ICAFS – 2018. Thirteenth International Conference on Applications of Fuzzy Systems and Soft Computing, August 27-28, 2018 Warsaw, Poland, **http://www.icafs2018.com/published in the Springer's Series, ISI Proceedings (Web of Scince), SCOPUS**.

Book Series: Advances in Intelligent Systems and Computing Volume: 896 Pages: 223-229 Published: 2019

https://www.springer.com/us/book/9783030041632

Fuzzy Analysis of Macroeconomic Stability

Gorkmaz Imanov[1] Yadulla Hasanli [2] Malahat Murtuzaeva[3]

[1, 3] Control Systems of Azerbaijan National Academy of Science, B.Vahabzadeh str., 9., Baku, Azerbaijan, AZ1102
[2] Scientific Research Institute of Economic Studies under Azerbaijan State University of Economics, Baku, Istiglaliyyat str., 6 (I building), AZ1001

korkmazi2000@gmail.com[1] , malaxat-55@rambler.ru[3], yadulla59@mail.ru[2]

Abstract. In the proposed paper, we investigate macroeconomic stability by using indicators proposed by World Bank. In order to define aggregate index of macroeconomic stability, we use instruments of intuitionistic linguistic fuzzy set.

Keywords: macroeconomic stability, intuitionistic linguistic fuzzy number, aggregate index of macroeconomic stability.

1 Introduction

World Bank describe macroeconomic stability as follows: when the inflation rate is low and predictable, real interest rates are appropriate, the real exchange rate is competitive and predictable, public sector saving rates are compatible with the resource mobilization requirements of the program, and the balance of payments situation is perceived as variable [1].

According to the Maastricht Treaty [2] macroeconomic stability is measured through five variables:

- Low and stable inflation (the Maastricht criteria capped at 3 %);
- Low long-term interest rate (the Maastricht criteria restricted to the range of 9 %);
- Low debt to Gross Domestic Product ratio (the Maastricht criteria capped at 60 % of GDP);
- Low deficit (the Maastricht criteria capped at 3 % of GDP);
- Monetary stability (the Maastricht criteria permitted fluctuation of at most 2.5 %).

In order to calculate level of macroeconomic stability, econometric models are mainly used. By means of linguistic intuitionistic fuzzy number we will calculate aggregate index of macroeconomic stability of Azerbaijan for the period 2010-2016 years [3]. With this purpose, we use following macroeconomic indicators:

1. Growth rate of Gross Domestic Product - **GGD;**
2. Inflation % - **INF**;
3. Interest rate % - **INR**;
4. National debt relative to GDP % - **NAD**;
5. Budget Deficit (% of GDP) - **DEF**;
6. Exchange-rate - **EXR**;
7. Current account balance (% of GDP) **- CAB;**
8. Unemployment rate % - **UNE**;
9. Growth rate of Foreign Investment – **FEI**

Calculating parameters of linguistic intuitionistic fuzzy set

On the basis of K.Atanassov [4] intuitionistic fuzzy set (IFS) J.Wang and H.Li proposed a linguistic intuitionistic fuzzy set [5].

$$A = \{\langle x, [S_{\theta(x)}, \mu_A(x), \nu_A(x)]\rangle | x \in X\} \qquad (1)$$

where $S_{\theta(x)} \in S$, $\mu_A: X \to [0,1]$ and $\nu_A: X \to [0,1]$, that satisfies the condition $\mu_A(x) + \nu_A(x) \leq 1$, $\mu_A(x)$ and $\nu_A(x)$, represent the membership and non-membership degrees, respectively, of elements x to the linguistic value $S_{\theta(x)}$.

For each intuitionistic linguistic set $A = \{\langle x, [S_{\theta(x)}, \mu_A(x), \nu_A(x)]\rangle | x \in X\}$, there is $\pi_A(x) = 1 - \mu_A(x) - \nu_A(x)$, which is called the fuzzy intuitionistic index of the element x of the linguistic variable $S_{\theta(x)}$.

For the intuitionistic linguistic set $A = \{\langle x, [S_{\theta(x)}, \mu_A(x), \nu_A(x)]\rangle | x \in X\}$, $(S_{\theta(x)}, (\mu_A(x), \nu_A(x)))$ triple is called an intuitionistic linguistic fuzzy number.

By using thresholds recommended by Maastricht treatment and Alert Mechanism European Commission [6] for indicators of macroeconomic stability, linguistic variable $S_{\theta(x)}$ is defined:

Linguistic variables of macroeconomic stability indicators **Table 1**

		Unstable-S_0			**Low stable-S_1**		
1	**GGD**	-∞	-1.05	0.1	0	1.25	2.5
2	**INF**	9	9.5	+∞	3	6.25	9.5
3	**NAD**	55	65	+∞	25	42.5	60
4	**INR**	9	9.5	+∞	3.5	6.5	9.5
5	**DEF**	9	9.5	+∞	3.5	6.75	10
6	**EXR**	$-\infty$	-50	-32	-	-11	-10
7	**CAB**	-∞	2	2.5	-3	-2.5	-2
8	**UNE**	11	11.5	+∞	7.5	9.75	12
9	**FDI**	-∞	-3	-2.5	-3	-2.25	-1.5

Continue table 1

		Stable-S_2			**High stable-S_3**		
1	**GGD**	2	2.5	3	2.5	4.25	7
2	**INF**	2.5	3.25	4	0	1.5	3
3	**NAD**	10	20	30	0	7.5	15
4	**INR**	1	2.5	4	-3	0	3
5	**DEF**	1.5	2.75	4	-1.5	0.25	2
6	**EXR**	-11	0	11	-30	-30	-30
7	**CAB**	-4	1	6	5	17.5	30
8	**UNE**	5.5	6.75	8	4	5	6
9	**FDI**	-2	0.65	3.3	3	10	+∞

In order to define membership and non-membership values, Attanassov's function [7] is used:

$$\mu_{\tilde{x}}(x) = \begin{cases} \frac{u_{\tilde{x}}(x-\underline{t})}{t-\underline{t}} & if\ \underline{t} \le x < t \\ u_{\tilde{x}} & if\ x = t \\ \frac{u_{\tilde{x}}(\overline{t}-x)}{\overline{t}-t} & if t < x \le \overline{t} \\ 0 & if\ x < \underline{t}\ or\ x > \overline{t} \end{cases} \quad (2)$$

$$\text{And}\quad \nu_{\tilde{x}}(x) = \begin{cases} \frac{[t-x+w_{\tilde{x}}(x-\underline{t})]}{t-\underline{t}} & if\ \underline{t} \le x < t \\ w_{\tilde{x}} & if\ x = t \\ [x - t + \frac{w_{\tilde{x}}(\overline{t}-x)}{\overline{t}-t} & if\ t < x \le \overline{t} \\ 1 & if\ x < \underline{t}\ or\ x > \overline{t} \end{cases} \quad (3)$$

For calculating membership and non-membership function are used reduction coefficients $(u_{\tilde{x}}, w_{\tilde{x}})$ which take into account accuracy of statistical information. The calculations' results of membership, non-membership degree and linguistic indices are presented in table 2.

IFN of macroeconomic stability indicators **Table 2**

		2010			2011			2012		
		S_θ	μ	ν	S_θ	μ	ν	S_θ	μ	ν
1	**GGD**	S_3	0.8	0.16	S_1	0.07	0.92	S_2	0.36	0.62
2	**INF**	S_1	0.67	0.25	S_1	0.39	0.56	S_3	0.53	0.4
3	**NAD**	S_1	0.78	0.18	S_3	0.024	0.97	S_0	0.9	0.05
4	**INR**	S_3	0.74	0.22	S_3	0.56	0.41	S_3	0.66	0.3
5	**DEF**	S_3	0.53	0.43	S_3	0.68	0.28	S_3	0.83	0.13
6	**EXR**	S_2	0.83	0.08	S_2	0.73	0.19	S_2	0.81	0.09
7	**CAB**	S_2	0.13	0.86	S_3	0.22	0.75	S_3	0.64	0.28
8	**UNE**	S_2	0.34	0.62	S_3	0.51	0.43	S_3	0.24	0.68
9	**FDI**	S_2	0.51	0.42	S_2	0.66	0.25	S_2	0.62	0.31

Continue table 2

		2013			2014			2015			2016		
		S_θ	μ	ν	S_θ	μ	ν	S_θ	μ	ν	S_θ	μ	ν
1	**GGD**	S_3	0.48	0.49	S_2	0.36	0.62	S_1	0.79	0.16	S_0	0.9	0.05
2	**INF**	S_3	0.32	0.64	S_3	0.75	0.04	S_1	0.25	0.72	S_0	0.8	0.1
3	**NAD**	S_0	0.9	0.05	S_0	0.9	0.05	S_0	0.9	0.05	S_3	0.44	0.54
4	**INR**	S_3	0.53	0.44	S_3	0.26	0.72	S_2	0.33	0.45	S_1	0.78	0.17
5	**DEF**	S_3	0.68	0.28	S_3	0.49	0.49	S_3	0.15	0.85	S_3	0.53	0.43
6	**EXR**	S_2	0.84	0.06	S_2	0.85	0.05	S_1	0.17	0.81	S_0	0.85	0.05
7	**CAB**	S_3	0.71	0.2	S_3	0.53	0.40	S_2	0.58	0.35	S_2	0.13	0.86
8	**UNE**	S_3	0.85	0.05	S_3	0.76	0.15	S_3	0.85	0.05	S_3	0.76	0.15
9	**FDI**	S_2	0.67	0.24	S_2	0.65	0.28	S_2	0.71	0.2	S_2	0.7	0.21

Then, the weights of k-th macroeconomic indicators in t-years are obtained by applying following formula [8]:

$$\lambda_k = \frac{(\mu_k + \pi_k\left(\frac{\mu_k}{\nu_k}\right))}{\sum_{k=1}^{l}(\mu_k + \pi_k\left(\frac{\mu_k}{\nu_k}\right)} \qquad (4)$$

and $\sum_{k=1}^{l} \lambda_k = 1$

Weights of macroeconomic indicators **Table 3**

		2010	2011	2012	2013	2014	2015	2016

1	**GGD**	0,15	0,02	0,06	0,08	0,06	0,16	0,15
2	**INF**	0,13	0,10	0,10	0,05	0,16	0,05	0,14
3	**NAD**	0,14	0,01	0,16	0,15	0,16	0,18	0,07
4	**INR**	0,14	0,14	0,12	0,09	0,04	0,08	0,13
5	**DEF**	0,10	0,17	0,15	0,11	0,08	0,03	0,09
6	**EXR**	0,16	0,19	0,15	0,15	0,16	0,03	0,15
7	**CAB**	0,02	0,06	0,12	0,12	0,09	0,12	0,02
8	**UNE**	0,06	0,13	0,04	0,15	0,14	0,18	0,13
9	**FDI**	0,10	0,17	0,11	0,11	0,12	0,15	0,12
		1	1	1	1	1	1	1

In order to calculate Aggregate Index of Macroeconomic Stability (**AIMS**) for each year, intuitionistic linguistic weighted average (**ILWA**) developed by J.Wang and H.Li [5] is used:

$$\boldsymbol{ILWA} = \langle S_{\sum_{k=1}^{t}\lambda_k\theta\left(a_{ij}^{k}\right),}(1-\prod_{k=1}^{t}(1-\mu\left(a_{ij}^{k}\right))^{\lambda_k,}\prod_{k=1}^{t}(\nu\left(a_{ij}^{k}\right))^{\lambda_k}\rangle \qquad (5)$$

The obtained results of calculations are given below:

AIMS (2010) = $\langle S_{2.1}(0.71, 0.22)\rangle$;
AIMS (2011) = $\langle S_{2.4}(0.60, 0.33)\rangle$;
AIMS (2012) = $\langle S_{2.2}(0.74, 0.19)\rangle$;
AIMS (2013) = $\langle S_{2.3}(0.76, 0.14)\rangle$;
AIMS (2014) = $\langle S_{2.2}(0.74, 0.13)\rangle$;
AIMS (2015) = $\langle S_{1.6}(0.75, 0.15)\rangle$;
AIMS (2016) = $\langle S_{1.3}(0.78,0.13)\rangle$;

As it is seen from result of calculation, macroeconomic stability was satisfying in 2010-2014, but in 2015-2016 the level of macroeconomic stability decreased and became low.

As it is seen from the table 2, fluctuation and decrease of GGD from high stability (S3) in 2010 to instability level (S0) in 2016 in dynamics of GGD trio can be mainly associated with price changes in oil sector due to global financial crisis. The change in oil price in the world market had its impact on GDP growth, as oil sector has the large share in GDP of Azerbaijan. Thus, the sharp decline in oil prices since the end of 2014 has led to a decline of the oil volume in GDP and the fact, that a devaluation has not been observed with a noticeable increase in the non-oil sector in a short time, led to instability in GDP.

Fluctuations in inflation can be mainly related to monetary policy governed by Central Bank. As large oil revenues in the country led to increase in the volume of currency reserves. In order to ensure and diversify economic stability in the country, monetary policy regulating inflation rate was implemented. In 2013-2014, as a consequence of implemented policy, high stability in the rate of inflation was provided. In subsequent years, the financial crisis occurred in the world resulted in decline of the national currency in the country. As a result, since long-term economic stability could not be achieved with a regulated monetary policy, the transition to floating exchange rate was started, which led to a change in inflation rate. Thus, fluctuations toward inflation instability were started.

The main factor of economic growth in the country during oil boom, which lasted until 2015, was oil revenues.

Loans are mainly directed to households (44% of credits in 2014), trade (15%), which are mostly non-commercial sectors that depend heavily on oil revenues, and construction (14%). The sum of share of industrial sector in credit portfolio of banks was 10%. Thus, the role of interest rate (INR) in economic growth this period was low and it is wrong to link high economic growth to the interest rate. The fall of interest rate from S3 to S1 in 2015-2016 is associated with decrease of the role of oil factor in this period.

The main reason of transition of national debt to GDP ratio (NAD) from low stability level (S1) in 2010 to high stability level in 2011 is increase in oil production, foreign currency flow to the country and relative increase of national currency (exchange rate- EXR). However, fall to instability level (S0) started from 2012 and continued up to 2016 was linked to decline in oil production on a regular basis. The high level of stability in 2016 can be associated with a downturn in indebtedness and an increase in gas production.

The main reason of high level stability (S3) in budget deficit (DEF) was at the expense of transfers to State Budget by Oil Fund.

Macroeconomic stability level (S2) of exchange rate (EXR) in 2010-2014 turned to the main factor for keeping exchange rate of manat stable during those period. The transition to low stability level (S1) and instability level (S0) can be explained with

the sharp decline of oil price in the world market and decrease in exchange rate of manat.

The rise of current account balance (CAB) from medium stability level (S2) in 2010 to high stability level (S3) in 2011 was related to increase in positive saldo of CAB- from 15.0 blln. U.S. dollars to 17.1 blln. dollars. Due to the substitution of positive saldo with negative one in 2015-2016 (0.2 blln. dollars and 1.4 blln. dollars relatively)related with decline in crude oil price in the world market for more than two times, its stability level decreased from high stability (S3) in 2014 to medium stability (S2) in 2015.

Unemployment rate (UNE) was almost 5% and stayed in high stability level (S3) during 2010-2016. State programs directed to ensuring social-economic development of regions, creating new work places, developing non-oil sector and etc. have a certain role in maintaining high stability level observed in unemployment rate.

The stability level of foreign investment growth rate (*FDI*) remained stable (medium stability level-S2) during 2010-2016 years. It is associated with high level and dynamic growth of foreign direct investments. It was 3.5 blln. dollars in 2010, 4.4 blln. dollars in 2011, 5.3 blln. dollars in 2012, 6.3 blln. dollars in 2013, 7.5 blln. dollars in 2014, 7.5 blln. dollars in 2015 and 7.4 blln. dollars in 2016.

Conclusion

Proposed approach to the analysis of macroeconomic stability give us possibility to define weak and strong sides of macroeconomic process in the country. It enables optimal control over macroeconomic processes. By using the result of investigation, in the future, we can forecast the direction of development of macroeconomic state of the country.

Reference

1. World Bank (1993). The East Asian economic miracle: Economic growth and public policy.
2. Afxentiou P.C., Convergence, the Maastricht criteria and their benefits. The Brown journal of World Affairs, winter/spring 2000, vol. VII, issue 1, 245-254 pp.

3. State Statistical Committee of Azerbaijan Republic (http:\\stat.gov.az).
4. Atanassov,K. Intuitionistic fuzzy sets. *Fuzzy Set System*. 1986, 20, 87-96 pp.
5. Wang, J.Q., Li, H.B. Multi-criteria decision-making method based on aggregation operators for intuitionistic linguistic fuzzy numbers. *Control Decis*. 2010, 25, 1571-1574 pp.
6. Alert Mechanism Report 2018, To the European Parliament, the Council, the European Central bank and the European Economic and Social Committee European Commission, Brussels, 22.11.2017, 48 p.
7. Atanassov, K. Intuitionistic Fuzzy Sets. Springer Physica-Verlag, Heidelberg, 1999.
8. Boran,F.E. , Genc,S., Kurt,M.m Akay,D.: A multi-criteria intuitionistic fuzzy group decision making for supplier with TOPSIS method. Expert Systems with applications, 36(8), 11363-11368, 2009.