

Sprint on Artificial Intelligence and Data Science for Economic Statistics

Shedding light on Economic Activities: GDP Nowcasting with Satellite Data

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Example country grouping based on data availability

SSA Country Groups

Group A	Angola	Nigeria	South Africa	
Group B	Botswana Ghana Madagascar Namibia Tanzania	Cabo Verde Guinea-Bissau Mali Rwanda Uganda	Cameroon Kenya Mauritius Senegal Zambia	Côte d'Ivoire Kenya Lesotho Zambia Mozambique Seychelles
Group C	Benin Chad Equatorial Guinea Gabon Malawi South Sudan	Burkina Faso Comoros Eritrea Gambia, The Niger Togo	Burundi Congo, Dem. Rep. Eswatini Guinea São Tomé and Príncipe Zimbabwe	Central African Rep. Congo, Rep. of Ethiopia Liberia Sierra Leone

Night light and economic activities



2019 IMF SIP



2024 World Bank study



Nitrogen Dioxide (NO2)



NO2 and economic activities



Correlation between Economic Activity and NO2 in Uganda

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Normalized Difference Vegetation Index (NDVI)



Enhanced Vegetation Index (EVI)



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Methodology

Elastic Net with Variable Selection Elastic Net (oneSE) with Variable Selection

Random Forest with Variable Selection

Random Forest (oneSE) with Variable Selection

Random Forest

Random Forest (oneSE) Stochastic Gradient Boosting Trees

Stochastic Gradient Boosting Trees (oneSE)

Support Vector Machine (Linear) (oneSE)

Support Vector Machine (Linear)

Relevance Vector Machine (RBF)

Gaussian Process (Linear)

Gaussian Process (RBF)

Gaussian Process (Polynomial)

Relevance Vector Machine (RBF) (oneSE)

Gaussian Process (Polynomial) (oneSE)

Uganda

Mean Squared Error: 12.329343336901454 Root Mean Squared Error: 3.5113164677797775 mean absolute error: 2.7758220650514454

Actual vs. Predicted GDP GROWTH-RATE

Botswana

Mean Squared Error: 0.1367093841974273 Root Mean Squared Error: 0.3697423213501902 mean absolute error: 0.315364199334613

Somalia

Complementing sparse traditional indicators with Satellite data - AFG

AFG: Quarterly GDP Growth Rate: Actual versus Nowcast (percent, YoY, 2014Q1-2024Q1)

Traditional	Non-traditional data
Goods balance	Nightlight data
Revenue	Nitrogen Dioxide (No2)
Exchange rate (REER)	Precipitation index
Revenue	Vegetation index
Rain	

Mean Squared Error: 2.4486617318810615 Root Mean Squared Error: 1.5648200317867424 mean absolute error: 1.0997525928765894

Feature Importance and Contribution - AFG

Model Explainability – Shapley Decomposition

- Night light appears to be the major driver of prediction.
 When the SHAP values are mostly positive, it leads to higher nowcast.
 And the reverse would lead to lower or negative nowcast.
- The summation of all the features SHAP values minus the intercept (E[f(X)] amounts to the nowcasted value f(X).

Partial Dependency Plots (PDP)

- When the plot is relatively flat, it indicates that the feature has little or no effect on the model's predictions.
- Increased Night light leads to increased predicted outcome. This suggests a positive relationship between the feature and the target variable.
- If the plot shows a non-linear pattern, such as a U-shape or inverted U-shape, it suggests that the relationship between the feature and the target is more complex.

Conclusions and next steps

- Satellite data (indicators) alone combined with machine learning can help shed light on the macro economic activities in different countries, especially the developing countries.
- Combining satellite data with sparse macroeconomic indicators fills the gaps, improves model quality and accuracy.
- The methods can be easily replicated for many countries under similar circumstances for broader use.

IMF | GDP Nowcasting Hub

Thank you!

Email us: BigDataCenter@imf.org

Annex

Time-varying – Shapley Decomposition

Feature Importance 2023-09-01

Feature Importance 2023-12-01

Contribution 2023-09-01

Explainable-Contribution 2023-09-01

Explainable-Contribution 2023-12-01

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All features PDP

PDP for feature rain Number of unique grid points: 10

PDP for feature no2_yoy Number of unique grid points: 10

PDP for feature ndvi_yoy Number of unique grid points:

PDP for feature goods_balance

PDP for feature revenue Number of unique grid points: 10

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