

The Impact of Globalization on Azerbaijan's Economic Growth: A Z-Reasoning Model Based on the KOF Globalization Index

Rasim Aliyev
Department of Management
Azerbaijan State Oil and Industry
University
Baku, Azerbaijan
aliyev.rasim1997@gmail.com

Abstract—This study investigates the impact of globalization on Azerbaijan's GDP per capita growth rate using the KOF Globalization Index, which measures economic, social, and political dimensions of globalization. By employing Fuzzy C-means clustering and Z-reasoning models, the research establishes IF-THEN rules to predict the relationship between globalization indices and economic growth. The findings reveal that while the Z-reasoning model provides insights into specific combinations of globalization indices corresponding to distinct growth outcomes, its predictions show limited alignment with actual data, particularly during periods of economic shocks such as the 2016 and 2020 crude oil price declines. The study underscores the importance of incorporating external factors, like commodity price fluctuations, into future models to better capture the complexities of Azerbaijan's oil-dependent economy. The results highlight the need for diversified economic strategies to mitigate vulnerability to external shocks and promote sustainable growth. This research contributes to the literature by introducing a predictive model based on fuzzy logic as a novel approach to analyzing globalization's impact on economic growth in Azerbaijan.

Keywords—globalization, economic growth, KOF Globalization Index, Fuzzy C-means clustering, Z-reasoning model, Azerbaijan, predictive modeling

I. INTRODUCTION

Globalization's impact on economic growth is complex and widely debated. Some researchers highlight its positive effects, particularly in high- and middle-income countries, where increased trade and investment promote growth [1], [2]. Conversely, others note its potential harm, especially in low-income countries, where it can exacerbate inequality [3].

The measurement of globalization has been a key focus in economic literature, with various indices developed to capture its dimensions. Among them, the KOF Globalization Index stands out for its comprehensive approach, making it the preferred choice for this study. The index measures globalization through an overall score and three sub-indices: economic, social, and political globalization. Dreher's seminal work on the KOF Globalization Index [4] later revisited [5], established a positive correlation between globalization and economic growth.

Studies spanning diverse datasets and regions reaffirm this relationship. For instance, research in Türkiye [6], South Asia [7], Central and Eastern Europe [8], and Vietnam [9] highlighted the positive impact of economic globalization. However, findings vary by context: political globalization sometimes negatively affects lower middle-income countries [10], while social globalization shows mixed results, as seen in Africa [11] and the Turkic states [12].

This study introduces the Z-reasoning model to analyze the impact of economic, social, and political globalization on Azerbaijan's GDP per capita growth rate. The model builds on the findings of a preliminary study [13] that utilized Fuzzy C-means clustering to establish IF-THEN rules between the KOF Globalization Index and Azerbaijan's GDP per capita growth rate. The model incorporates three inputs: economic (KOFecGI), social (KOFSoGI), and political (KOFPoGI) globalization sub-indices. In both models, Azerbaijan's GDP per capita growth rate is the chosen output.

II. PROBLEM STATEMENT

The literature generally indicates a positive relationship between at least one dimension of the KOF Globalization Index and economic growth. While previous research [12] has examined Turkic states, including Azerbaijan, as a group, this relationship has not been studied specifically in the context of Azerbaijan. Additionally, fuzzy logic has never been applied in the literature to analyze this relationship. This study aims to develop a predictive model based on IF-THEN rules to examine the effects of globalization on Azerbaijan's GDP per capita growth rate. The findings will inform policymakers and provide valuable insights into addressing the structural challenges within the Azerbaijani economy. To address this gap in the literature, this study proposes a novel approach using Fuzzy C-means clustering and Z-reasoning models.

III. SOLUTION

A. Fuzzy C-means groundwork

Since the goal is to develop a predictive model based on a set of IF-THEN rules, the first step is to introduce those rules derived from Fuzzy C-means clustering [13]:

IF-THEN Rules:

- Cluster 1: IF KOFecGI ≈ 57.65 & KOFSoGI ≈ 42.70 & KOFPoGI ≈ 45.92 THEN Azerbaijan's GDP per capita growth rate $\approx 12.64\%$
- Cluster 2: IF KOFecGI ≈ 37.62 & KOFSoGI ≈ 33.06 & KOFPoGI ≈ 26.84 THEN Azerbaijan's GDP per capita growth rate $\approx -10.91\%$
- Cluster 3: IF KOFecGI ≈ 66.30 & KOFSoGI ≈ 56.71 & KOFPoGI ≈ 62.68 THEN Azerbaijan's GDP per capita growth rate $\approx 3.32\%$

B. Z-reasoning model

Based on the rules introduced in section A, the Z-reasoning model has been developed. Variable and reliability parameters are given in Fig. 1, Fig. 2, and Fig. 3 for Cluster 1, Cluster 2, and Cluster 3, respectively.

In each figure, the variables are ordered from top to bottom: KOFecGI, KOFSoGI, and KOFPoGI (input variables), followed by Azerbaijan's GDP per capita growth rate (output variable). The degree of belief presented by the expert is located to the right of each variable.

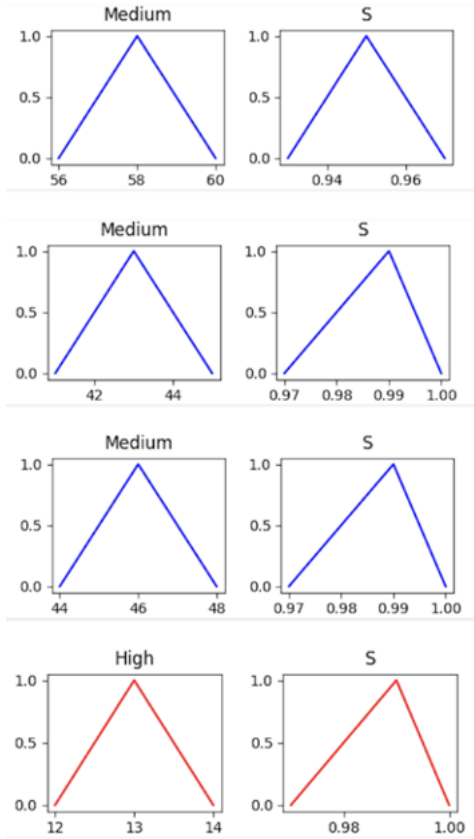


Fig. 1. Cluster 1 – IF-THEN rules

The Fuzzy C-means model built using the years from 1991 to 2013 as training data, therefore some example data from the years 2014-2023 can be used to test the Z-reasoning model. In Table 1 below, the prediction of the Z-reasoning model and its comparison to the actual data is presented.

As seen from Table 1, the output of the model does not vary a lot throughout the years. One main reason is that the globalization values have not changed dramatically. On the other hand, we observe that the output data matches only a few of the real data points. In some examples, as in the years 2016 and 2020, the data have the highest error rate. The model, in the mentioned years, has predicted a positive growth rate while the actual data have been negative. The crude oil prices could explain the drop in the aforementioned years: in January 2016 and April 2020 crude oil prices have seen a dramatic low point¹, which has likely affected the Azerbaijani economy, whose exports are dominated by crude oil.

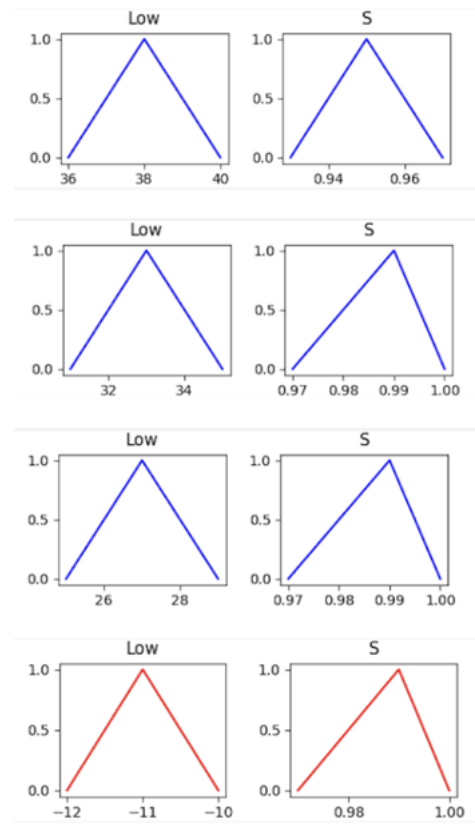


Fig. 2. Cluster 2 – IF-THEN rules

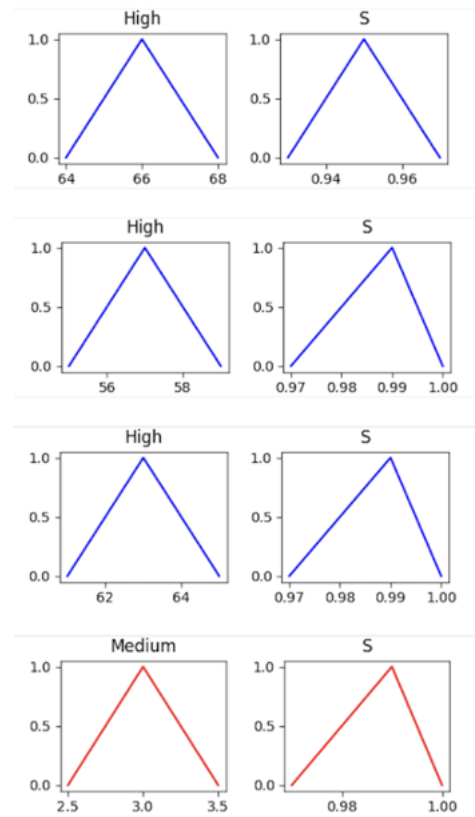


Fig. 3. Cluster 3 – IF-THEN rules

¹ <https://tradingeconomics.com/commodity/crude-oil>

TABLE I. OUTPUT OF THE Z-REASONING MODEL

Year	Input variables	Predicted output data	Actual output data
2014	KOFecGI: [64.0, 66.0, 66.0, 68.0] KOFSoGI: [56.0, 58.0, 58.0, 60.0] KOFPoGI: [58.0, 60.0, 60.0, 62.0]	[2.17, 2.95, 2.95, 3.72]	1.5%
2015	KOFecGI: [65.0, 67.0, 67.0, 69.0] KOFSoGI: [55.0, 57.0, 57.0, 59.0] KOFPoGI: [61.0, 63.0, 63.0, 65.0]	[2.19, 2.96, 2.96, 3.74]	-0.1%
2016	KOFecGI: [68.0, 70.0, 70.0, 72.0] KOFSoGI: [54.0, 56.0, 56.0, 58.0] KOFPoGI: [62.0, 64.0, 64.0, 66.0]	[2.15, 2.93, 2.93, 3.72]	-4.2%
2017	KOFecGI: [69.0, 71.0, 71.0, 73.0] KOFSoGI: [55.0, 57.0, 57.0, 59.0] KOFPoGI: [62.0, 64.0, 64.0, 66.0]	[2.14, 2.94, 2.94, 3.72]	-0.8%
2018	KOFecGI: [69.0, 71.0, 71.0, 73.0] KOFSoGI: [55.0, 57.0, 57.0, 59.0] KOFPoGI: [70.0, 72.0, 72.0, 74.0]	[1.98, 2.76, 2.76, 3.54]	0.6%
2019	KOFecGI: [69.0, 71.0, 71.0, 73.0] KOFSoGI: [55.0, 57.0, 57.0, 59.0] KOFPoGI: [70.0, 72.0, 72.0, 74.0]	[1.98, 2.76, 2.76, 3.54]	1.6%
2020	KOFecGI: [66.0, 68.0, 68.0, 70.0] KOFSoGI: [55.0, 57.0, 57.0, 59.0] KOFPoGI: [70.0, 72.0, 72.0, 74.0]	[1.98, 2.76, 2.76, 3.54]	-5%
2021	KOFecGI: [66.0, 68.0, 68.0, 70.0] KOFSoGI: [54.0, 56.0, 56.0, 58.0] KOFPoGI: [70.0, 72.0, 72.0, 74.0]	[1.98, 2.76, 2.76, 3.54]	5.2%

IV. CONCLUSION

This study explored the relationship between globalization and Azerbaijan's GDP per capita growth rate using the KOF Globalization sub-indices, Fuzzy C-means clustering, and Z-reasoning models. The findings offer valuable insights into how globalization influences Azerbaijan's economic growth.

The Z-reasoning model effectively established on a set of IF-THEN rules that highlight specific combinations of economic, social, and political globalization indices corresponding to distinct growth outcomes. However, the model's predictions showed limited alignment with actual data for the years 2014–2023, revealing discrepancies, particularly during periods of significant economic shocks, such as sharp declines in crude oil prices in 2016 and 2020. This underscores the importance of incorporating external factors, like commodity price fluctuations, into future models to better capture the complexity of Azerbaijan's oil-dependent economy and globalization indices alone are not good predictors of the performance of the Azerbaijani economy.

Despite these limitations, the study contributes to the literature by introducing fuzzy logic as a novel approach to analyzing globalization's impact on economic growth, specifically in the context of Azerbaijan.

For policymakers, the results emphasize the need for diversified economic strategies that mitigate vulnerability to external shocks. Structural refinements in the economy to translate the benefits of globalization into actual economic growth must be evaluated.

Future research should focus on refining the model by incorporating additional variables, such as oil price indices and geopolitical risks, and extending the dataset to improve predictive accuracy. By doing so, the Z-reasoning model could evolve into a more robust tool for economic analysis and policymaking in Azerbaijan and other similar economies.

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