# COMWARN METHODOLOGY

## The Structural Vulnerability Assessments System **(SVAs)**

A Primer on Structural Vulnerability Assessments and Guide to the Africa Prospects Tool as Implemented by COMESA Conflict Early Warning System (COMWARN)

A Component of The COMWARN Toolkit

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*Supported by the EU through the APSA Support Programme*

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# Preface by the Secretary General

The Fourth Summit of the COMESA Authority, which was held in Nairobi Kenya in May 1999 marked an important milestone for COMESA when it directed COMESA to set up a formal structure and modalities for engagement on matters of peace and security. This was done in recognition that peace, security and stability are basic factors in enabling investment, development, trade and regional integration. Although Article 3(d) of the COMESA treaty identifies peace and security among the objectives of COMESA, these issues were previously addressed through ad-hoc arrangements.

The COMESA Authority established a three-tier structure for peace and security comprising the Committee on Peace and Security, the Ministers of Foreign Affairs and the Authority and it directed the COMESA Ministers of Foreign Affairs to meet at least once a year. The Ministers were charged the responsibility of discussing the modalities for addressing issues of peace and security as well as monitor and advise the Authority on initiatives for the promotion of peace, security and stability in the region. The Authority also directed the Secretariat to ensure to work within the framework of the African Union and in close collaboration with other Regional Economic Communities. The Fifth and Sixth Summits, held in 2000 in Mauritius and 2001 in Cairo, Egypt developed and adopted an institutional structure and modalities for the promotion of Peace and Security while subsequent Meetings of the Authority provided guidance towards defining an Architecture for COMESA Peace and Security.

COMESA has since established programmes on conflict prevention, conflict management and post conflict reconstruction to address the full spectrum of the conflict life cycle as well as two overarching programmes that cut across the conflict life cycle, namely programmes on elections and democracy as well as a programme to address maritime insecurity and other transnational crimes.

On conflict prevention, COMESA has developed a robust data-driven and theory informed early warning system (COMWARN) that responds to respective decisions of the COMESA Policy Organs. The Ninth Meeting of the COMESA Ministers of Foreign Affairs, which was held in Zimbabwe in 2009 urged COMESA to "start the development of a conflict early warning system focusing primarily on structural factors of conflict while at the same time also ensuring to capture other structural factors to fulfil its conflict prevention mandate." In the following year, COMESA developed a the model that forecasts structural vulnerability assessments (SVAs) and validated it through governmental experts and also, working with the Statistics Unit, held a workshop for Bureaus of statistics to review and validate the global data used in the model. The Thirteenth Meeting of the COMESA Ministers of Foreign Affairs, which was held in Kinshasa, DRC in February 2014 adopted use of

global data sources as well as the reporting template and urged the Secretariat to start the production and dissemination of SVA forecasts and response options to member states.

COMWARN is therefore unique and differentiated from the early warning systems of other RECs because of its focus, which is structural factors of conflict. It therefore provides early warning at the very early stages of conflict formation. Another point of distinction is its "target". The COMWARN target is "peace and prosperity" and it therefore monitors indicators that provides a forecast on the proximity of any country towards increased peace and prosperity, or the converse. This is unlike the early warning systems of the other African RECs which have "conflict" as the target and thus monitor the proximity of any country towards specific levels of conflict.

COMESA has been provided SVA reports to Member States since 2015. In addition, and in compliance to a decision of the 15th Meeting of the COMESA Ministers of Foreign Affairs, which was held in Antananarivo, Madagascar in 2016, COMESA has been convening multi-sectoral consultations in member states to disseminate the outputs of the SVAs to a wide range of stakeholders. This is because the COMWAN SVAs touch on a wide range of sectors.

Two factors have guided the timing of the development of the COMWARN Tool Kit. Firstly, following the multi-stakeholder consultations that were held in 2018 and 2019, several member states have indicated a desire to incorporate COMWARN outputs into their respective national early warning systems. Having a document that provides and simplifies the COMWARN processes will likely make it easier for any country that choses to incorporate the SVAs into national early warning systems. Secondly, with COMESA at the threshold of implementing a new organizational structure, the issues around ensuring sustainability are an urgent consideration. The compilation this tool-kit will therefore ensure that any new staff can continue the implementation of the programme seamlessly.

***Chileshe Mpundu Kapwepwe***
***Secretary General***
***November 2019***

# Introduction to the **COMWARN** Toolkit

The COMWARN toolkit is a comprehensive publication that comprises three separate documents for use by COMESA COMWARN analysts to undertake COMWARN SVAs and to develop early warning reports for dissemination to member states. The toolkit is also useful for Member States and other RECs that may wish to incorporate the COMWARN methodology in their respective national or regional early warning systems.
The toolkit includes a primer on the COMWARN Structural Vulnerability Assessment (SVA) methodology, a description of the data and a manual on Conflict Analysis and Report writing[1]. It is noted that the SVA methodology was developed by the African Union Continental Early Warning system and adapted by COMESA for COMWARN.

The two components of this toolkit, the "Primer on SVAs" and the "COMWARN Data and Data Sources" are considered as "living documents" because the COMWARN SVA methodology is still relatively new particularly the use of a composite indicator for the target. It is noted that the COMESA Ministers of Foreign Affairs, in their 15th Meeting which was held in Antananarivo in 2016 called on the Secretariat to continue to improve the model; while in July 2018 the Ministers, in their 16th Meeting which was held in Lusaka called on the Secretariat to mobilize Resources to incorporate the analysis of dynamic data into the model. Similarly, with regard to the data, the 13th Meeting of the Ministers of Foreign Affairs, which was held in Kinshasa in February 2014 adopted the data and the use of the global data sources, they urged the Secretariat and Member States to "review and validate the data on a regular basis". It is therefore expected that as these decisions are progressively implemented, the Primer and the COMWARN Data and Data sources will continuously be updated.

### The Primer on Structural Vulnerability Assessments and Guide to the African Prospects Tool as implemented by COMESA COMWARN

The Primer introduces SVAs as well as provides an overview of the Africa Prospects software tool as developed by the African Union to assess structural vulnerability of countries. It provides the key features of the African Prospects. The Primer further highlights the customization of the Africa Prospects by COMESA to undertake SVAs for a composite target, the COMESA Peace and Prosperity Index (CPPI). The bulk of the Primer is a detailed ten-step process of conducting COMWARN SVAs, including the specification of the Target Variable, the selection of the Explanatory Variable, the compilation of indicator data sets, building and running the model, comparing results, collating results from the forecasted levels of CPPI, the identification of country specific indicators and their associated levels of CPPI, evaluation of the forecasts, and the formulation of actionable recommendations to mitigate structural vulnerabilities.

1 The COMESA programme on Peace and Security recognizes with appreciation, Professor Doug Bond from Harvard University for the development of the "Primer" and Dr. Martha Mutisi from IDRC for the development of the "Manual on Conflict Analysis and Report Writing".

### A Compendium of COMWARN Data and Data Sources

This is a compilation of the global data sources as used by the COMWARN model. It details the twelve data sources including a description of the indicators derived from these sources. It provides such information as the name of the indicator as used by the developer and the name as used by COMWARN and the basket in which the indicator fits. A brief description is given on the data source, the methods used to develop the indicator, the relevance of the indicators to peace and prosperity and any limitations the of the indicator with respect to its usage to support the analysis. Out of the twelve data sources, COMWARN gets 97 of its 144 indicators from three data sources, the World Bank (64), the World Economic Forum (16) and the Mo-Ibrahim Foundation (14). Therefore, the description of indicators from these sources is less detailed than the indicators sourced from the other nine sources. The document is supported by two annexes, the first contains the "Candidate Indicators" for COMWARN that were adopted by the 11th Meeting of the COMESA meeting of the Ministers of Foreign Affairs that was held in Lilongwe in October 2011. This followed the identification of common structural factors that affect COMESA peace and prosperity. The second annex provides a listing of all 144 indicators with a brief description of each.

### The Manual for Conflict analysis and report writing

The manual is developed for use by any practitioners in the field conflict prevention and peace building including students of peace studies. In addition, any person involved in developing early warning reports, mediation or mediation-related roles needs to have a good understanding of conflicts and their dynamics.

This introduction therefore serves to introduce the complete COMWARN toolkit to the reader noting and in view that some of the components can be used on their own. The introduction provides the reader information on the other components of the Toolkit and thus encourages the reader to consult the other components for a better understanding of the COMESA conflict early warning system.

**Elizabeth Mutunga**
**Head of Governance, Peace and Security**

# Structural Vulnerability Assessments – **An Introduction**

The process of conducting a Structural Vulnerability Assessment or SVA generally begins with the specification of something negative with the objective of preventing it from happening. For example, an SVA is often used to help clarify the structural influences and constraints that may contribute to escalation of a conflict into violence. However, an SVA can also be used to better understand how a (positive) condition may be attained. Such a use of an SVA might focus on identifying and bolstering the structural influences that promote wealth, health and/or some other objectives to be achieved.



In any case the purpose of an SVA reflects the institutional mandate as well as the objective. For COMESA, the SVA objective is defined broadly *as peaceful prosperity*. COMESA has developed an index to operationalize this objective: the COMESA Peace and Prosperity Index or CPPI. This index is discussed below.

Perhaps the most distinctive feature of all SVAs is their focus on the longer term, structural influences and constraints as opposed to the proximate indicators associated with dynamic event interactions and triggers. SVAs thus offer a systematic means of diagnosing conditions before they deteriorate. In other words, SVAs support very early warnings thereby facilitating an emphasis on structural prevention rather than on crisis intervention or mitigation of effects. In the case of positive objectives, the emphasis would be on identifying and nurturing longer term drivers of success.

Although this Primer focuses on the use of the Africa Prospects tool to conduct SVAs, the basic elements and the overall SVA processes are similar regardless of the tool used. The basic elements for all SVAs include *the objective* (either positive or negative in polarity) that represents the target variable to be prevented or realized, *the structural indicators* that influence or constrain progress away from or toward the target thereby making a country more or less vulnerable. The gist of the SVA process is to identify the relative impact of each structural indicator on the target for each country, with the results used to formulate strategies to prevent or mitigate their effects.

Africa Prospects automates the SVA calculations (projections, forecasts and performance metrics) in a systematic and transparent manner that supports theory-informed, data driven assessments of a country's vulnerability. However, the output of the SVA process to this point is but a prelude to the diagnosis of the drivers to determine which are operating in common across countries and which are manifest uniquely in any given country context. In other words, the output of the automated portion of the SVA process is really the input to the interpretation and formulation of recommendations that follow.

In sum, it is the diagnosis of structural drivers that is the basis for formulating the SVA output and recommendations designed to illuminate areas of potential intervention that in turn are prescribed to reduce a country's vulnerability.

### Africa Prospects – An Overview



The Africa Prospects software tool is designed to assess the structural vulnerability of countries to conflict escalation (or other target variables, including those with a positive polarity) based on their profile of structural attributes. The tool learns from historic country profiles with respect to a target variable, and then projects the profiles as a basis for forecasting their structural vulnerability with respect to that target variable into the future.

Africa Prospects, as implemented in COMWARN, provides a tool for enhancing trend analyses of events and actors by providing a measure of their structural vulnerability or context. The tool is optimized for the systematic examination of comparable structural indicators across countries, and it is best used by triangulating data from regional, continental and global data sets. Although the tool is also capable of running in a "country-specific" mode in which the objective is to assess the evolution of a set of indicators for a single country to illuminate their interaction and associated outcomes, use of the tool for such case studies is generally not practical due to data density and/or availability issues associated with the lengthy time series required for case studies.

Before turning to a presentation of the details on *Africa Prospects*, a note is warranted about the terminology used in this section. The terms "variables" and "indicators" are used more or less interchangeably, and both refer here exclusively to structural rather than dynamic indicators or variables. The "dependent variable" is called herein the "target" variable or custom index, while the "independent variables" are referred to as "explanatory variables." "Time series data" or profiles simply refer to a list of indicator values over time for a given country. In *Prospects*, the time series takes the form of a list of country-year observations, where each (country-year) case in the list is associated with particular values for each structural indicator, or in other words, a country profile.

As noted in the introduction, Africa Prospect's "output" is actually "input" to the analyst's diagnosis of drivers and attempt to understand how individual indicators contributed to a country's vulnerability. The tool supports the diagnosis by offering a trace back to the indicator data that produced each forecast: first, the structural indicators associated with each level of the target are identified as a way of identifying the overall drivers for each level; second, the drivers for individual counties are identified as a means to diagnose the specific drivers

associated with each unique country context. In short, COMWARN's implementation of *Africa Prospects* offers a transparent, testable and evidence-based tool for structural vulnerability assessment.

### Conducting SVAs with COMWARN's Africa Prospects

The basic idea behind Africa Prospect's structural vulnerability analysis is that various patterns of structural influences and constraints in a country are associated with a propensity for lower or higher levels of a given target variable or index. The specific pattern associated with a given level or intensity of the target is learned from historical time series data. The current patterns are then assessed and projected into the future along with their forecasted levels of the target based upon the historical data. Higher structural vulnerability to the target is assigned when the expected levels associated with current patterns are high. Conversely, lower structural vulnerability is assigned when the expected levels are low.



The target as used in COMWARN's implementation of Africa Prospects is a custom index that began with seven variables developed by COMESA and that is based on Article 3 of the COMESA treaty. (The original variables included peace, trade openness, food production, wealth, capital, health and education.) After lengthy discussion, several iterations and refinements it was determined that these seven variable indices blurred the distinction between ends and means. A more focused approach was then articulated using the following measures of prosperity and peace as the overarching goal:

**Prosperity**

Health – indicated by low child mortality rates (with life expectancy to be tested also)
Wealth – indicated by GDP / capita
Economic Integration – indicated by trade openness

**Peace**

Conflict Barometer – used to degrade the prosperity component as conflict increased

For now, equal weighting is applied to each of the prosperity measures, but testing is underway to determine the optimum. The conflict barometer provides a way of calculating a "peace dividend" as it increasingly degrades the prosperity score (currently by up to 50%) as the conflict intensity increases.

Again, this target index is called the COMESA Peace and Prosperity Index or CPPI. The CPPI can be used to assess the progress of COMESA as a whole as well as its individual Member States in reaching the overall goal

of promoting peace and prosperity.

The method used by Africa Prospects to conduct COMWARN SVAs is to retrospectively examine the relationships between various country profiles or patterns of structural indicators against the CPPI with which the historical profiles have been associated. The tool is trained and optimized with these retrospective data and its performance is measured against a known test data set, still historical, but drawn from a separate sample set within the time series.



After the retrospective forecast performance is deemed to be acceptable, the tool is run again from the present, using projections of the explanatory variables into future to forecast the CPPI into the future. Knowing the historical performance, and assuming continuity across a country's structural influences and constraints into the near-term future, the tool outputs these CPPI forecasts, transforming them into structural vulnerability ratings for each country with the performance metrics offering a measure of confidence in the forecasts. The tool then supports the interpretation of the forecasts by illuminating specific indicators or explanatory variables that produced the results. This interpretation is then used to support the formulation of recommendations for prevention and mitigation, both with respect to the drivers for each level of the CPPI as well as for each country context.

The following list outlines ten basic steps to perform a structural vulnerability assessment or SVA with the *Africa Prospects* tool as implemented by COMWARN. The first three are the same steps that one would follow to conduct a structural vulnerability assessment with almost any tool. The fourth step in conventional approaches is replaced by a series of steps (#5 through #10) that distinguish *Africa Prospects* in terms of its approach, method and utility. All of the steps are discussed in more detail below, preceded by a brief introduction to the distinguishing features of the tool.

1. Specify the target or dependent variable(s) – CPPI for COMESA

2. Select indicators or explanatory (independent) variables or indicators

3. Compile a structural indicator data set or country profiles for the world, continent and/or regional analyses

4. Rank the indicators by their importance or impact on conflict escalation and calculate the country vulnerability scores based on the weighted indicators – this complex step concludes most SVAs.

**NOTE:** With COMWARN's implementation of Africa Prospects, Step (#4) is replaced by the steps #5 through #9, as outlined below.



5. Build and run the Prospects model
   a. Optimize the indicator projections
   b. Specify a training set (e.g. 1998-2008)
   c. Specify a test set (e.g. 2009-2015)
   d. Specify a forecast window (e.g. 2016-2018)
   e. Run the specified model

   Check the performance metrics, iterating from step 4a until all requirements (accuracy, recall & precision) are met

6. Compare the results from A) alternative data "cuts" (e.g. global, continental and regional), B) target measures and C) indicator sets to illuminate shared and unique influences and constraints, iterating from step 1, 2 or 5 as needed

7. Collate each driver's forecasted level of the CPPI results – to identify the common drivers for each level of the COMESA index.

8. Identify the country-specific indicators and their associated values that drove the forecasted results for each individual country context – to identify the country-specific drivers.

9. Evaluate each of the country forecasts, drivers and data "cuts" with area and subject matter experts to assess the results and enhance their interpretation

10. Drawing upon the CPPI forecasts (#6), drivers (#7), data "cuts" and assessments (#8), formulate actionable, country-specific recommendations to prevent and mitigate each country's structural

vulnerability.

### Key Features of Africa Prospects

Unlike many approaches to forecasting based on regression methods of statistical analysis, Africa Prospects does not require statistical independence among the indicators it examines. That is, while conventional statistical models prohibit inclusion of explanatory variables that correlate closely with one another, the *Africa Prospects* approach permits high levels of multicollinearity. In this way the tool is particularly useful for discerning influence patterns within country profiles for which the constituent indicators are more often than not correlated.



Second, the Prospects tool's "fuzzy analysis" of statistical evidence method is noise tolerant and capable of handling a large number of missing values. This approach also facilitates the consideration of a large number of explanatory variables. Thus this approach is particularly useful for exploratory research to discover complex patterns, and provide a linkage between empirical, inductive reasoning and theory informed deduction.

Third, Africa Prospects incorporates in its calculations the target variable's levels or intensity rather than simply its presence or absence. These three capabilities (dealing effectively with missing data and high degrees of correlation among a large number of indicators and the use of an intensity measure for the dependent measure) help establish *Africa Prospects* as a particularly appropriate and useful tool for assessing the structural vulnerability of countries to customized target variables and indices.

Fourth, the tool is designed to run interactively with built-in performance metrics to help users make decisions about selecting the appropriate explanatory variables and training data sets. There is an inverse relationship between 'recall' and 'precision.' Accordingly, multiple measures are typically used to optimize the tool particularly when different performance criteria or policy requirements are invoked.

The formulas used to generate the performance metrics below are as follows:

| | | |
|---|---|---|
| F Score | 64.2% | Harmonic mean of recall and precision: (recall * precision * 2) / (recall + precision) |
| Recall | 71.2% | Higher scores minimize false negatives: TP / (TP + FN) |
| Precision | 58.4% | Higher scores minimize false positives: TP / (TP + FP) |
| Accuracy | 51.6% | Higher scores differentiate the forecasted levels: TP + TN / (TP + TN + FP + FN) |

*Where TP = true positives, FP = false positives, TN = true negative, FN = false negatives*



Fifth, the *Africa Prospects* tool is suitable for use with any time series interval, as well as with virtually any independent and any dependent variable sets. In other words, it is extensible for use at multiple levels of analysis from sub-national to national to regional to continental to global, and across any number of sectors from economic to political to social to environmental. Thus *Africa Prospects* is suitable for customization at the continental and regional levels and for focused analyses within specific sectors.

Ultimately the value of any SVA hinges upon the utility of its results. The use of the *Africa Prospects* tool provides a systematic and transparent method of monitoring the structural vulnerabilities of countries, in other words, to identify countries at risk in the longer term, including and specifically, *prior to the escalation of conflict into violence, state failure or other user-specified custom metric.*

It is important to note that some of the countries identified may not escalate or deteriorate. Still, the reasons for their inclusion as a highly vulnerable country may be traced back to the specific drivers evidenced over time. Likewise, a forecasted low structural vulnerability, especially for a country recently in conflict, may not seem plausible, but again, the historical drivers may be identified in a diagnostic procedure to determine whether the forecasts merit prioritization and increased scrutiny going forward.

The bottom line is that SVA results reflect forecasts of a future that is probabilistic rather than deterministic. All rankings of country vulnerability, in particular, should be used primarily to alert analysts to potentially structurally vulnerable countries that may need to be assessed in depth. Quarterly updates are expected to be conducted to reduce overall error, and refine the selection of explanatory indicators through regular SVAs.

Finally, the default target measure used in *Africa Prospects* is represented by levels of overall conflict based on data published annually since the early 1990s by Heidelberg University in their global "Conflict Barometer" (http://hiik.de/exhibit_09/). This target variable was chosen in part for its low (zero) fatality threshold compared with the higher thresholds (25 and 1,000 battle-related deaths) of the main alternatives, armed conflict and wars respectively. In other words, this measure supports the tracking of situations of contention and hostility, well before escalation into violence, which makes it particularly useful for vulnerability assessments.



COMESA, however, has implemented a custom index (CPPI) discussed above in place of the Conflict Barometer to tailor its results to its regional mandate. Since a modified scaling of the Conflict Barometer is a core component of the CPPI, we include below a discussion of its peace / conflict indicator. More recently, the AU-CEWS implementation of the Africa Prospects tool has adopted an integrated target variable similar to the CPPI. At CEWS a database of high intensity episodes of violence, including ethnic and revolutionary wars, genocides-politicides and irregular power transfers has been integrated into the Conflict Barometer measure to supplement its high intensity ratings.

### Target Variable Specification (Step 1)

To begin any systematic assessment one needs to specify a relevant and appropriate target or dependent variable. The target variable may be defined narrowly such as the level of battle deaths in a conflict or more broadly such as an intensity rating of all elements in a conflict situation. The target variable represents the situation to be avoided with respect to the assessment. Ideally the selection of the target variable should match as closely as possible the mandate and policy interests of the vulnerability assessment. Also, it is important that the time series includes historical data that is acknowledged to be representative of situations to be avoided. For best results at least a decade of annualized data is recommended.

As mentioned above, an ordinal measure of conflict intensity (the Conflict Barometer compiled by the Heidelberg Institute for Conflict Research in Germany) is the default target variable in the *Africa Prospects* tool. Heidelberg defines conflict broadly as

> …the clashing of interests (positional differences) over national values of some duration and magnitude between at least two parties (organized groups, states, groups of states, organizations) that are determined to pursue their interests and achieve their goals.

This definition of conflict includes contestation over territory, secession, decolonization, autonomy, system/ ideology, national power, regional predominance, international power and resources. Until 2002, Heidelberg classified conflict into four levels of intensity from latent conflict to crises to severe crises to war. Since 2003 a fifth intensity has been added between latent conflict and crises; it is called manifest conflict. The *Africa Prospects* tool collapses the highest intensity (war) into severe crises, which has the effect of shifting attention to the lower intensity conflicts where preventing escalation is still feasible.



In both the four- and five-level scales, only the highest intensity level of the year is recorded; in other words, the Conflict Barometer presents peak or maximum intensities. More complete definitions of the four levels are presented below:

1 - **Latent Conflict**: A positional difference over definable values of national meaning is considered to be a latent conflict if demands are articulated by one of the parties and perceived by the other as such. This conflict intensity level is nonviolent.

2 - **Manifest Conflict**: A manifest conflict includes the use of measures that are located in the stage preliminary to violent force. This includes for example verbal pressure, threatening explicitly with violence, or the imposition of economic sanctions. This conflict intensity level is also nonviolent.

3 - **Crisis**: A crisis is a tense situation in which at least one of the parties uses violent force in sporadic incidents. This conflict intensity level is violent.

4 - **Severe Crisis and War:** A conflict is considered to be a severe crisis if violent force is used repeatedly in an organized way. A war is a violent conflict in which violent force is used with certain continuity in an organized and systematic way. The conflict parties exercise extensive measures, depending on the situation. The extent of destruction is massive and of long duration. This conflict intensity level is also violent.

*Africa Prospects* is configured to handle a four-level scale of conflict intensity. The tool then transforms the classifications into low, medium and high intensity ratings based on their likelihood of occurrence. A "2/3rd rule" is used in this transformation such that a combined 67% likelihood is required across contiguous levels to yield a classification; this procedure places the resultant classification at the lower of the two contiguous levels that

achieve a combined likelihood of 67% or more. This 2/3rd rule procedure effectively eliminates classifications that are not likely due to their dispersion across levels.

Recall that the COMWARN implementation of the target variable is anchored around the COMESA Peace and Prosperity Index. This index was developed by COMESA through a series of consultations with area experts and analysts, including representatives from other RECs (EAC, ECOWAS & IGAD) and the AU-CEWS.



The CPPI is comprised of four components as shown below. The data availability refers to the data available from the specified sources for the nineteen COMESA Partner States as of May 2012

| **COMWARN Peace & Prosperity Index (CPPI)** | | | | |
|---|---|---|---|---|
| **An index of health, wealth and economic integration, with peace** | | | | |
| *(version 13.4 revised 4 April 2013, and still current as of Feb. 2020)* | | | | |
| **No.** | **Component** | **Description / Polarity** | **Code / Data Availability** | **Data Source** |
| 1 | **Peace** | Inverse scaling of the peak intensity of the clashing of interests over national values between parties in pursuit of their interests – note that this indicator is applied increasingly as a decrement to the prosperity indicators as conflict increases | Conflict Barometer (100%) | Heidelberg University http://www.hiik.de/en/konfl iktbarometer/index.html |
| 2 | **Health** | Inverse scaling of child mortality rate, under-5 (per 1,000 live births) – note testing of life expectancy to be conducted as an alternative indicator | SH.DYN.MOR T (98%) | World Bank http://data.worldbank.org/d ata-catalog |
| 3 | **Wealth** | GDP per capita, PPP (constant 2005 international $) | NY.GDP.PCAP.PP.KD (94%) | World Bank http://data.worldbank.org/d ata-catalog |
| 4 | **Trade Openness** | Trade (% of GDP) | NE.TRD.GNFS. ZS (92%) | World Bank http://data.worldbank.org/d ata-catalog |

Each of the three CPPI prosperity components was weighted equally (at 33.3% each) for the 2013 analyses. The peace dividend ratios applied by the Conflict Barometer indicators are as follows: peace and latent conflict = full value, manifest conflict = 17% decrement, crisis = 34% decrement, and sever crisis & war = 42% decrement. However, ongoing optimization may suggest a modification of these weights and decrements. Note too that the CPPI was normalized using a global data cut. Further experimentation on continental and regional data cuts to determine if these offer better results is planned.



In sum, the CPPI is a customized measure of progress toward the goal of peace and prosperity in the COMESA region. Although this index is accurately characterized as a work in progress, its development was led by COMESA over two years in multiple workshops with the assistance of numerous regional experts and analysts as well as COMESA staff members. The country-specific historical profiles generated by the index have been subjected to examination by these same professionals, and the very least the current version has been deemed to reasonably reflect "ground truth" even as further refinement is ongoing.

### Explanatory Variables Selection (Step 2)

Together with the specification of the target variable, the vulnerability assessment process requires theoretical guidance for indicator selection. These indicators are used to explain the variance in the target variable and are thus called explanatory variables. A default selection of explanatory variables based on academic studies and as reviewed in various workshops held by AU-CEWS, COMESA and ECOWAS is included with the *Africa Prospects* application. Most notably, a workshop in was held in 2011 where an exhaustive survey and review of candidate indicators was discussed. The current selection of indicators was guided and informed by this discussion in particular. Methodological criteria were also considered in the selection. Perhaps the most salient of these methodological criteria are the overall quality of the input data and parsimony in the selection of variables.

The parsimony criterion places a value on using fewer, more powerful indicators rather than using more indicators with less explanatory power. Of course invoking parsimony in indicator selection may be perceived as an over simplification of the processes that lead to conflict, but when combined with rigorous theoretical guidance, parsimony can effectively illuminate the complex processes underlying the interactions among the variables. Comparability of the data across countries is another methodological criterion especially given the goal of identifying the underlying influences and constraints that operate across different country contexts. Considerations of data availability, measurement and scaling are also important in the selection of indicators. These theoretical and methodological considerations also need to be balanced against pragmatic

considerations such as operational requirements and the institutional context. Especially when it comes to the cost of developing and maintaining custom time series data sets, pragmatism or organizational budget and deadline imperatives often preclude a full exploration of otherwise desirable theoretical questions. Thus, incremental, interactive approaches that balance theory, methodology and pragmatism more often than not rule the day. The imperative then becomes one of performance monitoring through empirical testing. Indeed, it is this balanced (theory-methods-pragmatics), evidence-based approach that guided the selection of illustrative indicators that follows.



Pragmatic considerations often trump theory as the specific objectives and deadlines for use of the tool and the costs of data development may preclude more in-depth analyses. For example, the indicators chosen for cross-national assessment are necessarily comparable across all countries in order to maximize their explanatory power and policy utility. Indicators selected for use in the country-specific or case study, on the other hand, are typically selected for their nuanced or even unique contributions to the particular country context under investigation. The country-specific indicators or variable sets, therefore, are not simply subsets of those used in the cross-national mode. Conversely, cross-national sets are not simply supersets of country-specific sets.

Beyond these methodological and pragmatic guides, there are continental-wide considerations of coordination (with AU-CEWS and with the other RECs) to make the most of the limited funds as well as to enhance the respective expertise of each unit. Accordingly, there is a large pool of explanatory variable data that includes the superset of all variables used by AU-CEWS and the RECs. Such a superset allows for cost effective updating of the data and documentation and synergy in interpreting the results. As of July 2013, this superset comprises some 71 explanatory variables or drivers.

### Compile Indicator Data Sets (Step 3)

The next step in the process of conducting a structural vulnerability assessment is the compilation of the structural data indicators or explanatory variables to be used in the SVA. Recall from the second step outlined above that the optimal use of the *Africa Prospects* tool is informed by a balance of theoretical, methodological and pragmatic considerations, and validated by empirical testing. This indicator compilation effort is critically important as the quality of the forecasts is dependent upon the input data – thus the adage, “garbage in, garbage out.” This effort also needs to be conducted at regular intervals, typically annually given the indicators’ yearly data updates.

Once the compilation of raw data is completed for each of the indicators, substantive and statistical reviews are conducted to assure their appropriate use in the SVA. To facilitate interpretation, to accommodate near continuous data and to mitigate the impact of highly skewed distributions, all drivers with more than ten discrete values are typically transformed into equal density deciles. It is these transformed, decile data that serve as the input to all of the SVA calculations.

### Rank the Indicators & Calculate the SVA Scores (Step 4)



The ranking in this step is typically conducted by area specialists and the results are embedded in weights that are assigned to each of the indicators based on their perceived relevance and importance or impact. These weighted indicators are then most often used in a statistical regression analysis that associates the historical indicator profiles with the incidence of past conflict. This complex step is difficult to reproduce and in particular the human ranking procedure, while expansive and nuanced, lacks the transparency and trace back required of a systematic, reproducible analysis. Thus, this fourth step is replaced by steps #5 through #10 (see below) when Prospects is used.

### Building and Running the Prospects Model (Step 5)

Here we detail the individual sub-steps that comprise the Prospects forecast modeling procedure, preceded with a brief introduction of the model's purpose. The sub-steps are generally conducted numerous times in iteration during the course of an SVA. The basic idea of this SVA (modeling) procedure is to examine the target variablev COMESA Peace and Prosperity Indexand identify the indicator values associated with the levels for each country during a historical (training) period. Based upon this training, the Prospects tool specifies the optimum algorithm that matches country profiles with their associated levels of peace and prosperity from year to year. This algorithm is used with a test set of different (still historical) data to performance for that period. The indicator values are then projected into the future and the optimized algorithm is used to forecast the level of peace and prosperity for each country year.

The main assumption with this modeling approach is that the future is somewhat continuous with the past. Assuming such continuity, one can have confidence that the historical profiles will have similar influences on future levels of peace and prosperity as they did in the recent past. This also implies that the performance metrics calculated in the test set may be extrapolated into the near-term future – at least for several years. Given that the indicator values are annualized, and the reality that structural influences and constraints do not change rapidly, these assumptions are reasonable. More importantly the assumptions are testable and embodied in the performance metrics.

Next we briefly describe each of the sub-steps for the modeling procedure.

a) Optimize the indicator projections and forecast parameters

The indicator data represent profiles of each country's structural attributes that are deemed to be most relevant to enhancing and constraining peace and prosperity. Being structural in character they change slowly from year to year. The first step in the *Africa Prospects* forecast procedure is to project the values from the present into the future in a way that reflects the underlying trend, seasonal and cyclic components. Toward this end the tool uses a double exponential smoothing method because it is better at capturing these non-random trends than the main alternative of using an average value into the future.

The basic idea here is that older observations in a country's profile are less important than more recent observations in their influence on future values. Thus recent observations are given relatively more weight in forecasting than the older observations.

The Prospects tool uses two user specifiable parameters to optimize the indicator projections: a smoothing constant (alpha) that adjusts the speed at which the older observations are dampened or smoothed and a calculation constant (gamma) that sets how far back the smoothing constant looks in its calculations. The two constants operate together to optimize the projections to more accurately reflect the nature of each explanatory variable. The tool has pre-set default values for both constants that work well across a range of indicators. Values closer to 1.0 emphasize more recent values in the calculations that tend to make the projections more responsive whereas values toward 0.0 do the opposite.

In addition to the indicator projection parameter settings, the Prospects tool also has two forecast parameters that users can optimize in light of the empirical characteristics of the data being analyzed. These parameters affect the algorithm used to learn and forecast peace and prosperity based on the indicator profiles.

The first forecast parameter (the learning "window") allows the user to vary the width of the window on the indicator values or levels. Narrow window sizes or bandwidth can generally fit a training set with 100% accuracy. However, if the bandwidth is too narrow the model will not

forecast well out-of-sample. The default value of 0.35 is acceptable for most analyses – the range is from 0.0 to 1.0. As with the projection parameters both forecast parameters are pre-set with defaults that work reasonably well with most data.

The second forecast parameter (the "Frank" parameter) optimizes the forecast for varying degrees of correlation among the indicators. On the Frank parameter, values toward 0.0 are useful for highly correlated variables whereas values towards 1.0 work well with indicators that are not correlated. The default value is set to 0.01. This adjustment factor allows us to deal with multicollinearity among the explanatory variables without dropping potentially relevant indicators from the model that may contribute to the accuracy of the forecasts.



b) Specify a training set

After the model projection and forecast settings have been optimized it is ready to specify the training, test and forecast samples. For this discussion we assume a data set spanning two decades has been compiled on a global, continental or regional set of countries for a target variable as well as multiple indicators deemed relevant to the associated level of peace and prosperity for each country-year. The specification of these three sets is done over the next three sub-steps in the Prospects modeling.

For example, assume the training set is set to 1995 through 2004, a ten-year period for which both target and indicator profile values are known. Once specified the data from this period will be used to train the Prospects algorithm to produce the best match between the indicators associated with higher and lower levels of peace and prosperity.

c) Specify a test set

Before conducting a forecast, it is customary to test the (trained) model on a test period. Let us assume here that the test period extends from 2005 through 2011 (this assumes both target and indicator data are available through 2011). More specifically, we use only the indicator profiles data from this (still historical) test set as we temporarily "hide" from the tool the target data – the levels of peace and prosperity that were associated with these profiles. Of course, since the test set period is in the past, we already know the levels of peace and prosperity experienced in each of the countries, and we hide these values only to test the algorithm trained (optimized) in

the previous sub-step. In this way, we can assess the performance of the optimized algorithm against known data.

Recall that the Prospects forecasting approach is premised on the assumption of continuity from training to test to forecast data sets or time periods. In other words, exogenous factors sometimes disrupt the indicator influences over time, and if so, this assumption of historical continuity is violated. For example, the years 1989-1991 may be viewed as a discontinuity in the previous period of superpower rivalry. In Africa, a relevant example may be the 1994 Rwandan genocide. Likewise, the "9/11" terrorism arguably marked another paradigm shift in international relations – all these watershed events changed the world in ways that to some extent modified the other ongoing influence and constraints of structural indicators on countries.

Relevant to the issue of historical continuity, the example from COMESA's June 2012 SVA workshop is informative. We systematically tested all combinations of training and test sets, measuring their performance after each run. Based on the performance metrics we dropped records prior to 1999 due to their consistently lower performance. In other words, we truncated the training set so that it began in 1999 instead of 1991. This decision was based on performance and an apparent discontinuity in historical reality that generated consistently lower metrics prior to 1999. The performance issue may also have been caused by data problems in the earlier years. In any case, it does not make sense to include these years when the later years offer a much better performance.

On the more recent end of the data series, one could argue that the best predictor is simply the most recent (single) year for a training set, but such a minimalist approach over emphasizes the most recent year to the exclusion of all others, and it subjects the forecast to irrational anomalies in that single year. Thus all of the SVA runs conducted after the June 2012 COMESA workshop utilize a data series that begins with 1999. Specifically, the forecasts are all based on a training set that extends from 1999 through 2010 with a forecast window of 2011 through 2013. All performance metrics for these runs are based on the 1999-2007 training and 2008-2010 test sets.

d) Specify a forecast set or window

Given the training to optimize and the testing to evaluate the algorithm's performance, the next sub-step in *Africa Prospects* modeling is to actually conduct a forecast into the future. To do this, the user specifies a forecast window. For example, and following from the examples above, a user might specify the period 2012 through 2014 as the window for which each year a forecast is to be produced. In general, the shorter this forecast window (i.e. towards a single year) the more accurate the forecast and the longer the window (say a decade or more) the forecast is inherently less accurate given the infinite indeterminacies of the longer-range future.



*Africa Prospects* country vulnerability ratings are based upon the forecasted conflict intensities for each year during the specified forecast window. Countries with forecasts of lower levels of peace and prosperity are considered to be more vulnerable than countries with forecasts of higher levels of peace and prosperity. It is generally desirable to weight short-term forecasts more than longer-term forecasts due to the inherent indeterminacy as one predicts farther into the future. However, the forecasts may be used with any or no weighting in the vulnerability assessments. For example, when using a two year forecast window, it may be determined that the average value of the two years will be used as a basis because of the relatively narrow window, but if using a ten year window, one might elect to use a weighted average with declining weights for each successive year. In this way the indeterminacy of the longer-term forecasts is weighted less.

One major constraint in the running SVAs is data availability for the indicators. For example, in the June 2012 runs, the World Bank's most recent release of their data was dated May, in which the most recent data extended only through 2010. Thus, in practice SVAs are often run overlapping with the recent past such that an SVA conducted in 2012 may use input data through 2010 to retrospectively 2011, part of 2012 and forward into 2013 and beyond using the declining weight scheme mentioned above.

e) Run the specified model

At this point, the model is ready to run. In the discussion above and for the June 2012 SVA, we have specified the following training, test and forecast sets or periods:

| Function | Historical (all data known) | Known Profiles (but target hidden) | Unknown (predict future conflict) |
|---|---|---|---|
| Train | 1999-2007 | | |
| Test | | 2008-2010 | |
| Forecast | | | 2011-2013 |

f) Check the performance metrics, iterating from sub-steps a-d until all performance requirements (accuracy, recall & precision) are met

The previous sub-step completes the actual modeling process. However, the one or more sub-steps process is typically repeated numerous times to refine it. With each run, the user may modify one or more projection or forecast parameters, or change the training, test or forecast sets. The ultimate criterion against which the performance is based is unknowable given that the forecast extends into the future. However, a close approximation can be substituted for this unknowable (in the future) criterion by calculating performance metrics based on all but the most recent year of data as a training set, and comparing these results with the most recent year to establish the best estimate of how well the forecast can be expected to predict the next year. These metrics are calculated automatically by the Prospects tool as part of the modeling procedure.

The performance metric most important to the objective of the COMWARN SVAs is recall or rate of true positives (TP / (TP+FN)). This true positives rate is germane to the objective of identifying vulnerable countries while minimizing false negatives. Similarly, the true negatives rate, calculated as (TN / (TN+FP)) taps into Prospects' ability to identify true negatives while minimizing false positives. These two metrics taken together are the best measures of Prospects performance.

### Comparing the Results (Step 6)

This sub-step compares the results from A) alternative data "cuts" (e.g. global, continental and regional), B)

target measures and C) indicator sets to illuminate shared and unique influences and constraints, iterating from step 1 as needed.

In addition to the optimization of projection and forecast parameters discussed above, three additional aspects to the Prospects model are available for user specification, again to optimize the results to the user's specific mandate and data. The first of these is the data "cut" or cube. Most simply, it represents the scope of the model and generally most modeling begins at the global level and moves progressively to the continental and to the regional as desired and as feasible.



Modeling typically begins at the global level as a means to understand the big picture of the indicators that are operative across all countries. Successive cuts are then made to illuminate the indicators that are more specific to a continent or a region. Feasibility comes into play with the smaller data cuts (i.e. regional) because the matrix is smaller, the density may be lower, and the algorithm performance is improves with larger data sets.

Another aspect that can be refined to suit particular mandates is to change the target measure. For example, the Conflict Barometer used by AU-CEWS is a useful measure of the peak level of overall conflict in a country, but one may want to isolated domestic from cross-border conflict, or focus narrowly on one type of conflict such as insurgency rather than overall conflict. The prospects tool works with any target variable that represents some kind of intensity or level, so these swaps of target variables are helpful in understanding the specific influences that indicators have on various target measures. COMESA has developed a custom target measure that has been discussed above, the CPPI.

A third basic variant that can be introduced in the Prospects model is reflected in the selection of the indicator set or profile. Users may choose different indicators to predict different targets, or use more or less number of indicators to see their marginal effects of their influence. The June 2012 SVAs conducted at the COMESA workshop used a total of 54 explanatory variables. This listing will evolve and be refined with each successive run.

The combinations are interminable when one considers the various settings in the Prospects tool and in the selections of target and indicator data. Such a situation might appear to undermine the goal of accurate forecasts, but the tool's built-in measurement of performance enables the multitude of decisions to be guided

by theory as well as driven by the empirical testing of data.

When the user is satisfied that the forecasts are optimized the modeling is complete. The next steps involve the compilation and interpretation of the specific results.

**Collate the results from each driver's forecasted level of the CPPI (Step 7)**



The forecasted level of the CPPI for each of the explanatory variables or indicators is the Prospects tool primary output – including both common and country-specific drivers. The predicted result for each level of the CPPI is presented as a normalized probability so that it may be compared with the other levels. Normally, decision makers require a high degree of confidence in the results to make informed decisions. Thus the tool invokes a "2/3rds" rule (mentioned above in the target variable section) that combines juxtaposed predictions to determine whether they meet the threshold of 67%. In this way, the final output is presented as a prediction when this rule is met and indeterminate when the rule is not met. For example, a prediction of 25% across each of the four levels of the CPPI would not be useful, and is thus presented as indeterminate. However, a prediction of 87% for a high level of CPPI and 13% for the next level down would be reflected in a high forecast.

The primary output for each of the indicators identifies the common drivers across the four levels of the CPPI. In other words, the influences and constraints embodied in the indicators associates the indicators with a given level of the CPPI.

To determine the overall contribution of each driver to the forecasted discrimination across the four levels of the target variable, the mean sum of the absolute values of the forecasted probabilities across the four levels are subtracted from 0.25 (representing a non-discriminating forecast) are calculated for each driver. A rank ordering of the drivers by this discrimination value offers a single, integrated measure of driver performance that controls for missing data.

This integrated measure enhances the Class Probabilities produced by the forecast, and is used for the identification of the common drivers. After highlighting the entire worksheet, the analyst sorts by the mean measure resulting in a ranking of the common indicators. Once this is completed the forecasts for each of the drivers are sorted one by one. With each sort, the analyst reviews the class distributions in the four adjacent columns (to the right of each indicator) to see how the lowest and highest indicator scores are associated with the four levels of the CPPI.

For example, government legitimacy has been advanced as an important driver, particularly in Africa. In other words, a government that scores high on legitimacy will be associated with higher levels of peace and, presumably, with higher levels of prosperity. Similarly, battle deaths (as recorded in Uppsala University's armed conflict database) are

associated with lower intensity levels of peace in Africa, but less so in the world as a whole. The fact that much of the world's armed conflict has taken place in Africa is one of the reasons behind this finding.

More importantly, what these illustrative common driver results suggest is that the promotion of government legitimacy and the reduction of the use of armed conflict to resolve conflict in Africa are action options to be considered for structural prevention.



By reviewing each of the explanatory variables or structural indicators in this manner, the analyst can identify the common drivers that are associated with higher and lower CPPIs. The top common drivers identified in the June 2012 COMESA workshop included the following: Male 15+ Employed / Pop, Consumer Price Index, Female Labor %, Military Expenditures / GDP and Energy Efficiency. Note, however, *these results on the top common drivers have been superseded in runs done subsequent to the workshop.*

### Identify country-specific indicators and their associated levels of CPPI (Step 8)

The interpretation of common drivers may be complemented by the identification of country-specific drivers that are available in the same worksheets. To determine the country-specific contribution of each driver to the forecast discrimination across the four levels of the target variable, the mean sum of the absolute values of the forecasted probabilities across the four levels are subtracted from 0.25 (a non-discriminating forecast) and calculated for each driver for each forecasted year. The rank ordering of these country-specific drivers is readily viewed by filtering on each country's mean value.

To identify the country-specific drivers, one simply sorts the country-specific drivers listing by the country and examines each of explanatory indicators or drivers that were associated with it. In this procedure, one is identifying the set of drivers that contributed to each specific country instead of using all of the country forecasts combined.

### Evaluate the forecasts, drivers and data "cuts" with area experts to assess the results and enhance their interpretation (Step 9)

At this point in the modeling process, a great deal of care has been taken to select appropriate data, indicators and measures, and to adjust a multitude of settings upon which the results are based. These decisions are manifest in numbers for the most part, but the choices reflect theoretical, empirical, normative and pragmatic concerns. In this light the modeling process is infused with qualitative judgments based on best scientific practice. However, the

process is not complete without the infusion of the same kind of qualitative assessments contributed by area or country specialists.

Although the *Africa Prospects* tool is void of content *per se* – it will work on any suitable matrix of numbers – the numbers do represent measures of indicators deemed to be important as guided by theoretical and domain expertise. Thus as the modeling process is concluded and its results integrated into recommendations, it is not only appropriate but absolutely necessary for a qualitative assessment to be conducted on the results. Ideally, this assessment should be just as rigorous and systematic as the continuous evaluation of performance metrics during the modeling process.



The concept of triangulation is critical to this evaluation / interpretation step in the SVA. In addition to examining both common and country-specific drivers, each of these procedures may be repeated with different data cuts (e.g. global, continental and regional) as well as different target measures (e.g. the Conflict Barometer and the CPPI). It is through this process of triangulation that the breadth of the drivers' influence on the forecast can best be understood. And it is from this base of a comprehensive evaluation and interpretation that empirical results can be derived from which actionable recommendations can be formulated.

### Drawing upon the forecast (#7), drivers (#8), data "cuts" and assessments (#9), formulate actionable recommendations to mitigate the structural vulnerability (Step 10)

The modeling process blends into the formulation of recommendations, but the overall process is really continuous as new indicators may emerge or discontinuities may become evident. At this point, the domain experts clearly need to lead the process. Tools like *Africa Prospects* are useful for systematic and transparent analysis of complex situations, and their results can be verified with empirical tests, but no tool can take results gleaned from general knowledge and formulate case or country specific recommendations that integrate common and idiosyncratic information into an actionable recommendation.

By illuminating the common and country-specific driver forecasts associated with each level of the CPPI, the Prospects tool supports the assessment of actions that can be recommended to prevent or mitigate the structural vulnerabilities associated with each indicator. One aspect of the Prospects results not highlighted in this discussion is the rankings of countries by the levels of CPPI. Such rankings have proven to be sensitive for obvious reasons, but they can also be misleading when the emphasis on relative risk does not associate the various levels of risk with their drivers. After all, it is the values of the drivers that are to be addressed and that need to be incorporated into recommendations for structural prevention and mitigation. Therefore, with the exception of identifying at risk countries for internal use and priority attention, such country rankings are generally ill-advised for communicating

the results of an SVA.

A comprehensive SVA should provide a narrative about ***why*** the analysis arrived at its calculations for each country – an examination of the common and country-specific contributions of each driver helps, but it is not complete. It is incumbent on the analyst to contextualize this empirical information within the framework of the mandate and scope of effort to assure actionable recommendations.



**Concluding Comments**

A major consideration in the interpretation of forecast results and in the formulation of recommendations includes addressing how (not just how much) the explanatory indicators contributed to the forecasted CPPI for any given country. Especially for indicators that appear to influence only a few countries the challenge of understanding and communicating how these drivers operated is imperative. The accompanying materials include a template for summarizing the drivers (see the workshop forecasts "driver summary" tab).

Another set of considerations for periodic SVAs relate to changes in the relative ranking of common and country-specific drivers since the last time an SVA was completed. If notable changes can be documented, how can they be explained in terms of the underlying explanatory indicators? This is where technical staff and country specialists need to work together to refine the ongoing SVAs through their selection of indicators, data and the optimization of the SVA settings.

Ultimately, there is no set template or formula for drafting the narrative for a structural vulnerability assessment. However, the analyst should be guided by clear objectives in drafting this material. The reader of the SVA must receive a concise and informative data-driven presentation of 1) the common and 2) country-specific drivers for each forecasted level of the CPPI and 3) a measure of confidence in these results, as well as 4) a clear linkage of these drivers to the recommended actions and their expected outcomes.

We close by simply reminding the reader that the theoretical and empirical basis for linking the CPPI level to structural attributes has strengthened considerably with advances in research conducted over the past half Century. The *Africa Prospects* tool leverages leading research in this area to support comprehensive structural vulnerability assessments for countries across the globe, continent or region. However, SVAs provide only one tool for the analyst in making judgments about the future. The more proximate, dynamic indicators of behavior and events also need to be monitored and analyzed. Only an integrated approach can hope to yield timely and actionable results that will contribute to the prevention of structural vulnerability and the management and mitigation of situations that have already deteriorated.

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# Appendix:

## VRA Prospects Application Guide

*Current version: 2.2.0.2*

Prospects offers a scientific, testable, and evidence-based tool for vulnerability assessment based upon and in operating in support of the COMESA early warning mandate.

It is designed to assess the vulnerability of countries to conflict escalation based on its profile or set of structural indicators. The tool identifies the underlying influences and constraints embodied in country profiles or sets of structural indicators with respect to the intensity of a country's associated conflict, violence or similar target. The tool's output is accompanied by a transparent trace back to the individual indicators to support what-if analyses.



### Prospects Architecture

The add-in sits on top of the Microsoft Excel API. It has three major modules: FASE, Forecast, and Presentation. The following sections describe the design details of these modules along with the user interface.

### Requirements

- Microsoft Windows Operating System
- Microsoft Office suite – Excel

### Prerequisites

Install the following programs before using Prospects. All the prerequisites are included in the installation package.

- Microsoft Office 2003 Web Components (OWC11) included in the program package
- Visual Studio 2010 Tools for Office Runtime (VSTO40) included in the program package

### Input Data Format

Two data preparation steps are required in order to use Prospects, 1) Compile a time series data set of the selected target variable's (DV) intensity, and 2) Compile a time series data set of candidate indicators in decile associated with the target's intensity. The current design assumes that the input records are yearly data and for countries.

Although Prospects is suitable for use with any time series interval, as well as with virtually any independent and any dependent variable sets, the input data needs to be a specific format as described below;

| Country | Year | CPPI | SFI Security Effectiveness | SFI Security Legitimacy | ... |
|---|---|---|---|---|---|
| Country "x" | 2000 | 1 | 1 | 0 | Decile (0-10) |
| Country "x" | 2001 | 1 | 1 | 0 | |
| Country "x" | 2002 | 1 | 1 | 0 | |
| Country "x" | 2003 | 1 | 1 | 0 | |

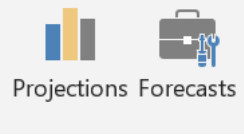
- First column: **Country (text)**
- Second column: **Year (integer)** - the input data should contain the temporal information
- Third column: **CPPI (1-4 range)**
- Fourth column and forward: structural indicators, normalized structural data values **made into decile** (0-10, where 0 is regarded as no data)

### Analysis: Forecasts and Optimization

The approach of Prospects is to retrospectively examine the relationships between various country profiles or patterns of indicators against a target variable (dependent variable) or outcomes with which the profiles are associated.

### Projections and Forecasts

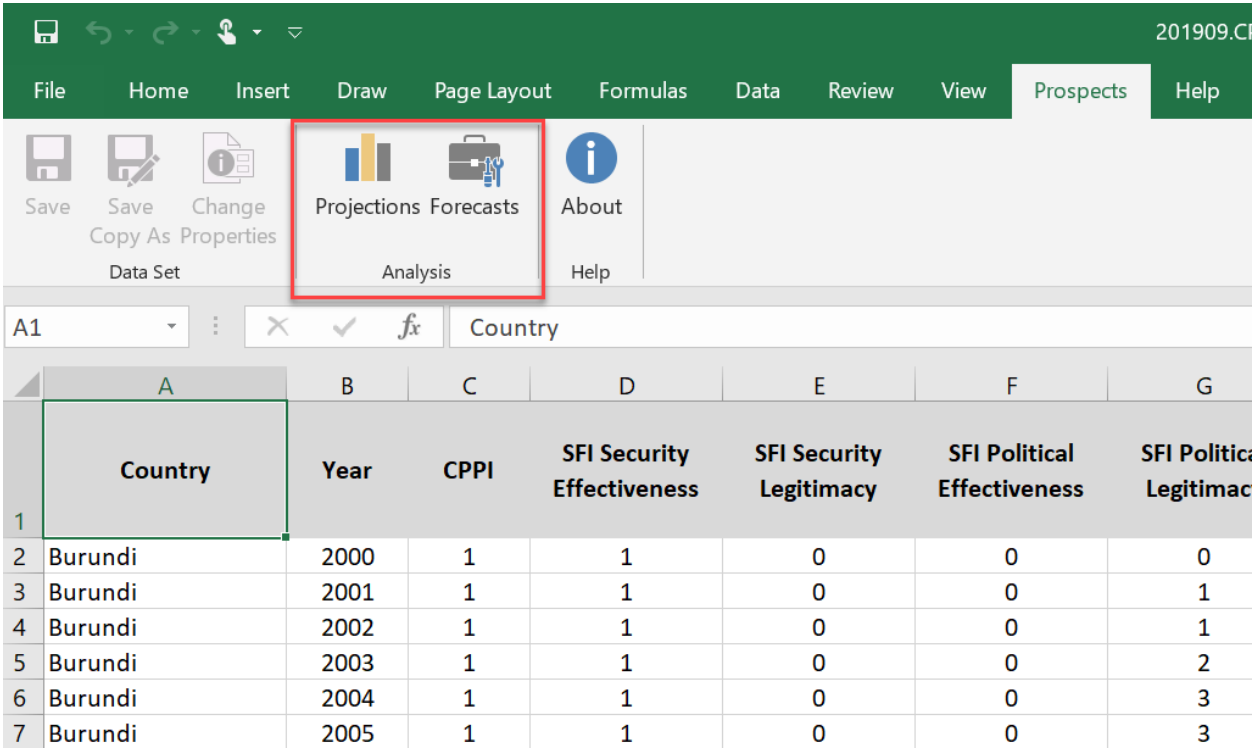
The add-in provides a couple of command buttons within the host Excel application toolbar area for the user to initiate data processing.




Projections or Forecasts take the user to a forecasting window the Prospects add-in. The function is similar except the underlying calculations that focus on either projections or forecasts.

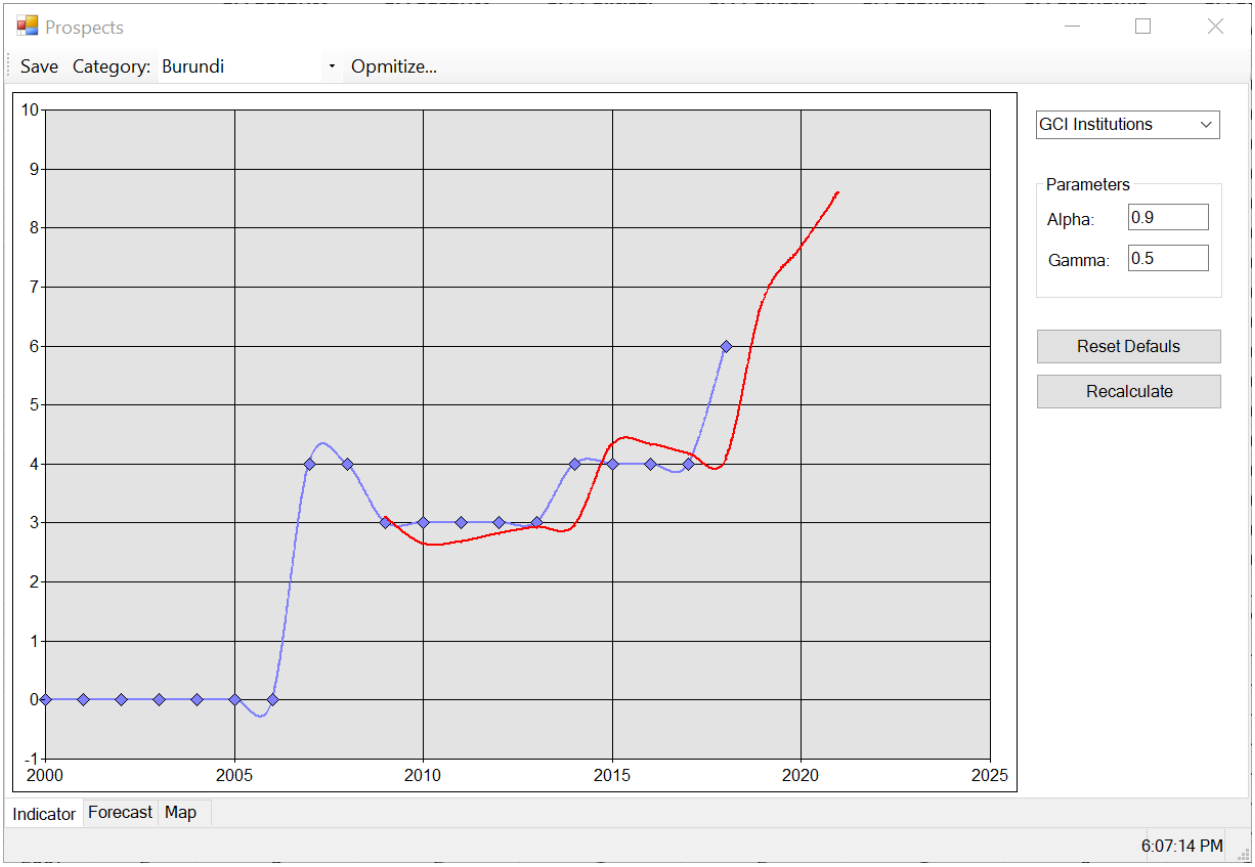
- Window displays one indicator at a time with the future (i.e., forecasted) indicator values projected in red. Any structural data can be used as indicator input.
- Select a country and indicator of interest from the menu at the top of the form.
- To generate a forecast of the target variable (i.e., conflict intensity), click the FASE button located on the left-hand side of the bottom of the application.






| | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|
| 1 | Country | Year | CPPI | SFI Security Effectiveness | SFI Security Legitimacy | SFI Political Effectiveness | SFI Politica Legitimac |
| 2 | Burundi | 2000 | 1 | 1 | 0 | 0 | 0 |
| 3 | Burundi | 2001 | 1 | 1 | 0 | 0 | 1 |
| 4 | Burundi | 2002 | 1 | 1 | 0 | 0 | 1 |
| 5 | Burundi | 2003 | 1 | 1 | 0 | 0 | 2 |
| 6 | Burundi | 2004 | 1 | 1 | 0 | 0 | 3 |
| 7 | Burundi | 2005 | 1 | 1 | 0 | 0 | 3 |

The presentation module collates the data either by time (year) or location (country). When the data is collated by time, the resulting data identified for all countries in the input data are displayed on a map of the world for a specified year. When the data is collated by country, the resulting data are time-series of various structural indicators. The time-series are plotted as graphs with country and indicator selectors.



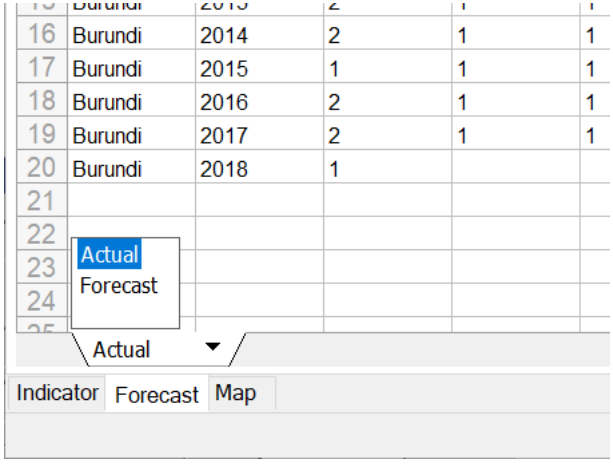

- The forecast window displays one indicator at a time with future (i.e., forecasted) indicator values projected in red. Any structural data can be used as indicator input.

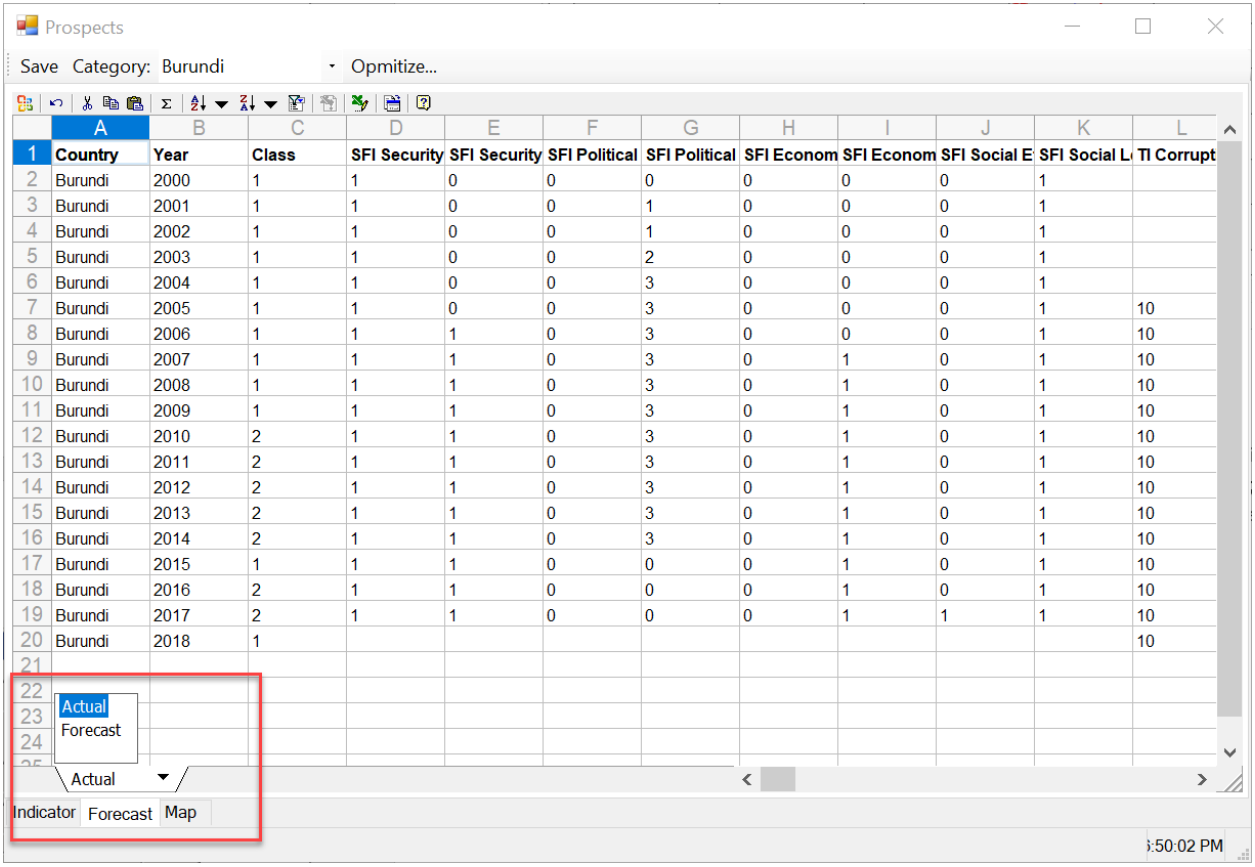
- Select a country and indicator of interest from the menu at the top of the form.

- To generate a forecast of the target variable (i.e., conflict intensity), click the Forecast button located on the left-hand side of the bottom of the application.

### Actual and Forecast

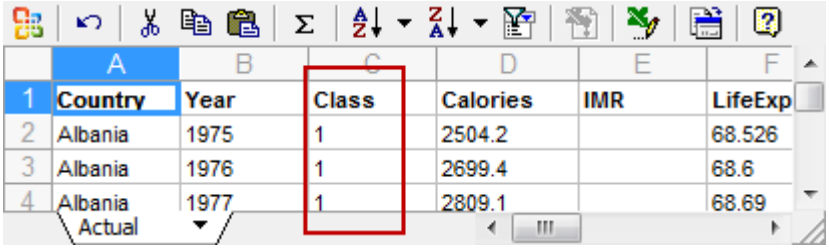
The Forecast tab is the statistical approach used by Prospects to project class values. The Forecast consists of two tables: Actual and Forecast;






| | A | B | C | D | E | F | G | H | I | J | K | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Country | Year | Class | SFI Security | SFI Security | SFI Political | SFI Political | SFI Econom | SFI Econom | SFI Social E | SFI Social L | TI Corrupt |
| 2 | Burundi | 2000 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | |
| 3 | Burundi | 2001 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | |
| 4 | Burundi | 2002 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | |
| 5 | Burundi | 2003 | 1 | 1 | 0 | 0 | 2 | 0 | 0 | 0 | 1 | |
| 6 | Burundi | 2004 | 1 | 1 | 0 | 0 | 3 | 0 | 0 | 0 | 1 | |
| 7 | Burundi | 2005 | 1 | 1 | 0 | 0 | 3 | 0 | 0 | 0 | 1 | 10 |
| 8 | Burundi | 2006 | 1 | 1 | 1 | 0 | 3 | 0 | 0 | 0 | 1 | 10 |
| 9 | Burundi | 2007 | 1 | 1 | 1 | 0 | 3 | 0 | 1 | 0 | 1 | 10 |
| 10 | Burundi | 2008 | 1 | 1 | 1 | 0 | 3 | 0 | 1 | 0 | 1 | 10 |
| 11 | Burundi | 2009 | 1 | 1 | 1 | 0 | 3 | 0 | 1 | 0 | 1 | 10 |
| 12 | Burundi | 2010 | 2 | 1 | 1 | 0 | 3 | 0 | 1 | 0 | 1 | 10 |
| 13 | Burundi | 2011 | 2 | 1 | 1 | 0 | 3 | 0 | 1 | 0 | 1 | 10 |
| 14 | Burundi | 2012 | 2 | 1 | 1 | 0 | 3 | 0 | 1 | 0 | 1 | 10 |
| 15 | Burundi | 2013 | 2 | 1 | 1 | 0 | 3 | 0 | 1 | 0 | 1 | 10 |
| 16 | Burundi | 2014 | 2 | 1 | 1 | 0 | 3 | 0 | 1 | 0 | 1 | 10 |
| 17 | Burundi | 2015 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 10 |
| 18 | Burundi | 2016 | 2 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 10 |
| 19 | Burundi | 2017 | 2 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 10 |
| 20 | Burundi | 2018 | 1 | | | | | | | | | 10 |

- The Actual displays the values input from the workbook (i.e., dataset) and
- The Forecast displays the projected indicator values. From the projected indicator values, the FASE algorithm calculates the class value or projected outcome (i.e., the dependent variable).

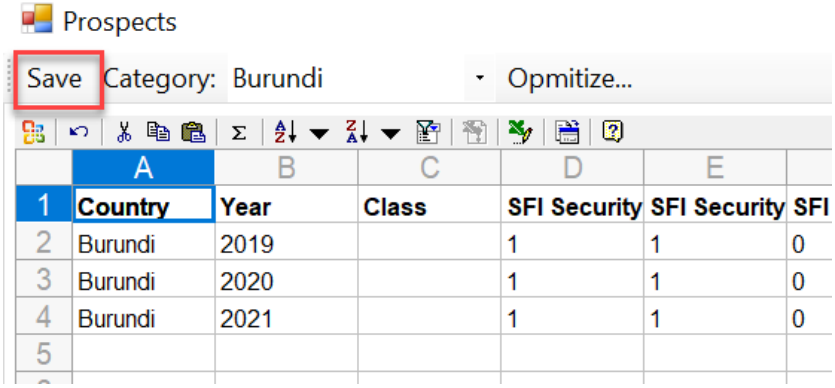


| | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| 1 | Country | Year | Class | Calories | IMR | LifeExp |
| 2 | Albania | 1975 | 1 | 2504.2 | | 68.526 |
| 3 | Albania | 1976 | 1 | 2699.4 | | 68.6 |
| 4 | Albania | 1977 | 1 | 2809.1 | | 68.69 |

Actual



The class number “1” indicates the stability of a country (i.e., the dependent variable.



Prospects

Save Category: Burundi Opmitize...

| | A | B | C | D | E | |
|---|---|---|---|---|---|---|
| 1 | Country | Year | Class | SFI Security | SFI Security | SFI |
| 2 | Burundi | 2019 | | 1 | 1 | 0 |
| 3 | Burundi | 2020 | | 1 | 1 | 0 |
| 4 | Burundi | 2021 | | 1 | 1 | 0 |
| 5 | | | | | | |

The Save button calculates all future classes and saves the values into the worksheet.

## Optimization

This section explains how to train an algorithm that explains the historical target intensities with the candidate indicators

FASE is sufficiently robust that the choice of density estimation has only marginal consequences on the results (Chen 2000). The window size or bandwidth is the more critical choice; a narrow band can fit a training set with 100% accuracy. However, if the bandwidth is too narrow, the model will not forecast well.

Prospects

Save Category: Burundi Opmitize...

| | A | B | C | D | | F | G | H |
|---|---|---|---|---|---|---|---|---|
| 1 | Country | Year | Class | SFI Security | SFI Security | SFI Political | SFI Political | SFI Ecor |
| 2 | Burundi | 2000 | 1 | 1 | 0 | 0 | 0 | 0 |
| 3 | Burundi | 2001 | 1 | 1 | 0 | 0 | 1 | 0 |
| 4 | Burundi | 2002 | 1 | 1 | 0 | 0 | 1 | 0 |
| 5 | Burundi | 2003 | 1 | 1 | 0 | 0 | 2 | 0 |
| 6 | Burundi | 2004 | 1 | 1 | 0 | 0 | 3 | 0 |
| 7 | Burundi | 2005 | 1 | 1 | 0 | 0 | 3 | 0 |
| 8 | Burundi | 2006 | 1 | 1 | 1 | 0 | 3 | 0 |
| 9 | Burundi | 2007 | 1 | 1 | 1 | 0 | 3 | 0 |
| 10 | Burundi | 2008 | 1 | 1 | 1 | 0 | 3 | 0 |
| 11 | Burundi | 2009 | 1 | 1 | 1 | 0 | 3 | 0 |
| 12 | Burundi | 2010 | 2 | 1 | 1 | 0 | 3 | 0 |
| 13 | Burundi | 2011 | 2 | 1 | 1 | 0 | 3 | 0 |

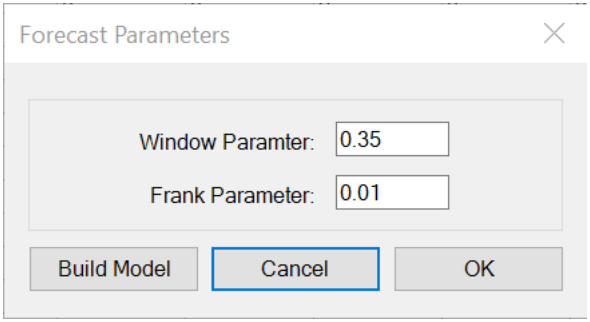
*Frank Parameter*

The Frank Parameter is an adjustment parameter that is set close to 0 when independent variables are highly correlated and close to, but not equal to1 if they are independent (The default is 0.01). This parameter is used to adjust for multicollinearity and thus avoiding the need to drop potentially salient indicators from the model that may contribute toward better predictions. Frank's Rule is applied to the possibility scores for the attributes on each class label. This produces overall likelihood ratios, which, again, are normalized into overall possibility measures for each class label. The overall possibility measure of a class label indicates that class label's likelihood, given a vector of observed (or forecast) attribute values. For ease of interpretation, these overall possibility scores for each class on the dependent variable can be transformed back into probability measures by straightforward normalization. When s is set to very close to 1, the Frank Rule is nearly equivalent to a naïve Bayesian model.

*Window parameter*

The Window parameter refers to the window size or bandwidth. A narrow band can generally fit a training set

with 100% accuracy. However, if the bandwidth is too narrow the model will not forecast well. The default value of 0.35 is acceptable for most analyses.



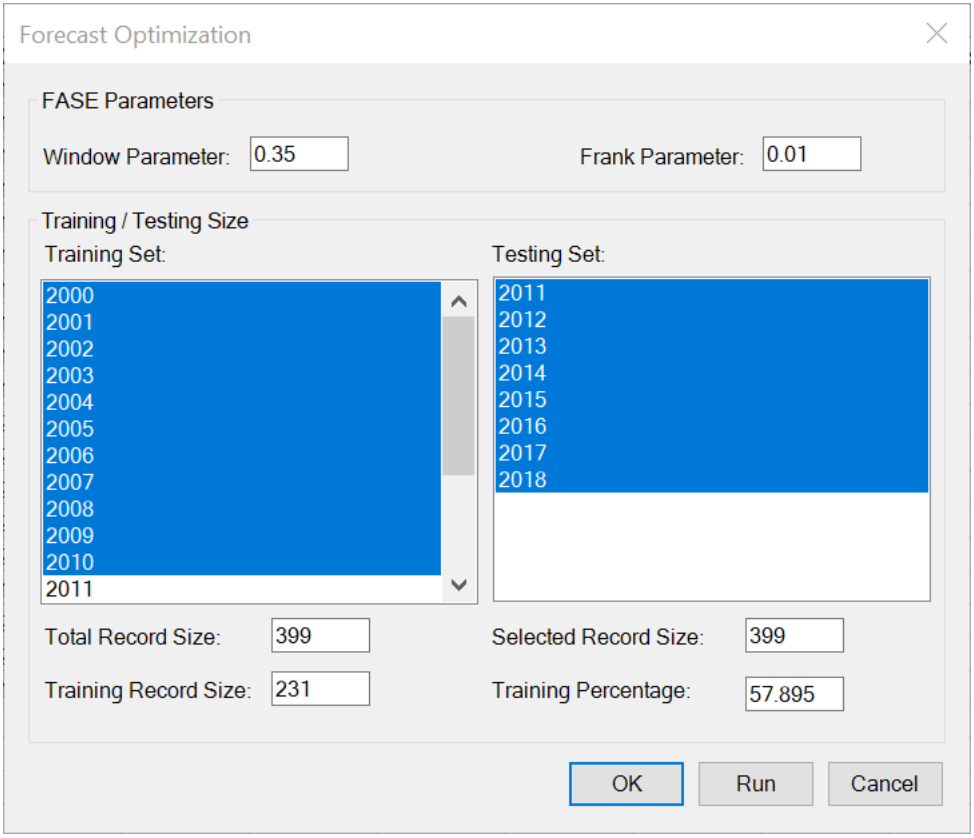



*Alpha and Gamma*

Alpha is the first smoothing constant, used to smooth the observations and Gamma is the second smoothing constant, used to smooth the trend. These smoothing constants must be a value in the range 0 to 1.0. Determining the values to use depends on the data series being modeled. When the smoothing constant is close to 1.0, dampening is quick and more weight is given to recent observations. When the smoothing constant is close to 0, dampening is slow and relatively less weight is given to recent observations.

The default values for the Alpha and Gamma parameters are 0.9 and 0.5, respectively. Once you have selected the parameters, you must click the recalculate button at the bottom of the Forecast Parameters box.

### Training and Testing set Size




A training dataset is a dataset of examples used for learning – it is a set of examples used to fit the parameters. A test dataset is independent of the training dataset which is used to predict the responses, providing an unbiased evaluation of a FASE model fit on the training dataset.

Use Ctrl + Select to define both *Training Set* and *Testing Set* size by year. You can get a following performance metrics when run.

Forecast Optimization Results

| | A | B | C | D | E | F | G | H | I |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Training | 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011 | | | | | | | |
| 2 | Testing | 2012, 2013, 2014, 2015, 2016, 2017, 2018 | | | | | | | |
| 3 | | | | | | | | | |
| 4 | | 1 | 2 | 3 | 4 | Total | | | |
| 5 | Uncertain | 0 | 0 | 0 | 0 | 0 | | | |
| 6 | Low | 0 | 6 | 8 | 4 | 18 | | | |
| 7 | Moderate | 19 | 15 | 21 | 19 | 74 | | | |
| 8 | High | 9 | 11 | 17 | 18 | 55 | | | |
| 9 | Total | 28 | 32 | 46 | 41 | 147 | | | |
| 10 | | | | | | | | | |
| 11 | | Negative | Positive | | | | | | |
| 12 | True | 6 | 71 | | | | | | |
| 13 | False | 31 | 39 | | | | | | |
| 14 | | | | | | | | | |
| 15 | Accuracy | 52.4% | | | | | | | |
| 16 | Recall | 69.6% | | | | | | | |
| 17 | Precision | 64.5% | | | | | | | |
| 18 | F-Score | 67.0% | | | | | | | |
| 19 | | | | | | | | | |
| 20 | | | | | | | | | |
| 21 | | | | | | | | | |

Performance

## Performance Metrics

Prospects provides built-in performance metrics to evaluate user-selectable training and test data sets. The metrics come with multiple measures of accuracy, recall and precision. Given the inverse relationship between recall and precision, multiple measures are typically used to optimize the tool particularly when different performance criteria or policy requirements are invoked.

*Accuracy*

Accuracy is defined as the ratio of correct classifications (True Positive + True Negative) to all classifications (Grand Total). It may be expressed as below and represents the ability of the algorithm to distinguish between countries that do and do not experience a given level of conflict.

$$\frac{True\ Positive + True\ Negative}{Grand\ Total}$$

*Recall*

Recall is defined as the ratio of correct classifications (True Positive) to the observed classification (True Positive + False Negative). It may be expressed as below and represents the ability of the algorithm to classify the conflicts as they were observed.



$$\frac{True\ Positive}{True\ Positive + False\ Negative}$$

*Precision*

Precision is defined as the ratio of correct classifications (True Positive) to correct and incorrect classifications (False Positive). It may be expressed as below and illuminates the algorithm's false positives; specifically, the higher the ratio the lower the false positives.

$$\frac{True\ Positive}{True\ Positive + False\ Positive}$$

*F Score*

The F Score offers a single measure that combines precision and recall.

$$\frac{recall * precision * 2}{recall + precision}$$