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Income Inequality Convergence among Iran's Provinces: Finding New Evidence Using Parametric and Nonparametric Approaches

Arash Hadizadeh*[1]

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Abstract

The income inequality convergence is the second part of neoclassical growth theory. The hypothesis predicts that income inequality among countries/provinces/regions disappear over the time. In this paper, the income inequality convergence is investigated among Iran's provinces over the period 2000–2015. For this purpose, we employed parametric approach (GMM-system estimator of dynamic panel data model), and non-parametric approach (distribution dynamics). The distribution dynamics approach indicated that the Gini index of Iran's provinces were converged toward unique steady state about 0.3, and the results of absolute β convergence hypothesis indicated that the Gini index of Iran's provinces moved halfway to the steady state in about 17 years after 2015.

Keywords: Convergence Hypothesis, Distribution Dynamics, Dynamic Panel Data, Gini Index, Income Inequality.

JEL Classifications: C_{21}, D_{31}, O_{15}, O_{47}.

1. Introduction

The income inequality convergence is defined as the countries' tendency toward equalization over time in terms of per capita income. It is the main prediction of neoclassical growth theory. Bénabou (1996) stated that the first part of the theory is the income per capita convergence, and the second is related to the personal income distribution. The inequality convergence means countries or regions with similar fundamentals and preferences tend to move toward the

1. Department of Economics, Qazvin Branch, Islamic Azad University, Qazvin, Iran (Corresponding Author: hadizadeh@qiau.ac.ir).

same income invariant distribution, with falling (rising) inequality in economies of initially high (low) inequality. Therefore, the convergence analysis in income inequality can be regarded as an extension of the enormous literature that investigates convergence in terms of per capita income. Also, he states other reasons about the inequality convergence importance. The first point is that investigating of the inequality convergence is interesting by itself. Large regional differences in inequality have been documented across countries, with East Asia being the most equal region, followed by Europe, Africa, and Latin America the most unequal areas. The equal income distribution played a significant role in the takeoff of South Korea and East Asia, whereas the high levels of wealth concentration in Philippines and Latin America were a serious impediment to growth. Moreover, even in the developed countries, there seems to exist diverging patterns in inequality dynamics. In particular, US-type inequality is often used by the policymakers in Europe to justify redistribution policy, and minimize wage legislation. As such, testing for income inequality convergence or divergence among regions can offer certain evidence for justifying policy. Moreover, the test for inequality convergence can be used as direct evidence against (or for) theoretical models that predict multiple steady states pioneered by Galor, and Zeira (1993), Banerjee and Newman (1993), and Piketty (1997)[1]

Numerous studies have empirically examined the income distribution convergence. Bénabou (1996) linked the income inequality to growth, and found evidence in support of income inequality convergence among various countries. Ravallion (2001; 2003) suggested that within-country income inequalities had been slowly converging since the 1980s, and inequality was tending to fall in countries with initially high inequality, and was tending to rise in countries with initially low inequality. Bleaney and Nishiyama (2003) claimed that the inequality convergence was significantly slower among the developing countries. Ezcurra and Pascual (2005) used data for European regions provided by the European Community Household Panel, and revealed that there existed a convergence process in regional

1. Although the convergence hypothesis has developed after Solow (1956) in the 1990s, but with regard to the econometric advances in panel data and time series, empirical work continues to test this hypothesis.

inequality levels. Panizza (2001) studied the 48 contiguous states of the US to investigate the inequality convergence, and found evidence on inequality convergence. Likewise, Gomes (2007) worked on 5,507 Brazilian municipalities to investigate income inequality convergence, and suggested that the Brazilian municipalities were converging to an inequality level higher than the year 2000 level. Lin and Huang (2012) found overwhelming evidence in support of convergence in income inequality on a large panel of annual data for the 48 contiguous states in the US over the period of 1916–2005, by implementing the panel LM unit root test allowing for the presence of structural breaks and heterogeneity in the panel. Ho (2015) examined the stochastic convergence of income inequality within 48 contiguous US states over the period 1916–2012 using panel unit root tests. He found that income distribution of the US was state-specific, and did not converge to either the national level or the state-average. Tian et al. (2016) tested the club convergence hypothesis in regional income inequality in China by Phillips and Sul (2007) methodology. The results of paper indicate provincial incomes are converging into two clubs: seven east-coastal provinces (Shanghai, Tianjin, Jiangsu, Zhejiang, Guangdong, Shandong, and Fujian) and Inner Mongolia are converging into a high income club, and the remaining provinces are converging into a low income club. Using a new dataset of regional income inequalities within countries, Lessmann and Seidel (2017) found that approximately 67–70% of all countries experience sigma-convergence. Also, they found an N-shaped relationship between development and regional inequality. Resources, mobility, trade openness, aid, federalism and human capital are also very important. Apergis et al. (2018) tested the club convergence hypothesis in Income Inequality across States in the U.S. They found strong support for convergence through the late 1970s and early 1980s, and then evidence of divergence.

Having gone through the above mentioned empirical works, we found three employed approaches to test for the inequality convergence, namely cross-sectional approach, distribution approach, and time series approach. In the cross-sectional approach, the growth rate of income inequality proxy, as such Gini index is regressed on initial Gini index, and a negative correlation between two variables is interpreted as evidence of the convergence. In the distribution approach, which was pioneered by Quah (1996), it is tested for a unimodal distribution against that of a multimodal distribution using kernel estimation methods. Sigma convergence is another version of the distribution approach, which is calculated by the standard deviation. If the cross-country standard deviation of the Gini index decreases over time, there will exist the sigma convergence. In the time series approach, there were tested for the stochastic properties of Gini index series using univariate/panel unit root/stationary tests, and rejection of the unit root in the Gini index was a finding in favor of inequality convergence.

Following the Islamic revolution of 1979, the Iranian Authorities, from Ayatollah Khomeini, his successor, Ayatollah Khamenei, and all presidents proclaimed equity and social justice as the Revolution's main objective. As noted by Salehi-Isfahani (2009), the picture of inequality in terms of household expenditures, education attainment, and access to health and basic services is a mixed one: success in improving the standard of living and the life quality for the poor, and failure in improving the overall distribution of income. Going through the empirical literature, it is indicated that a number of studies have also questioned income inequality in Iran, e.g. Hadi Zenooz (2005), Noorbakhsh (2005), Salehi-Isfahani (2008 & 2017), Oryoie and Abbasinejad (2017), and Abbasian et al. (2017). But on our best knowledge, none of them tested for inequality convergence within Iran's provinces. In this paper, we are going to test for the inequality convergence among Iran's provinces using the parametric (dynamic panel data model) and non-parametric (distribution dynamics) methods.

The remainder of this paper is organized as follows. Section 2 presents the data used in this paper. Section 3 briefly describes the empirical models, and section 4 presents the empirical results. Section 5 concludes the paper.

2. Data Description

Table 1 presents the average value and growth rate of Gini index over the three sub-periods 2000–2005, 2006–2010, and 2011–2015 in panels A and B. In this Table, the bold numbers are for the provinces with highest average value or growth rate of Gini index, and the underlined bold numbers are for the provinces with lowest average value or growth rate of Gini index. As can be seen, over the period 2000–2005, Khorasan, Yazd, Golestan, Isfahan, and Markazi have highest Gini index, and in contrast, Tehran, Chahar Mahaal and Bakhtiari, Kurdistan, Lorestan, and Khuzestan have lowest Gini index. Over the period, the Gini index grew in Qom, Hormozgan, and Kerman, and in other provinces, it fell. The most reduction in the Gini index occurred in Kermanshah, Ilam, Zanjan, Kurdistan, and Semnan.

Over the period 2006–2010, Hormozgan, Markazi, Sistan and Baluchestan, Khorasan, Kohgiluyeh and Boyer-Ahmad, and Golestan had highest Gini index, and Khuzestan, Bushehr, Ilam, Chahar Mahaal and Bakhtiari, and Kurdistan had lowest Gini index. Over this period, the Gini index reduced among all provinces except in Khuzestan.

Table 1: Average Value and Growth Rate of Gini Index

Province	**Panel A: Average value of Gini index**			**Panel B: Growth rate of Gini index**		
	2000 – 2005	**2006 – 2010**	**2011 – 2015**	**2000 – 2005**	**2006 – 2010**	**2011 – 2015**
Ardabil	0.440	0.398	0.296	-4.019	-22.624	**-14.286**
Isfahan	**0.490**	0.400	**0.338**	-3.393	**-29.521**	**3.030**
Ilam	0.407	**0.359**	**0.282**	**-14.408**	-7.231	**-22.388**
Azerbaijan, East	0.462	0.391	0.319	-5.024	**-24.455**	0.000
Azerbaijan, West	0.419	0.386	0.296	-4.208	-21.040	**-17.742**
Bushehr	0.407	**0.359**	0.300	-7.972	-11.787	-8.955
Tehran	**0.402**	0.391	0.328	-6.082	-14.279	**4.688**
Chahar Mahaal and Bakhtiari	**0.402**	**0.348**	0.307	-13.369	-5.220	**3.125**
Khorasan	**0.507**	**0.436**	0.326	-12.228	-21.581	**1.538**
Khuzestan	**0.313**	**0.361**	0.304	-9.936	**0.265**	-1.587
Zanjan	0.464	0.364	**0.271**	**-14.744**	**-24.094**	-1.852
Semnan	0.436	0.379	0.312	**-18.124**	-9.761	-7.813
Sistan and Baluchestan	0.449	**0.452**	**0.334**	-6.929	-0.166	-12.162
Fars	0.425	0.426	**0.337**	-4.747	-16.250	-5.797
Qazvin	0.413	0.368	0.297	-4.471	-19.883	-1.695
Qom	0.413	0.362	0.323	**31.744**	-16.505	-13.235

Province	Panel A: Average value of Gini index			Panel B: Growth rate of Gini index		
	2000 – 2005	**2006 – 2010**	**2011 – 2015**	**2000 – 2005**	**2006 – 2010**	**2011 – 2015**
Kurdistan	**0.401**	**0.338**	**0.290**	**-16.915**	-21.836	-5.085
Kerman	0.470	0.412	0.322	**3.401**	-21.086	**7.812**
Kermanshah	0.432	0.402	0.305	**-14.213**	-16.361	-10.769
Kohgiluyeh and Boyer-Ahmad	0.459	**0.434**	**0.273**	-8.294	**-24.884**	**1.754**
Golestan	**0.494**	0.432	**0.356**	-7.712	-16.702	0.000
Gilan	0.417	0.394	0.319	-9.415	-21.179	**1.563**
Lorestan	**0.390**	0.395	**0.290**	-7.502	-19.543	**-15.517**
Mazandaran	0.430	0.401	0.296	-0.934	-24.059	-9.677
Markazi	**0.483**	**0.455**	**0.335**	-1.894	-16.173	-9.859
Hormozgan	0.460	**0.506**	0.314	**8.884**	-6.812	**13.793**
Hamadan	0.449	0.399	0.321	-3.817	**-24.242**	-1.538
Yazd	**0.503**	0.416	0.318	-5.941	-23.300	**-14.706**

Note: The bold numbers are for the provinces with highest average value or growth rate of Gini index, and the underlined bold numbers are for the provinces with lowest average value or growth rate of Gini index.

Over the period 2011–2015, Golestan, Isfahan, Fars, Markazi, Sistan and Baluchestan, and Tehran had highest Gini index. The interesting finding is that Tehran had lowest Gini index over the period 2000–2010. But over the final sub-period, the income inequality increased in the province. The Gini index in the provinces including Hormozgan, Kerman, Tehran, Chahar Mahaal and Bakhtiari, Isfahan, Kohgiluyeh and Boyer-Ahmad, Gilan, and Khorasan grew over the period 2011–2015.

In panel A of Figure 1, we present Gini index dynamics for Iran's provinces, and in panel B of Figure 1, we present cross-sectional standard deviation value of Gini index over the period 2000–2015. As can be seen, on the average, the mean of Gini index in the provinces reduced over the 2000–2015, which means that the income moved to equality among provinces, and also the dispersion of Gini index among provinces reduced. This finding indicates that the provinces have converged over the period 2000–2015.

Panel A: Gini index dynamics	**Panel B: Standard deviation value of Gini index**

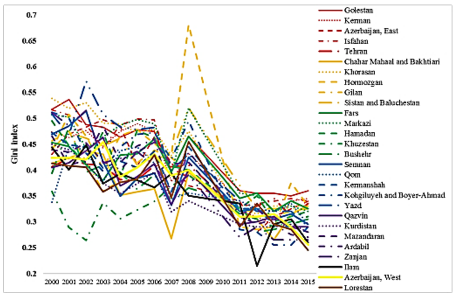

Figure 1: Gini Index Dynamics among Iran's Provinces

3. Methodology

To test the convergence hypothesis among Gini index of Iran's provinces, we used the two parametric and non-parametric approaches. The parametric approach is used due to β-convergence equation:

$$\frac{\ln\left(gini_{i.t}/gini_{i.t-4}\right)}{3} = \alpha + \beta\ln(gini_{i.t-4}) + \gamma_1 inf_{i.t} + \gamma_2 inf_{i.t}^2 + \gamma_3\ln(GDPP_{i.t}) + \gamma_4(\ln(GDPP_{i.t}))^2 + \gamma_5\ln(pop_{i.t}) + \varepsilon_{i.t} \quad (1)$$

In Equation 1, $gini_t$ is Gini index at time t and province i. To construct the dataset to estimate the Equation 1, we consider sub-periods 4 years, i.e., 2000–2003, 2004–2007, 2008–2011, and 2012–2015. Hence $\frac{\ln\left(gini_{i.t}/gini_{i.t-4}\right)}{3}$ is the average yearly growth rate of Gini index over any sub-period. $\ln(gini_{i.t-4})$ is Gini index (in logs form) in the initial year of any sub-period. If the coefficient β is negative and significant statistically, the Gini index convergence among Iran's provinces will not be rejected. According to the availability of provinces' dataset of macroeconomic variables, we included three explanatory variables, namely inflation (inf), real GDP per capita (in logs form) (GDPP), and population (in logs form) (pop). Also, according to Kuznets hypothesis, we included squares of real GDP per capita. We expect γ_3 be positive, and γ_4 be negative. It indicates that in the first stage of economic development, the economic growth may lead to an increase in the income inequality, and when the development process continues, the economic growth may lead to a decrease in the income inequality. We, also, include the square of inflation rate, and expect coefficients γ_1 be negative, and γ_2 be positive. It means that the increasing the inflation rates under a threshold rate helps to the expansion of economic activities, and thus, may reduce the income inequality. But if it is higher than the threshold level, it will harm for the economic development, and will increase the income inequality. Finally, we expect a positive relationship between the population and the Gini index.

As noted by Caselli et al. (1996), the Equation 1 has a dynamic structure, and there is possibility omitted or endogenous variables when we use the fixed effect or random effects estimators. He states that the best estimator is the GMM procedure. This procedure requires that we take the first difference of all the explanatory variables, and use them as instruments. However, Bond et al. (1995) note that "When the individual series have near unit root properties, the instruments available for the equations in first difference are likely to be weak … and can be subject to serious finite sample biases". To solve the problem, Blundell and Bond (1998) propose a GMM-system estimator which combines the regression in differences with the regression in levels. The result of their simulation demonstrated that the GMM-System estimator became more efficient as the coefficient on the lagged dependent variable approached unity. The GMM estimator's consistency depends on the instruments validity as well as the serial correlation absence. To determine the instruments validity, we applied the Sargan test; to investigate the possibility of the first and second order serial correlation of the differenced residuals, we used m_j statistic, where j is the autocorrelation order. This statistic has an asymptotically normal distribution N(0,1).

The nonparametric approach or distribution dynamics approach to test the convergence hypothesis was suggested by Quah (1996). It models intra-distribution dynamics of Gini index as a first-order Markov process. In fact, it assumes that density distribution ψ_t has evolved time-invariant and Markovian in accordance with the following equation:

$$\psi_{t+\tau} = M\psi_t \tag{2}$$

where M is an operator that maps the transition of Gini index distribution between the period t and t+h. If we model the density distribution ψ_t as discrete, the operator M will be called Markov's transition matrices, and if we model it as continuous, the operator M will be called stochastic kernel.

In order to describe the distribution dynamics approach, three benchmark stochastic kernel contours are presented by Figure 2. The vertical axis measures the time t of Gini index distribution, and the horizontal one measures the time t+h of Gini index distribution. If the stochastic kernel contours of Gini index for our sample are as panel A of Figure 2, there will not be any movement across countries for equalization in Gini index. If the stochastic kernel contours of Gini index are as Panel B of Figure 2—in other words, the stochastic kernel contours of Gini index have counterclockwise movement, over time, the Gini index of countries will move toward equalization. But if the stochastic kernel contours of Gini index has clockwise movement around the 45° line (as panel C of Figure 2), the countries are diverging.

Panel A: **The probability mass moves along the 45° line.**	**Panel B:** **The probability mass moves counterclockwise around the 45° line.**	**Panel C:** **The probability mass moves clockwise around the 45° line.**

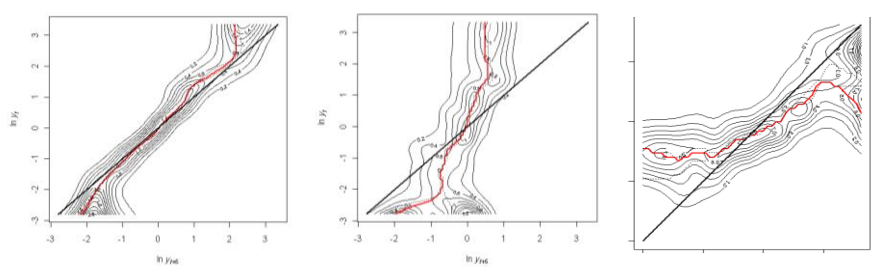

Figure 2: Benchmark Stochastic Kernel Contour Plots

Note: The red lines are the estimated median value of y at t + h conditional on their value at time t.

4. Estimation Results

4.1 Parametric Model (Dynamic Panel Data)

We present the GMM-system estimator results of Equation 1 in Table 2. To estimate the Equation 1, first we test the absolute β convergence hypothesis. To the end, we regress the average growth rate of Gini index to the initial Gini index ($\ln(gini_{i.t-4})$), and drop other explanatory variable. In this way, we determine that how quickly the provinces converge towards the same steady state. Results are prepared in the panel A of Table 2. Regarding the specification tests, the m_1 and m_2 serial correlation test and Sargan test validate the instruments choice in all four cases. Results indicate that the coefficient $\ln(gini_{i.t-4})$ i.e. (β) is negative, equals -0.176, and is statistically significant at 1 percent, and thus the absolute β convergence hypothesis is not rejected among Iran provinces. According to β convergence equation which extracts from neoclassical growth model, the absolute value of β equals $(1-e^{-4\lambda})$, and thus the halfway to same steady state equals $\frac{\ln(0.5)}{\lambda}$[1]. According to absolute β convergence estimation results in panel A of Table 2, the Gini index of Iran's provinces move halfway to the same steady state in about 17 years after 2015.

In panel B of Table 2, we prepared the conditional β convergence results. Accordingly, the Gini index of each province is converged toward its specific steady state. Regarding the specification tests, the m_1 and m_2 serial correlation test and Sargan test validate the instruments choice in all four cases. Results indicate that all variables have the expected signs. The coefficient $\ln(gini_{i.t-4})$ (β) is negative, equals -0.254, and is significant at 1 percent. Results indicate that the β-convergence hypothesis among Gini index of Iran's provinces is not rejected at 1 percent. β equals -0.254, which indicates that the provinces move halfway to their specific steady state in about 9.5 years. As seen, the conditional convergence's speed is more than absolute convergence (9.5 years against 17 years).

1. For more details, see Mankiw et al., 1992: 423.

Table 2: Estimation Results of Equation 1 Using GMM-System

Control variables	Panel A: Absolute convergence			Panel B: Conditional convergence		
	Coefficient	**Standard error**	**P-value**	**Coefficient**	**Standard error**	**P-value**
$\ln(gini_{i.t-4})$	-0.176	0.004	0.000	-0.254	0.046	0.000
$inf_{i.t}$				-0.093	0.022	0.000
$inf_{i.t}^2$				0.002	0.001	0.000
$\ln(GDPP_{i.t})$				0.187	0.659	0.776
$\ln(GDPP_{i.t}^2)$				-0.005	0.023	0.842
$\ln(pop_{i.t})$				0.104	0.039	0.008
Constant	-0.201	0.004	0.000	-2.624	4.471	0.557
Specification tests						
Sargan test (P-value)	27.029 (0.255)			10.563 (0.480)		
m_1 (P-value)	-1.863 (0.062)			-2.177 (0.029)		
m_2 (P-value)	-0.992 (0.321)			-0.164 (0.869)		

Notes:
1) Dependent variable: Growth rate of Gini index.
2) Cross-province panel data consisting of non-overlapping 4-year averages spanning 2000–2015.
3) Estimation method: GMM-SYS estimator (Arellano and Bover, 1995; Blundell and Bond, 1998).
4) In all regressions, we treat right-hand variables as endogenous in all regressions and instrument them using lags t-2 and t-3 in the first-differenced equation, and lags t-1 and t-3 in the level equation.

The coefficient γ_1 equals -0.093, γ_2 equals 0.002, and both are statistically significant at 1 percent. These findings confirm our hypothesis about reaction income inequality to inflation rate over different stage of development. The coefficients of real GDP per capita and its square have expected signs. But none of them is statistically significant at 10 percent. Population (in logs form) has a positive effect on Gini index growth rate, and its coefficient equals 0.104 and is statistically significant at 1 percent. Results indicated that if population rate increased as 10 percent in the provinces, the growth rate of Gini index increased as 1.04 point.

4.2 Distribution Dynamics Result

To analyze the distribution dynamics of Gini index, we used the Quah (1996) stochastic kernel. In this approach, the evaluation of Gini index, as a Markov process, measures the transitions in the cross province from one Gini index class to another, over h-year transitions[1]. We analyzed the dynamic stochastic kernel for 4-year transitions (h=4), and planned it in panel A of Figure 3. We further plotted its contour, and the estimated median value of Gini index (red line) at time t+4 conditional on the value at time t in panel B. As can be seen in panel B, there are three peaks in the dynamic stochastic kernel, but only one of them is equilibrium state.

The contour plot displaying the stochastic kernel has a counter-clockwise movement around the 45° line, especially in two end tiles. Also, the estimated median value of Gini index (red line) crossed the 45° line in one point that we named A. It should be noted that point A has a stable equilibrium. According to counter-clockwise movement of contour plot, we expected that the provinces with Gini index less than about 0.3, likely experience upward convergence and move toward point A. The provinces with Gini index greater than 0.3 experience downward convergence, and move toward point A[2].

Panel A: Stochastic kernel	Panel B: Contour plot of stochastic kernel

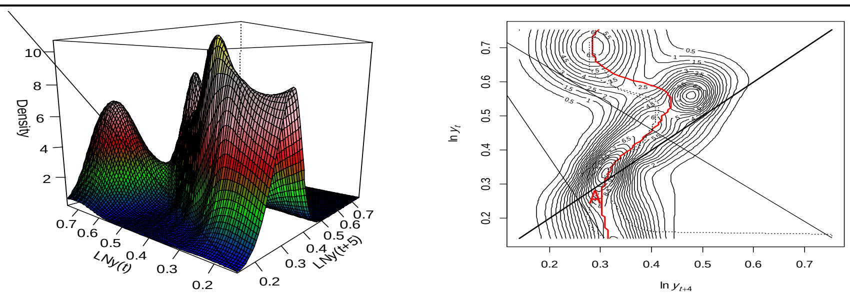

Figure 3: Distribution Dynamics of Gini Index among Iran’s Province

5. Conclusion

This paper tests the convergence hypothesis among Iran’s provinces over the period 2000–2015, using absolute and conditional β convergence equations and distributional dynamics approach. To estimate the absolute and conditional β convergence equations, we use the dynamic panel data model (GMM-system estimator), and to

1. For more details on distribution dynamics and its application in convergence, see Epstein et al. (2003).

2. As noted by an anonymous referee, we re-tested the distribution dynamics of GINI index after control for explanatory variables in equation (1) and found the results remain almost fixed. The results are prepared upon request

analyze the distribution dynamics of Gini index, we use Quah (1996) stochastic kernel.

The estimation results of absolute and conditional β convergence equations indicate that the absolute and conditional β convergence hypothesis is not rejected at 1 percent, and the absolute convergence speed is about 1.8 times the conditional convergence. Other results, using parametric approach, indicate that the inflation and population have positive effect on income inequality, and the inflation rate effect is nonlinear.

Distribution dynamics of Gini index indicate that there is a steady state among Iran's provinces, and its value is about 0.3.

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