) Age Range



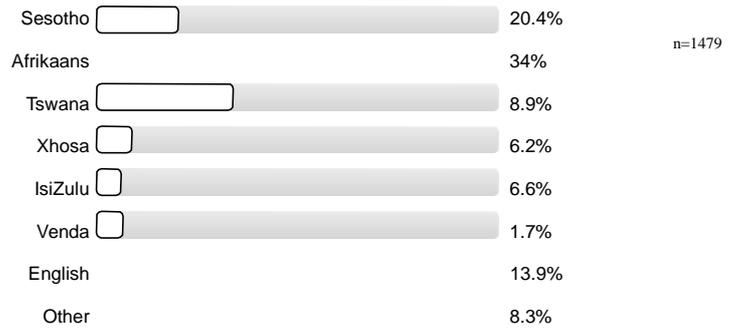


---

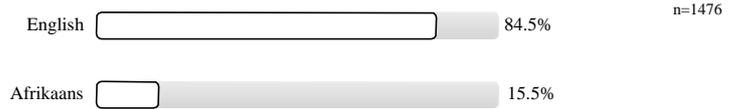
2.3) Residential status



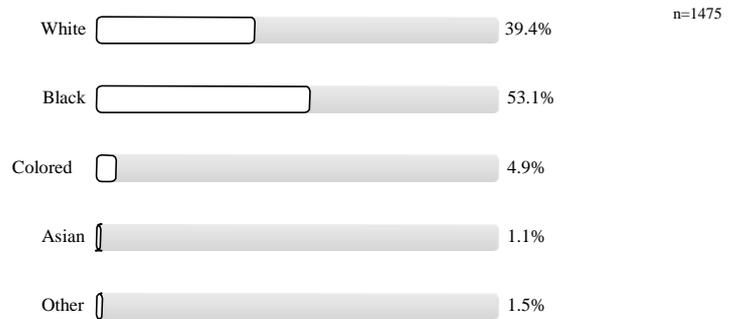
2.4) Home Language



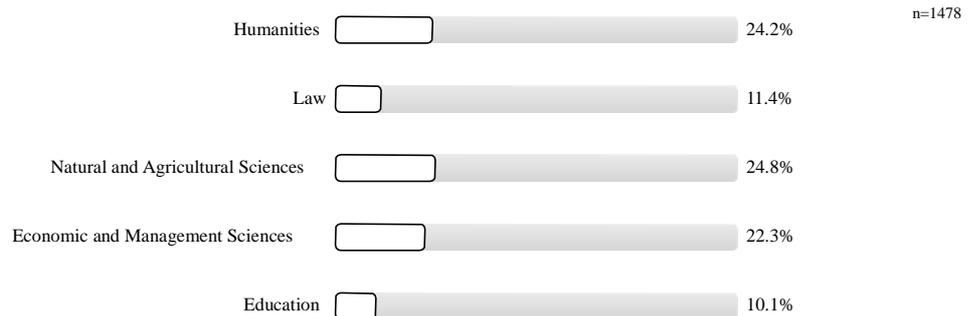
2.5) Language of Instruction



2.6) Race



2.7) Faculty



Theology 1.6%

Health Sciences 5.8%