

Creating statistical indicators of Macroprudential Stability to guide Financial Regulation in South Africa

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Abstract:

Statistical indicators are conceptualized as products of statistical value chains. Statistical value chains are seen as processes that produce statistical indicators. This architecture in statistical indicator systems is identified in some of the major statistical indicator systems and extended into a general approach for the creation and management of statistical indicator systems. The approach involves the management of a collection of statistical value chains, data inputs, data outputs, data quality assessments and information visualizations. The techniques used are those of sample survey theory, statistical data quality assessment, decision theory, and sensitivity analysis. A simple case of the approach is used to develop and use a simple macroprudential indicator framework to conduct a macroprudential analysis of the South African economy. The system is based on enhancements of available financial supervision data under the legislative frameworks that govern the South African Reserve Bank, and the South African Financial Services Board; and the legislative framework governing data collection by Statistics South Africa. The paper concludes with a summary of the technical aspects of statistical indicator construction, their limitations and pointers for future directions of the research.

1. Introduction

The research aimed at exploring statistical indicators. Statistical indicators are defined in the Conference Of European Statisticians Statistical Standards And Studies – No. 53 on “Terminology on Statistical Metadata”, in Geneva 2000, as “a data element that represents statistical data for a specified time, place, and other characteristics”. In “A Methodology for valuing statistical benefits” by (G. Wallis), UK Office of National Statistics, (2006), statistical data is defined as “Data that are collected and/or generated by statistics in process of statistical observations or statistical data processing”.

In “Metadata use in the Statistical Value Chain” (UNECE-Eurostat-OECD Meeting on Management of Statistical Information Systems (MSIS) Luxembourg, 7-9 April 2008” G. Pongas defined a Statistical Value Chain(SVC) as being composed of seven steps:

Expression of Need, Data collection design, specification and development of the tools needed for the data collection, data collection, data editing and imputation; and data processing and data dissemination.

Each of the seven steps of the SVC is part of sample survey methodology and information technology. Statistical data can be seen as being produced by a SVC.

The data that is produced using a statistical value chain will have a certain level of statistical quality. The statistical quality of data from the SVC is defined in the “Draft Data Quality Framework 001: Statistical Quality Assessment (SASQAF)” in January 2006 by M.Strode as “fitness for use”. And this is usually evaluated using a data quality assessment framework. A data quality assessment framework can be extended to include the methods of decision theory to evaluate the impact of the statistical dissemination on society or its use by stakeholders, in order to identify to identify areas for quality improvement in the SVC and how it carries out its functions.

2. The Statistical Indicator Value Chain (SIVC)

The study of statistical indicator methods began with an analysis of a paper “Macro prudential Indicators of Financial System Soundness”, O. Evans, et al. (2000). The paper dealt with the steps involved in developing a set of indicators of the financial health and soundness of financial systems for International Monetary Fund (IMF)’s activities in the joint World Bank-IMF Financial Sector Assessment Program (FSAP), and the related Financial System Stability Assessments (FSSAs). The paper focused on how Macro prudential Indicators (MPIs) could be used most effectively by the IMF in its surveillance work under Article IV of the IMF’s charter and within the framework of the FSSAs, the modalities and options for the compilation of such data; and the possible dissemination of MPIs to the public, including through the Special Data Dissemination Standard.

This was followed by a review of texts from the Commonwealth Conference in Cape Town (South Africa) on the 7th of September 2005. The papers reviewed were those presented in sessions 4, 6 and session 7. These were “Toward developing regional sustainability”, P. Meadows (2005), “Indicators of Sustainable Development”, S. Hall (2005), “Organizing for National Framework Statistics for a nation in transition”, J. Kahimbaara (2005), “Measurement problem: The Role of Statistics in Evidence-Based Policy-Making”, C. Scott (2005), “Strengthening Statistical Capacity in African Countries under the framework of the International Comparison Program for Africa (ICP-Africa)”, C. Lufumpa, M. Mouyelo-Katoula (2005), “South African Index of Multiple Deprivation”, M. Babita (2005), “Moving from a postal to a field enumerated CPI-the South African Experience, and M. Pistorius (2005).

The major new consideration was local Agenda 21 identified in [6] during the creation of linkage indicators in Statistics New Zealand. The papers [9] and [8], outline the issues involved in the use of statistical indicators for empirical-based policy-making and the incorporation of statistical indicator systems into the official statistics agency. The paper [7] provides considerations in the creation of sustainable development indicators in the UK. The paper [12] gives an account of the movement of Statistics South Africa from a postal to a field enumerated CPI. The major consideration in the paper is its implementation of local Agenda 21 for the Consumer Price Index in South Africa, which is a major improvement in the quality of the indicator because of local Agenda 21.

The next group of papers were “Combining Census and survey data to construct a poverty map of South Africa” by Alderman, Babita, J Lanjouw, P Lanjouw, Makhatha, Mohamed, Özler and Qaba(2000), “Key Baseline Statistics for Poverty Measurement”, Hirschowitz, Orkin and Alberts (2000), “Earnings and Inequality in South Africa”, Bundleder (2000), and “Income Distribution in South Africa: A Social Accounting Matrix Approach”, Malan (2000).

The paper[31] uses data fusion to combine the 1995 October and 1995 Income and Expenditure Surveys with Census 1996 data to create a poverty map of South Africa. The structure of the statistical indication agrees with local Agenda 21 of the Rio de Janeiro declaration of 1992 and World Summit on Sustainable Development in Johannesburg

2002 for South Africa. The paper [32] creates a poverty map of South Africa using the 1995 October and 1995 Income and Expenditure Surveys with Census 1996 and 1996 Census Post Enumeration Survey data. The paper also derives an infrastructure index and household circumstances index using Factor Analysis with a rotation. The paper [33] aims to determine trends on inequality using the October Household surveys for the years 1995 to 1998. The problem with the work in terms of the SIVC is the reporting on the data quality. The paper [34] uses the Social Accounting Matrices for 1978, 1988 and 1993 to answer the questions of an impact of an exogenous increase in household income (by race and income quintile) on GDP; and the impact of an exogenous increase in household income on imports.

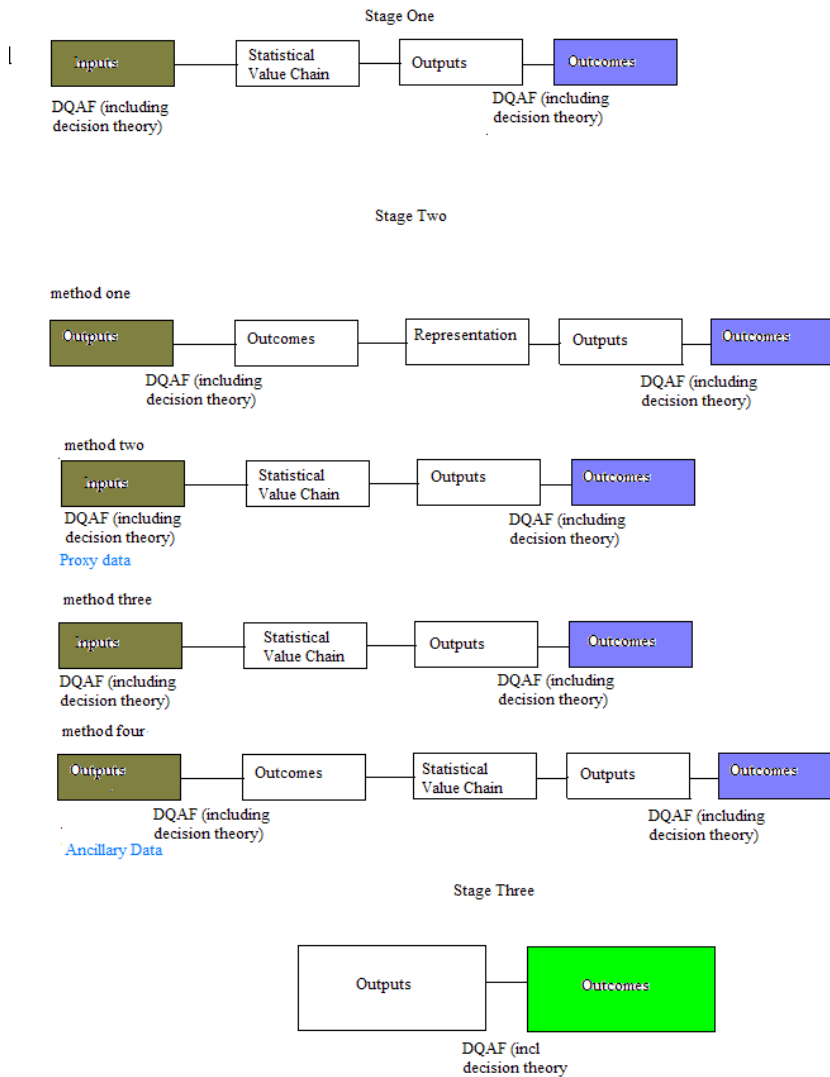
The next group of texts reviewed were “Statistical Indicators for the economic and social science”, Horn (1993), “Problem of Numeracy” Ehrenberg, Book Review: Statistical Indicators for the economic and social sciences” David (1994), “Lessons from History: Social Indicator Movement”, Cobb and Rixford (1998), “History of Statistics” Meitzen (1891), “Introduction to Survey Quality” Biemer, Lyberg (2003), “Index Numbers in theory and Practice”, Allen (1975), Cost of Living Index numbers, Barnejee (1975), “The making of Index numbers”, I. Fisher(1922), “Exact and Superlative Index Numbers “, W. Diewert (1976), “Survey Sampling” Kish (1995), “The Element of Probability in Index-Numbers”, F. Edgeworth, (1925), and Sensitivity and Uncertainty Analysis, Saltelli and Chan (2000).

What began to emerge in the texts and other indicators analysed is that statistical data can be represented in four immediate ways using other data (statistical indicators), these being, firstly, one can perform further processing on the statistical data with ancillary (fusion with another SVC), or one can measure (or find) new statistical data (statistical data from another SVC of a proxy or) that is an approximation to the statistical data (the SVC process on the outputs can be repeated as in the first case for the proxy series) or the statistical data can be represented by itself (identical SVC) or one can simply perform a representation of the statistical data without further processing. This can be represented diagrammatically as in figure one below.

In stage one; one identifies the data to be represented. In statistical indicator creation this can be a long procedure, and is usually part of the presentation stage during dissemination (stage two presentation outputs or outputs of the SVIC in stage three).

The collection of methods (including each DQAF of each set of SVC’s output and outcomes) in stage one, two and three can be seen as methods for the creation and management of a statistical indicator value chain (SIVC). Each of the four methods in stage two except method one above contains a SVC. The methods are also applicable if the original data is measured and available in stage one. One would use method one in stage two to present the statistical indicators. However, generalizations are possible where data can be processed and presented after repeating sequences of methods in stage two. An example is the application of method one to the available data from stage one and then use method three to combine it with ancillary data and then present the output using method one of stage two.

When one has a statistical value chain composed of a set of sample survey techniques applied to a set of inputs to produce outputs that result in outcomes, one usually has to assume a model (i.e. in the SVC). Methods for the creation, management and evaluation of models are those of Sensitivity and Uncertainty Analysis.



Since the statistical indicator value chain is composed of inputs, outputs, outcomes, statistical value chains, DQAF's, which involve modeling Sensitivity and uncertainty Analysis for the creation and management of the models within it.

According to A. Karr and A. Sanil, and D. Banks (2006) data quality is the “capability of data to be used effectively, economically and rapidly to inform and evaluate decisions.” This not only depended on data quality but also on how the data is represented or presented during dissemination. Representation involves assessment of the choice of method to represent the statistical data as outputs. The optimal choice of method will help avoid the situation of statistical indicators being of high quality but still remain ineffective for generating the desired outcomes. Representation according to Tufte (1990)

“to envision information, and what splendid visions can result-is to work at the intersection of image, word, number, art”. Tufte then specifies the basic form of the Representation Value Chain, “the instruments are those of writing and typography, of managing large datasets and statistical analysis, of line and layout and color.” Tufte then specifies the importance of a quality assessment framework for the representation section of the SVC as “And the standards of quality are those derived from visual principles that tell us how to put the right mark at the right place.”

Hence, in the creation and management of statistical indicators, one has methods of Survey Sampling, Data Quality Assessment, Sensitivity and Uncertainty Analysis and methods of information representation (i.e. envisioning information).

2. Statistical Indicator techniques

Using mostly Horn(1993), Cobb(1998), David(1994), Meitzen(1891), O. Sheynin(2005), Satletlli, et al (2000), Tufte (1990), Allen (1975), Barnejee (1975), Fisher (1943), Fisher, et al (1993), Stuvell (1989), Gandin (1970), Cressie (1993), Haining (2003), Kish(1995), White(1969),and the texts reviewed in Chapter One, some general statistical indicator techniques for the management of the SIVC were identified.

2.1 Identification

[13] provides a working definition of statistical indicator types as direct-objective and indirect-objective. A direct-objective indicator is a statistical indicator that is measured for a specific purpose for which it is to be used. These are subdivided into single-variable concept statistical indicators used for concepts that can be captured by single variables, combined-fixed concept for fixed concepts that are captured by many variables and combined-dynamic concept statistical indicators for concepts that need to be captured by a combined set of dynamic variables.

Indirect-objective statistical indicators are those that allow for indirect conclusions to be reached about some phenomenon, without directly measuring it. This corresponds to method three in the SIVC.

The important point to note is that the identification of a statistical indicator involves a data quality assessment framework, representation, decision theory analysis of outcomes and the structure SVC (but in some cases the SIVC) of the inputs into any SIVC method. The current methodology makes two additions, firstly that of [6], which states that additionally this identification should occur at a community level, according to local Agenda 21(because of the spatial quality of the resulting measurement and enhancement of representation). Secondly, that of [19] for analyzing the output, input and structure of models (whether represented in a computer or not).

Statistical indicator identification is the same as classification as used in official statistical agencies. [13] outlines the importance of homogeneity in the statistical quality of indicators. Classification also determines what will be represented, how it will be represented and to whom.

2.2. Sample Survey Techniques and Methods

Sampling techniques are important for defining the target population and its associated statistical populations. The definitions and how they are operationalised determine the statistical quality of the resulting statistical indicators.

2.3. Presentation

[13], [6], [39],[15], [16], [19], [21] and [6], identify tables, graphs, charts and picturegrams as the method of presenting indicators. The methods are those of graphics (representation of attributes in space), cartography (effective representation and optimal use of presentation space), numerical analysis (when working with tables, percentages and comparisons), and meaningfulness at a localized level before presentation at a higher level of aggregation. The next eight techniques are used in statistical indicator presentation.

2.3.1. Stocks and flows

In accounting, national accounting, environmental accounting and environmental reporting, physical (or nonphysical) quantities are expressed as stocks at a fixed point in time and flows over an interval of time. This allows for analysis in time of a sequence of values of a direct-objective or indirect-objective indicator by its property of being diachronic. Secondly, it allows for spatial or structural analyses by its property of being synchronic [13].

2.3.2. Aggregates, Ratios, Ranks and Measures of location

Aggregates are collections of similar sampling units for at different orders of spatial zones (real or abstract). Ratio statistical indicators are quantities that divide one variable by another to form a combined measure with a numerator and denominator. Measures of location include means, percentiles and other (parametric and non-parametric) measures of location.

2.3.3. Scaling, and weighting

In choosing the direction of comparison of the disseminated results, one has to decide on a scale or taxonomy. Weighting is also used as a representation or indicator technique when it comes to concepts like post-stratification, data fusion, subclass analyses, sub-sampling or removing unwanted biases, one has to make a decision about weighting and equivalence scales. “Weighting” is the relative significance of a quantity (random variable) in a given statistical indicator value (like a composite index).

2.3.4. Index numbers

Index numbers are numbers that designed to show percentage change over time and space

as well as a difference at a point in time and space of a quantity not susceptible to measurement [35]. Index numbers need to be homogenous in order to provide meaningful comparisons. The components of an index number can be any statistical variable that can be compared in time and/or space.

2.3.5. Correlation and regression

When looking at relationships between series for indicator purposes, one has to explore relationships between values of a variable as indicators of its future values or relationships in one or more indicators as indicators for the future value of one. The method that is used to quantify these relationships in a simple manner is regression. Regression may be linear or non-linear. Regression can be used to determine significant links between real life random variables.

2.3.6. Time Series Analysis

Time Series Analysis is a collection of methods that are especially adapted to quantify relationships of a series of related observations in time or in a straight line. The methods are of two broad categories, an additive model and a multiplicative model. The methods are involved with the decomposition of an observation into a secular trend, seasonal trend, cyclical movements and residual random fluctuations. The aim is that after the adjustment of the process using additive or multiplicative methods, one remains with a residual term whose decomposition can provide indicators showing the strength of each of the secular trend, seasonal trend, and cyclic movements.

2.3.7. Multivariate analysis

These are method used for the analysis of dependence and analysis of interdependence. These include regression, confluence analysis, canonical analysis, variance and covariance analysis (stochastic processes), component analysis, correlation analysis, cluster analysis, factor analysis, multidimensional scaling, association/contingency analysis, discriminant analysis and all other supervised and unsupervised multivariate methods of Data Mining.

2.3.8. Sensitivity and Uncertainty Analysis

This is carried out throughout the SIVC formulation. A SA is a study of how the variation in the output of a model (numerical or otherwise) can be apportioned, qualitatively or quantitatively, to different sources of variation and how a given model depends upon the information fed to it [18]. Part of model evaluation is the statistical quality of outputs.

3. Continuous quality improvement

These methods manage statistical quality in every step of the SIVC as well as using feedback from customers about the products of the SIVC.

3. Data Analysis

Macroprudential indicators are indicators of the financial health and stability of financial systems (Evans, 2000). The IMF/World Bank Financial Sector Assessment Program (FSAP), which began in 1999, has recommended that countries begin compiling macroprudential indicators to monitor the financial health and stability of their financial systems and identify possible threats.

The MPIs that are identified and recommended in Evans 2000 and the IMF's 2006, Financial Soundness Indicators: Compilation Guide, (FSI2006) are those of the capital adequacy, assets quality, management quality, earnings and liquidity, and market risk (CAMELS)¹ Macroprudential indicator framework for macroprudential analysis. The next table gives the core indicator set for deposit-takers of the framework:

Table One

Core Set	
Deposit takers	Macro-prudential Indicator
Capital adequacy	Regulatory capital to risk-weighted assets
	Regulatory Tier 1 capital to risk-weighted assets
	Nonperforming loans net of provisions to capital
Asset quality	Nonperforming loans to total gross loans
	Sectorial distribution of loans to total loans
Earnings to profitability	Return on assets
	Return on equity
	Interest margin to gross income
	Non-interest expenses to gross income
Liquidity	Liquid assets to total assets (liquid asset ratio)
	Liquid assets to short-term liabilities
Sensitivity to market risk	Net open position in foreign exchange capital

Source: Financial Soundness Indicators: Compilation guide, IMF, 2006

The next step was to use the FSI2006, component series data sources, and the simple statistical indicator methodology to compile the CAMELS system macroprudential indicators (core, recommended set and additional but relevant indicators) for the South African economy.

The component series data sources were the Statistics South Africa Economic Statistics cluster, South African Reserve Bank Supervision and Regulation data, and the Financial Services Board industrial aggregates (Insurance sector bases).

The simple statistical indicator methodology identified in the literature review requires that there be first identification, which is followed by use of sample surveying techniques and methods, presentation, and continuous quality improvement.

¹ "Macro prudential Indicators of Financial System Soundness", O. Evans, et al. (2000).

The statistical indicators for macroprudential analysis that were identified for the South African economy are all those in the FSI2006, which are the statistical indicators in the CAMELS framework as well as those from Macroprudential stress tests.

Once the statistical indicators were identified the next step was to use the methods of sample survey methods and techniques to identify the statistical populations required for a macroprudential statistical indicator framework. These were the statistical populations of the deposit taking sector, other financial sectors, non-financial sector, households, and any other populations.

A list of the financial intermediaries population is available from Institutional Sector Classification Guide for South Africa, SARB (2005). The annual reports of the publicly registered financial corporations are available from the company websites. The financial intermediaries can be stratified by the Standard Industrial Classification of All Economic Activities (SIC). The list of corporations was used as the target population for the various statistical indicator populations that were required in the compilation of the FSIs. This statistical basis was used in the stress tests and their supporting sensitivity and uncertainty analyses.

Supervision data is available on a monthly basis from the SARB website for the compilation of the Deposit Taking FSIs. Statistics South Africa economic data on financial corporation financial statements is available quarterly, and annually. Supervision data is available from the Financial Services Board on an annual basis other financial corporations (Unit Trusts Survey, Insurance Industry information) with appropriate lists for the target population units. Supervision and regulation policies by the SARB, and the Bank of International Settlements provide the regulatory and supervision framework. The regulatory framework and the SARB financial surveys provide the statistical properties for banking data. Financial Service Board regulatory and supervision framework provide the framework for the operation of all financial intermediaries.

The statistical properties of the system were modeled with a sampling-theory based model with econometric-statistical theory extensions and based on this assumption the system resiliency was evaluated using stress tests. The model is based on updated population lists, based on business sector institutional lists found on [43]. These provide the sampling frame for the target populations from which a statistical basis of the observed estimates from SARB is based. This is important for preparing harmonized macroprudential statistical indicators from different sources of data. Additionally, the design and efficiency, plausibility of the sampling theory model can be tested using sensitivity and uncertainty analysis. The plausibility of model results during stress testing is also usually evaluated using sensitivity and uncertainty analysis, which both require the statistical properties of the target populations.

A set of the core, recommended and related FSIs for South Africa from Statistics South Africa, and SARB data is given in the three tables below:

Table Two

Macroprudential indicators for South Africa	Month of December 2007	Macroprudential indicators for South Africa	Month of December 2007
Core		Other financial corporations	
Regulatory capital to risk-weighted-assets Ratio	0.125	Non-banking assets to GDP*	0.26
Regulatory Tier 1 capital to Risk-Weighted-Assets	0.095	Non-financial corporations	
Nonperforming loans net of provisions to capital	0.055	Debt to equity*	1.84
Nonperforming loans to Total Gross loans	0.014	Return on equity*	0.31
Return on equity	0.182	Interest payments to profit after tax*	0.21
Return on assets	0.001	Civil Summons for debt (private persons)	51522
interest margin to gross income	0.650	Households	
non-interest expenses to gross income	0.228	Household debt (annual percentage change)*	22.17
Banks share price change	0.061	Disposable income (annual percentage change)*	13.57
Net foreign exchange exposure to capital	0.001	Income gearing*	10.9
Encouraged		Household debt as percentage of disposable income (right-hand scale)*	77.6
Capital to Assets	0.00007	Real estate	
Gross asset position in financial derivatives to capital	0.8719	Overdue mortgage loans as percentage of total mortgage loans*	1.5
Gross liability position in financial derivatives to capital	0.2902	Mortgage debt as percentage of market value of housing*	63
Spread between the highest and lowest interbank rate	0.0050	Overdue mortgage loans (right hand scale)*	84.3
Spread between the reference lending and borrowing rates**	0.0350	House price index	11.1
Foreign currency denominated loans to total loans	0.0940	Market liquidity	
Foreign currency denominated liabilities to total liabilities	0.0018	Average daily turnover ratio over all securities markets	5205
customer deposit to total (non-interbank) loans	0.8589		

variation of daily rates over the month, *available monthly, ^available annually, Source: SARB and Statistics South Africa (AFS figures are based on a turnover estimate of 342 142 million, with an Relative standard error of 3.14. GDP and SARB data are part of the SDDS, with negligible error The case data are based on a monthly sample of 151 magistrates covering 95% of all cases

Table Three

GEOGRAPHICAL DISTRIBUTION OF DISCOUNTS, LOANS AND ADVANCES (MONTHLY) as % of marginal totals									
Description	South Africa	Other African countries	Europe	Asia	Russian Federation/ former USSR	Americas North	Americas South	Oceania and other	Total
Distribution (%)	89,73%	0,45%	8,27%	0,47%	0,01%	1,01%	0,00%	0,06%	2124255223
Number of clients	99,64%	0,28%	0,07%	0,00%	0,01%	0,00%	0,00%	0,00%	17485933
Specific provisions	98,26%	0,05%	1,30%	0,19%	0,00%	0,21%	0,00%	0,01%	18208233

Source: SARB, DI bank returns

Table Four

Industry by SIC category	% of portfolio
Agriculture Forestry and fishing	1,57%
Mining	2,02%
Manufacturing	3,91%
Construction	1,13%
Electricity, gas and water	0,71%
Trade and accommodation	3,14%
Transport and communication	2,26%
Finance and insurance	27,70%
Real estate and business services	10,03%
Community, social and personal services	2,07%
Individuals	40,16%
Other	5,29%

Source: SARB

Related	
Gini concentration index	83.4
H-index	0.19
Market share of top four banks	85.1
JSE Banking Index	38633.94
Guidotti Ratio GR	1.2
Augmented Guidotti Ratio GR	0.65
Guidotti Ratio/Augmented Guidotti Ratio Threshold	1

Source: SARB

However, before the statistical model can be used it is imperative to assess the statistical quality of the data. This was done using the South African Statistical Quality Assessment Framework (SASQAF) from [42]. The assessment of the Banking supervision data from SARB yielded a SASQAF score or rating of 224, 223, or 212 (out-of-212). The statistics South Africa data are official and also have a score 224 on the SASQAF. The data for encouraged and extended FSIs (with their measures of error and statistical metadata) is available from Statistics South Africa, Financial Services Board and the South African Reserve Bank.

Once the statistical properties of the data (i.e. target or sampling population, parameters, key variables and measures of error) were defined, the next step was to analyse the data in order to assess the plausibility of the sample survey model in describing the real-life population within its environment (i.e. financial markets).

The regulatory capital to risk-weighted ratio continues to grow monthly, which is an indication of the financial strength of the system. This growth can also be observed in the Tier 1 to risk-weighted capital ratio. The increase in the level of impairments may be interpreted as a result of increased economic activity or volumes and variety of trades in the financial markets leading to more contracts being invalidated or repudiated (which may be linked with the higher GDP growth level); or increase in the number of people

who are defaulting as a result of a general shortage of funds in the economic system (which may be linked to a higher deflator growth rate, or inflation rate).

The same results may be seen from the profitability indicators, with a small return on equity (based on gross income for banks before tax). The net foreign exchange exposure to capital of 0.07 % indicates a low exposure to foreign exchange risk relative to banking industry capital. There are small movements in the bank rate of 0.5 % for the month, which indicates small shocks to the system. The banks are keeping exposure to local companies. The stress tests in the Financial Stability Review of March 2008 by the SARB indicate an ability of the economy to absorb major shocks impacting the capital adequacy of banks in the financial system.

The above simple macroprudential analysis can be made more detailed by the analysis of all the FSIs; construction of a statistical model; design control using sensitivity and uncertainty analysis; conducting stress tests; and constructing qualitative indicators.

4. Conclusion

A simple set of statistical indicators were created using SIVC methodology from the macroprudential indicator framework recommended by the Bank of International Settlements, IMF and the SARB. The experience highlighted the difficulties involved in creating indicators from a variety of data sources, these being managing data quality, creating appropriate statistical models, and unifying the various results into a harmonized framework. The management of data quality involves accurate classification, knowledge of sample survey and sampling techniques, efficient use proxy or ancillary sources of data, and sensitivity and uncertainty analysis. The management of a statistical indicator system involves all the above considerations as well as an effective method of representation and assessment of the quality of representation (decision theory) from the final data customer.

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