PROVINCIAL LOGISTICS CAPABILITY AND ECONOMIC DEVELOPMENT IN SOUTH AFRICA

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ABSTRACT

The study involves the determination of Provincial Logistics Capability for South African provinces. Provincial Logistic Capability (PLC) is the effectiveness and efficiency of a province in facilitating logistics activities both within the province and outside its borders. The Simple Multi-Attribute Rating Technique (SMART) with Rank Order Distribution (ROD) was used to determine the PLC of all of the provinces. The PLC was calculated based on five weighted criteria: location, labour, service, administration and infrastructure. Each province was scored on each of these criteria as well as the sub-criteria. The results of this study show that infrastructure (capacity and condition) is the most important factor influencing PLC, with a weight of 34.7%, The second most important factor is labour force (availability and quality), with a weight of 26.9%. Gauteng has the highest logistics capability with a score of 17 while the Northern Cape is scored lowest with a PLC of 3. The PLC is then compared to the economy of that province. The comparison shows that there is a positive correlation between the PLC and the economy of the province.

Keywords: Province, Logistics, Capability, Economic, Infrastructure

1. INTRODUCTION AND BACKGROUND

Logistics is that part of the supply chain that plans, implements and controls the efficient and effective flow and storage of goods, services and related information from the point of origin to the point of consumption in order to meet customer requirements (King and Botha, 2007). Logistics management is very important in the business environment today because it provides an opportunity for cost reduction and allows an organisation to differentiate itself from its competitors. The need for efficient logistics services to ensure customer satisfaction and business competitiveness has increased with the continual realisation that businesses are now operating in a global environment. As such, the World Bank has developed the Logistics Performance Index (LPI) which is meant to explore the relationship between logistics and the economy at a national level (Arvis, et al., 2007). The LPI developed by the World Bank is a tool that assists countries in identifying the challenges and opportunities they are facing in their performance on trade logistics and how they can improve their situations (World Bank, 2010).

The generalisation of logistics capabilities to all the provinces of South Africa creates some distortions when decisions for a province are made based on national logistics capabilities as opposed to actual provincial logistics capabilities. For the purposes of this research, Provincial Logistic Capability (PLC) is the effectiveness and efficiency of a province in facilitating logistics activities both within the province and outside its borders (Song, J., et al 2009). Logistics performance indicators should be estimated for separate economic regions with specific features and logistics efficiency (Kisperska-Moron, 2009). The need for local or provincial study of logistics is also justified by the spatial inequality of economic development in South Africa. Economic development is not uniform throughout South African provinces, therefore, logistics requirements and capabilities are most likely to differ from one province to the other.

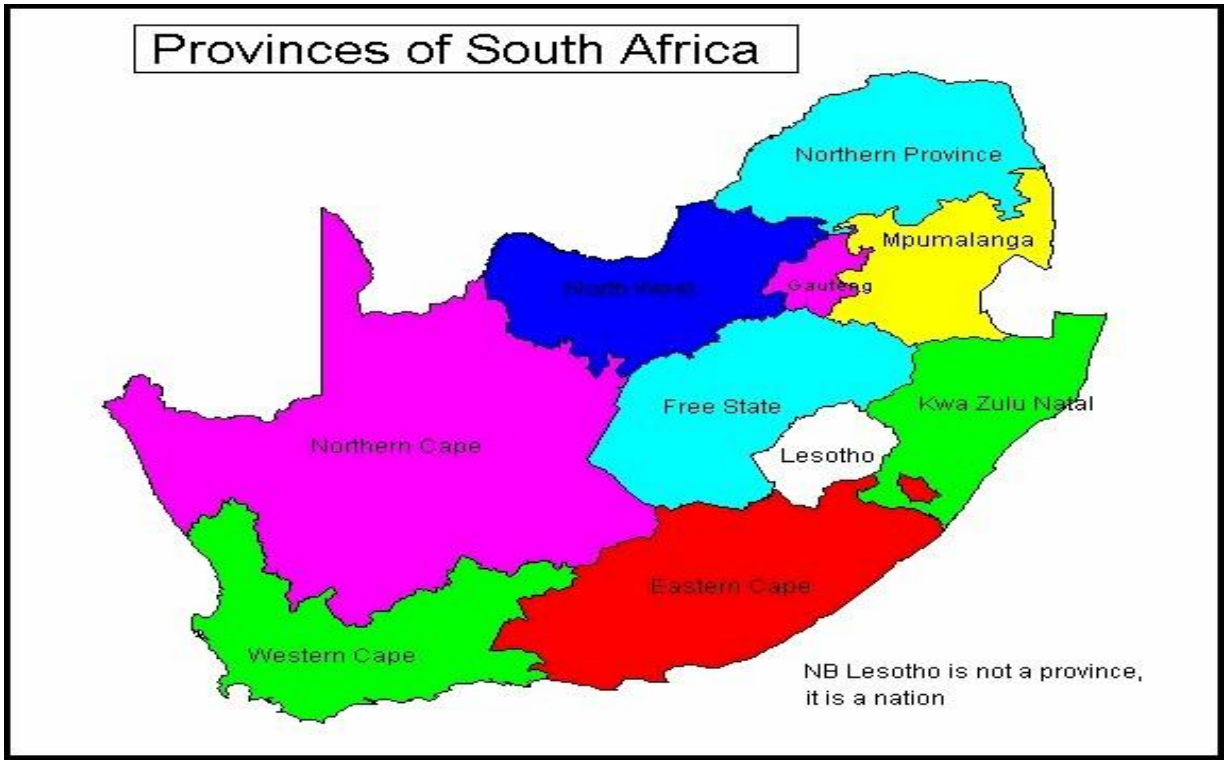

Figure 1: Provinces of South Africa. Source: Water Rhapsody, 2010

Figure 1 shows that South Africa consists of nine provinces namely Gauteng, Eastern Cape, Western Cape, Free State, Mpumalanga, Limpopo, North West, Northern Cape and KwaZulu Natal (DEAT, 1999). For the purposes of this study, the provincial boundaries are used as the economic regions of South Africa. This study considers the PLC of each of the economic regions of South Africa and relates it to economic development of the respective provinces. Table 1 shows a demographic summary of South African provinces. This includes the population per province, the area of the province in km^2 and the contribution of each province to the national GDP.

Table 1: Demographic Information on South African Provinces. Source: Statistics South Africa, 2012.

PROVINCE	POPULATION (2011)	AREA(km^2)	2011 GDP CONTRIBUTION (%)
Gauteng	11 328 203	17 010	34.5
Limpopo	5 554 657	123 900	7.1
Mpumalanga	3 657 181	79 490	7.0
Free State	2 759 644	129 480	5.3
Kwa Zulu-Natal	10 819 130	92 100	15.7
Eastern Cape	6 829 958	169 580	7.5
Western Cape	5 287 863	129 370	14.2
Northern Cape	1 096 731	361 830	2.2
North West	3 253 390	116 320	6.5

The main objective of this paper is the development of a measurement framework for determining the logistics capability of South African provinces. There is also an effort to determine the relationship between logistics capability and the economy of the province

2 RESEARCH METHODOLOGY

Multi-attribute decision methods involve making preference decisions (such as evaluation, prioritisation, selection over the available alternatives that are characterised by multiple, usually conflicting, attributes (Azar, F.S., 2000). Multi-Attribute Utility Theory (MAUT) is used to develop the PLC scores for each of the regions. The Simple Multi-Attribute Rating Technique (SMART) is the simplest form of MAUT (Fulop, J., 2005). SMART with Rank Order Distribution (ROD) was used for the study in order to reduce bias and improve precision. Several factors were considered in choosing the model to solve the problem; one of them is that the model should allow for 'stand-alone' evaluation (Öztayşi, B & Uçal, I., 2009). Stand-alone evaluation is the ability of the model to give meaningful results by itself without any comparisons. The model must also allow for tracing of performance change over time through the generation of meaningful results (Öztayşi, B & Uçal, I., 2009). This means that the model should allow for use of updated data to generate results after a period of time. The SMART-ROD technique was chosen because it satisfies these requirements in addition to allowing for ordinal ranking of competing alternatives thereby eliminating the analysis of pairwise comparisons necessary in the Analytic Hierarchy Process (AHP) (Song et al., 2009). The other factor considered in choosing the SMART-ROD method was the need for a simplified MAUT decision analysis method that is robust and able to replicate decisions made with more complex MAUT analysis with a higher degree of confidence (Baker et al, 2001). The SMART-ROD method was also easier to explain to the interviewees who were invited to participate in this study (Song et al., 2009).

The PLC is determined in three main steps:

- Determining the weights for all criteria and sub-criteria that influence logistics capability at provincial level.
- Determining the performance scores, that is, how each of the provinces performs on each of the sub-criteria chosen above.
- Compiling the PLC value for each province.

2.1 The SMART-ROD Method

The SMART technique is an MAUT procedure that determines additive Multi Attribute Value (MAV) scores for finite sets of alternatives (Song et al., 2009). MAUT provides comprehensive, quantitative and qualitative ways of justifying a decision between alternatives by enabling the decision maker to incorporate preference and value trade-offs for each criterion and measures the relative importance of each (Collins, T. R., et al 2006). The provincial logistic capability value can be described in the following model:

$$P_i = \sum_j W_j S_{ij} = \sum_j W_j \sum_k W_{jk} S_{ijk} \qquad (1)$$

Where *Pi* is the overall PLC value of the province *i*;
Wj is the weight of criterion *j* reflecting its importance when compared to the other criteria;
Wjk is the sub criterion level weight assigned to indicator *k* under criterion *j*; and
Sijk is the score of province *i* on indicator *k* under criterion *j*.

2.1.1 Determining the Criteria Weights

The next stage of the study was to determine the criteria weights Wj and Wjk (from equation 1) which show the importance of the different criteria under consideration relative to each other. The weighting factors of the criteria for provincial logistics are elicited in the next step in accordance with the SMART method. Logistics experts from a wide range of backgrounds were interviewed using structured questions to rank the criteria. In order to reduce bias in the assessments, a large group of experts was interviewed. The Rank Order Distribution (ROD) method was used to reduce further bias and improve the precision of the relative weighting factors (Song et al., 2009). Roberts and Goodwin (2002) suggest the use of 'surrogate' weights to approximate the decision-maker's 'true' weights. In this study, these 'surrogate' weights were used to estimate the 'true' weights from the experts.

2.2 Performance Scores for Each Province

The provincial scores were determined by considering a set of criteria that influence provincial logistics capability. Performance scores were determined from raw performance data **(*x*).** The raw performance data are functions of physical or judged quantities that are obtained from statistical sources and ultimately converted to performance scores, ***S(*x)** (Song et al., 2009).

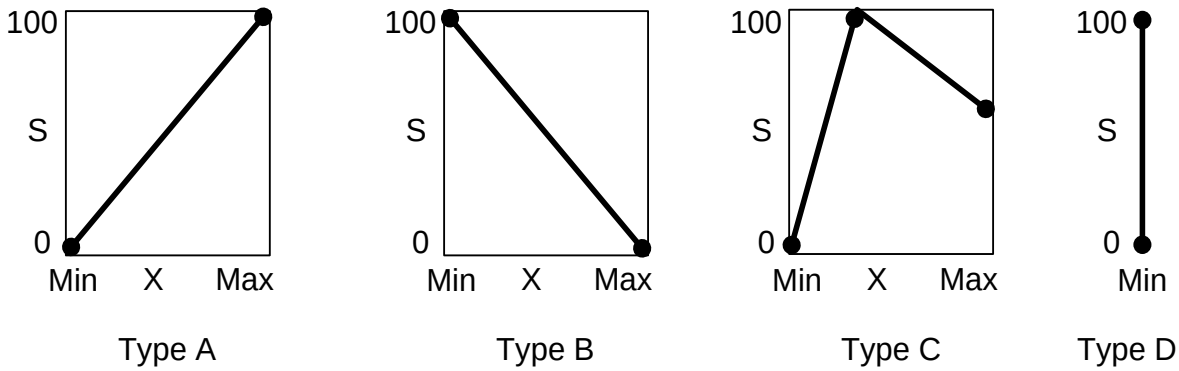

Figure 2: Four types of Linear Utility Functions.

Figure 2 shows that type A functions are those in which more of x is better than less, e.g. the rail network. Type B functions are those in which less of x is better than more, e.g. administrative costs. Type C utility functions are those that have an interior maximum of x. Type D are functions in which direct rating is used since there is no single physical variable to describe them.

The following equations can be used to convert the raw performance data (x) in the type A, B, C functions to the performance score S(x), which ranges from 0 (worst case) to 100 (best case) (Song et al., 2009).

$$S_{ij} = S(x) = \begin{cases} 0 & x \leq \min \\ 100 \times (x - \min)/(\max - \min) & \min < x < max \\ 100 & x \geq \max \end{cases} \quad (2)$$

$$S_{ij} = S(x) = \begin{cases} 100 & x \leq \min \\ 100 \times (\max - x)/(\max - \min) & \min < x < max \\ 0 & x \geq \max \end{cases} \quad (3)$$

$$S_{ij} = S(x) = \begin{cases} 100 \times (x - \min)/(\text{best} - \min & x \leq \min \\ 100 \times (\max - x)/(\max - \text{best}) & \min < x < max \\ 0 & \text{else} \end{cases} \quad (4)$$

3 DETERMINANTS OF PROVINCIAL LOGISTIC CAPABILITY IN SOUTH AFRICAN PROVINCES

A number of factors influence the logistics capability of a province. The following criteria were used in this study: location, labour, service, administration and infrastructure. Each of these main criteria is also composed of sub-criteria that determine the overall score of the main criteria. Table 2 shows the weights attributed by the respondents to each of the criteria and sub-criteria influencing logistics in the provinces. These results were derived from the responses to the questionnaire that was sent to logistics experts in South Africa.

4 RESULTS

The following section presents results of the study. The weights attributed to the criteria and sub-criteria are shown in Table 2.

Table 2: ROD Weights for criteria and sub-criteria influencing logistics

Main CRITERIA	Criteria weights to PLC	SUB-CRITERIA	Sub-criteria ROD	Sub-criteria weights to PLC (%)
Infrastructure	0.347	Road	0.297	10.3
		Rail	0.188	6.5
		Coastal ports	0.241	8.4
		Air	0.09	3.1
		Pipeline	0.045	1.6
		ICT	0.139	4.8
Location	0.127	Ease of access to Markets	0.693	8.8
		Security	0.307	3.9
Labour Force	0.269	Labour Cost	0.523	14.1
		Professional skills	0.324	8.7
		International language	0.153	4.1
Services	0.196	Transportation	0.347	6.8
		Warehousing	0.196	3.8
		Knowledge and Financial	0.269	5.3
		ICT	0.127	2.5
		Value added	0.062	1.2
Regulations	0.062	Government Regulations	0.418	2.6
		Customs	0.299	1.9
		Documents	0.191	1.2
		Policing	0.092	0.6

4.1 Main Criteria Weights

The results show that most experts believe that infrastructure is the most important factor influencing the provincial logistic capability with a criteria weight of 34.7%. Both the availability and quality of infrastructure are important contributors to PLC. The second most important criterion is labour force with an assigned weight of 26.9%. This further highlights the importance of logistics skills to South Africa's economy. A logistics service (19.6%) is third in terms of importance followed by location (12.7%). The least important of the criteria used in this study is government regulations and most of the respondents feel that they are not very significant for logistics activities within a province but will only have an effect at a national level with regards customs and national border control.

4.2 Sub-criteria

Infrastructure: The contribution of the different infrastructure sub-criteria is shown in Table 2. The most important sub-criterion contributing to PLC is the road network with a

contribution of 10.3%. This is followed by coastal ports with a contribution of 8.5%. Rail has a 6.5% contribution to the PLC. ICT infrastructure (4.8%) was rated ahead of pipeline (1.6%) and air (3.1%) showing the importance given to ICT infrastructure when it comes to logistics facilitation. The fact that responses are compiled for the whole country and not province specific means that some important sub-criteria that do not exist in some of the provinces for example pipeline were penalised by the respondents.

Location: Ease of access to markets contributes 8.8% and security has a contribution of 3.9%. The responses show that ease of access to markets is one of the most important contributors to the PLC.

Labour force*:* According to the responses labour cost is a significant contributor to PLC in South African provinces with a score of 14.1%. Professional skills have a contribution of 8.7% according to the respondents. The importance of international language, in this case English, to PLC is 4.1%.

Services: For services the responses show that the most important form of service is transportation with a contribution of 6.8%. Knowledge and financial services are also important with a contribution of 5.3%, followed by warehousing services. For more information refer to Table 2.

Regulations*:* With regards to the regulation criterion, government regulations have the most significant influence on the PLC (See Table 2).

4.3 PERFOMANCE SCORES

Table 3 presents the main criteria, sub-criteria and the measure or proxy that was used to score each province. Data for scoring the provinces on infrastructure was obtained from publications from the South African Department of Transport and the Airports Company South Africa (ACSA). Information on crime was obtained from the South African Police Service (SAPS) Crime Information Management. Most of the economic data used for the study was derived from Statistics South Africa. The performance scores for government regulations are the same for all provinces because there is no difference in how this is done per province and the only differences are reflected at national level.

Table 3: Performance Scores per Province

CRITERIA	SUB-CRITERIA	Measure or Proxy	GP	EC	KZN	MP	LM	NW	NC	WC	FS
			Sij	Sij	Sij	Sij	Sij	Sij	Sij	Sij	Sij
Infrastructure	Road	Road density = Length of road network/area of region	100	5.5	26	13	8	11	0	14	19
	Rail	Railway line density	100	23	49	45	2	13	0	13	28
	Coastal Ports	Cargo handled/Area being served	0	3	100	0	0	0	0	24	0
	Pipeline	Tonnage/population	47	0	61	0	0	0	0	0	100
	Airport	Cargo handled/Area being served	100	1	3	0	1	0	0	21	0
	ICT	PCs, internet and telephone	62	14	43	16	0	19	16	100	28
Location	Market Access		93	65	100	27	52	33	0	43	22
	Security	Crime per capita (SAPS, 2009)	46	2	75	64	100	64	49	0	46
Labour	Professional Skills	Number of professionals in transport, storage and communications/Total population (Stats SA, 2012)	100	0	33	25	0	25	33	42	33
	Demography	% of population living below the minimum living line (Stats SA, 2012)	90	7	40	0	44	40	33	100	32
	Labour Cost	Mean hourly wages by industry and province (Stats SA, 2012)	0	59	71	100	48	83	35	55	55
	International Language		100	3	32	17	0	56	10	63	34
Service	Transport	Transport Storage and Communication (Stats SA, 2012)	100	17	68	14	13	13	0	44	8
	Warehousing	Warehouse space by province data (Stats SA, 2012)	100	33	29	8	2	0	3	45	2
	Knowledge and Financial	Finance, Real Estate and Business Services (Stats SA, 2012)	100	15	33	7	10	7	0	49	7
	Value Added	Manufacturing data (Stats SA, 2012)	100	18	52	17	3	5	0	36	9
Administration	Government Regulations	LPI Index f[1]or South Africa 2011 used as uniform score	5	5	5	5	5	5	5	5	5
	Customs clearance time & documentation	LPI Index for South Africa 2011 used as uniform score	5	5	5	5	5	5	5	5	5

[1] GP- Gauteng, LM-Limpopo, EC-Eastern Cape, FS- Free State, WP-Western Cape, NW-North West, NC-Northern Cape, KZN-Kwa-Zulu Natal, MP Mpumalanga

4.4 PLC Results and Comparison to Economic Development of Regions.

Table 4 shows the PLC scores that were calculated for each province using the weights and the performance scores from Table 2 and 3 respectively. The PLC values show that Gauteng has the Highest PLC of 17 followed by KZN with 13 and Western Cape with 10. The worst performing province is Northern Cape with a score of 3. This means that Gauteng has the best performance when it comes to facilitating logistics within and outside its borders.

Table 4: PLC Scores and Ranking

Province	PLC	Ranking	Contribution to GDP %
Gauteng	17	1	34.5
Kwa Zulu Natal	13	2	15.7
Western Cape	10	3	14.2
Mpumalanga	8	4	7.0
Free State	7	5	5.3
North West	7	5	6.5
Eastern Cape	5	7	7.5
Limpopo	4	8	7.1
Northern Cape	3	9	2.2

4.4.1 Relationship between PLC and the Provincial Economy

The PLC values were compared with the contribution of each of the provinces to the GDP. Figure 2 shows that there is a positive relationship between PLC and GDP; PLC is predicted to increase by 0.42 when GDP increases by one unit

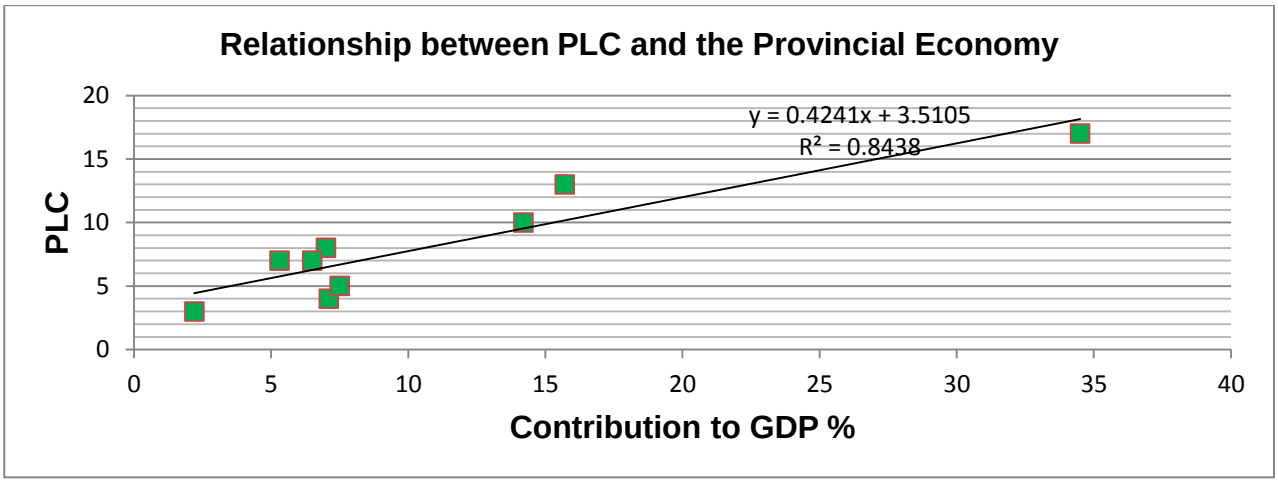

Figure 2: Graph of PLC against contribution to GDP for each Province.

5 CONCLUSION

Gauteng is the best performing province in terms of facilitating logistics activities within and outside of its boundaries with a score of 17. Following up is KwaZulu-Natal and Western Cape with Scores of 13 and 10 respectively. There is a definite positive

correlation between the PLC scores and the province's contribution to GDP**.** This means that the level of development of the logistic system in a province improves the economy of that province. However, whether logistics capability influences economic development, or vice versa, has not yet been established. The causality of this relationship should be further investigated.

6 REFERENCES

1. King, D.J and Botha, M. (2007). The State of Logistics in South Africa. A review of the past 5 years. CSIR Built Environment, Pretoria, South Africa.

2. Arvis, J F., Mustra, M.A., Panzer, J., Ojala, L., and Naula, T. (2007). Connecting to Compete- Trade Logistics in the Global Economy: the Logistics Performance Index and Its Indicators, the World bank, www.worldbank.org/pl

3. Kisperska-Moron, J. (2009). Validity of Logistics Performance Index for Evaluation of National logistics Competence. Proceedings of the 14th Annual Logistics Research Network Conference, Cardiff Business School, UK.

4. Song, J., Butcher, T., Mangan, J. (2009). Proceedings of the 14th Annual Logistics Research Network Conference, Cardiff Business School, UK.

5. The World Bank (2010). Logistics Performance Index (LPI). http://web.worldbank.org. Accessed 25 March 2010.

6. Fulop, J., 2009. Introduction to Decision Making Methods. Laboratory of Operations Research and Decision Systems, Computer and Automation Systems, Hungarian Institute.

7. Collins, T. R., Rossetti, D.M., Nachtmann, H.L. and Oldham J.R., 2006. The use of Multi-Attribute Utility Theory to Determine the Overall Best - in - Class performance in a Benchmarking Study. Department of Industrial Engineering. Texas Tech University.

8. Baker, D., Bridges, D., Hunter, R., Johnson, G., Krupa, J., Murphy, J. and Sorenson, K. (2001). Guidebook to Decision Making Methods. Developed for the Department of Energy, United States of America.

9. Öztayşi, B and Uçal, B. (2009). Comparing MADM Techniques for Use in Performance Measurement. Proceedings of the 10th InternationalSymposium on the Analytic Hierarchy/Network Process, Multi-criteria Decision Making, July 29 - August 1, 2009 University of Pittsburgh, Pittsburgh, Pennsylvania, USA.

10. Roberts, R. and Goodwin, P. (2002). Weight Approximations in Multi-attribute Decision Models. Journal of Multi-criteria Decision Analysis. Vol 11 (291-303).

11. Statistics South Africa, Statistical Release P0441. Gross Domestic product. http://www.statssa.gov.za/publications/P0441/P04413rdQuarter2012.pdf

12. Multiattribute Decision-Making: Use of Three Scoring Methods to Compare the Performance of Imaging Techniques for Breast Cancer Detection. Technical Reports (CIS). Department of Computer & Information Science University of Pennsylvania

13. SAPS, 2009. Crime Information Management: South African Police Service.