E C O N O M I C S B U L L E T I N

A new empirical regularity in world income distribution dynamics, 1960−2001

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Abstract

The aim of this paper is to present a new empirical regularity in world income distribution using cross−country panel data, 1960−2001. It shows the fact that the real cross−country GDP per capita is significantly approximated to a geometric sequence, and that its common ratio is decreasing consistently during the period. It seems rather natural to believe that inequality is not necessarily permanent in our economy.

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1. Introduction

Ever since the sustained growth of productivity levels and living standards have been realized, the world's income inequality has inevitably become a controversial subject. While some economists have been devoted to build economic growth models that try to explain cross-country growth differences, other economists have been eager to find statistical evidence showing whether the degree of income differences is increasing. Despite the research, it is still controversial as to whether there is a convergence towards the richer countries by the poorer countries. Although statistically stylized facts are sought after by macro economists, very few are agreed upon.

The aim of this paper is to show a new empirical regularity in world income distribution favoring the view of a tendency towards world's income equality. We find an extremely robust law that cross-country GDP per capita approximately follows a geometric sequence, and its common ratio is consistently diminishing for the period between 1960-2001. In addition, two indexes are examined in this paper. Firstly, we show that a coefficient of variation is stable during the period. Secondly, we show that what the rich/poor type index implies differs depending on its definition. These facts indicate that cross-country inequality is not necessarily to be a permanent feature in our economy.

This paper is organized as follows. Statistical evidence examined by cross-country panel data 1960-2001 is presented in Section 2. Discussion on the world's income distribution is presented in accordance to our findings, together with a brief overview of related research, in section 3. Section 4 gives a conclusion.

2. Empirical Evidence

In this section, a new empirical regularity in cross-country per capita GDP is shown. Figure 1 provides a good starting-point. The thick line describes the real cross-country GDP per capita in 1976 ordered by size, where the data for cross-country GDP has been collected from the World Development Indicators 2003 on CD-ROM. The broken line shows a geometrical sequence whose initial term is 211.7 (same as the GDP per capita for 6th smallest country) and whose common ratio is 1.04341. Note how the cross-country real GDP per capita is significantly approximated to a geometric sequence whose initial term and common ratio are appropriately selected .

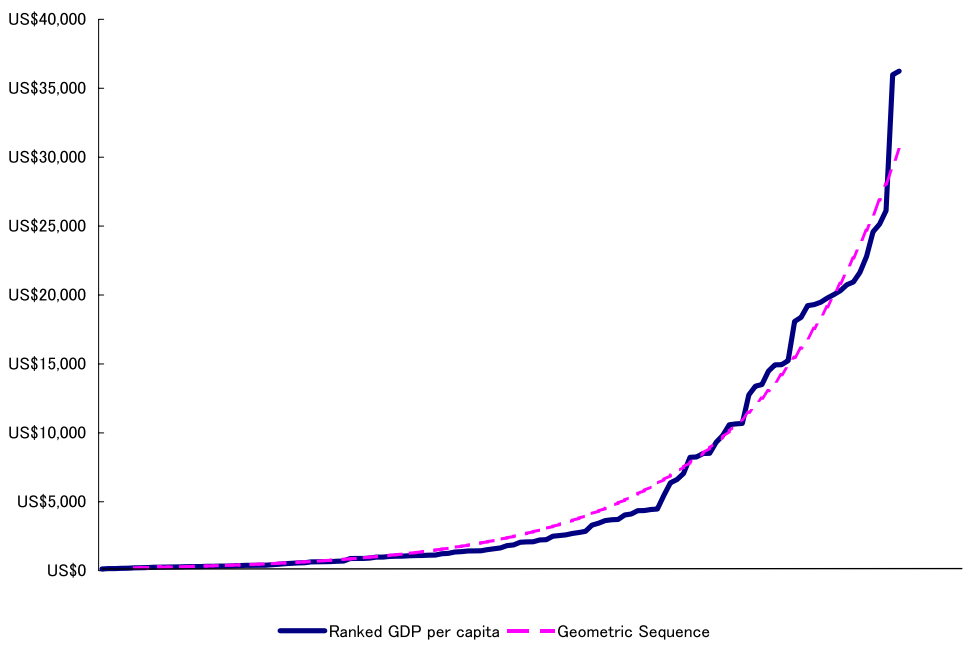

Figure1. Ranked real cross-country GDP per capita(1976) and a geometric sequence

Our finding is that the real cross-country GDP per capita ordered by size is significantly approximated to a geometric sequence for all the period between 1960-2001. Since the number of a term is linear to the logarithm of the term in a geometric sequence[1], we have regressed the Log GDP per capita on its rank (defined as the order from the poorest country to the richest country.) using OLS method for each period during 1960-2001. Table 1 summarizes this result. There are two notable features that appear in the table. Firstly, during 1960-2001, the lines are of excellent fit (In fact, the adjusted R^2 is larger than 0.9748.). Secondly, it shows us that the coefficient of regression is consistently decreasing during the period, which imply the

[1]Since a geometric sequence is described as ar^{n-1} (a: initial term, r: common ratio, n: the number of term), its logarithm is described as $\alpha+\beta n$, where $\alpha = \log a/r$ and $\beta = \log r$.

decrease of the common ratio for the corresponding geometric sequence. This allows us to guess that the world income inequality may be diminishing[2].

Year	Coeff.	Adj.R2	obs.	Year	Coeff.	Adj.R2	obs.
1960	0.048 (6.45E-04)	0.982	101	1981	0.036 (3.10E-04)	0.989	145
1961	0.048 (6.77E-04)	0.980	102	1982	0.035 (2.96E-04)	0.990	148
1962	0.049 (7.77E-04)	0.975	103	1983	0.035 (3.09E-04)	0.989	148
1963	0.049 (7.32E-04)	0.978	103	1984	0.035 (2.75E-04)	0.991	151
1964	0.050 (7.23E-04)	0.979	103	1985	0.034 (2.96E-04)	0.989	154
1965	0.047 (6.02E-04)	0.983	109	1986	0.034 (2.91E-04)	0.989	157
1966	0.047 (5.85E-04)	0.983	110	1987	0.032 (2.95E-04)	0.987	163
1967	0.046 (5.51E-04)	0.984	112	1988	0.032 (2.93E-04)	0.987	165
1968	0.046 (5.26E-04)	0.986	113	1989	0.032 (3.02E-04)	0.985	166
1969	0.046 (5.21E-04)	0.986	113	1990	0.030 (2.72E-04)	0.986	174
1970	0.044 (5.26E-04)	0.984	117	1991	0.030 (2.79E-04)	0.986	174
1971	0.044 (5.01E-04)	0.985	118	1992	0.030 (2.76E-04)	0.986	177
1972	0.045 (4.50E-04)	0.988	118	1993	0.031 (2.80E-04)	0.986	177
1973	0.045 (4.28E-04)	0.990	120	1994	0.031 (2.91E-04)	0.984	179
1974	0.045 (3.92E-04)	0.991	121	1995	0.030 (2.91E-04)	0.984	180
1975	0.043 (3.44E-04)	0.992	123	1996	0.030 (2.87E-04)	0.984	180
1976	0.043 (3.31E-04)	0.993	123	1997	0.030 (2.70E-04)	0.986	180
1977	0.041 (3.27E-04)	0.992	127	1998	0.030 (2.69E-04)	0.986	180
1978	0.041 (3.24E-04)	0.992	128	1999	0.031 (2.88E-04)	0.985	178
1979	0.041 (3.25E-04)	0.992	129	2000	0.031 (2.93E-04)	0.984	178
1980	0.037 (3.11E-04)	0.991	140	2001	0.031 (3.48E-04)	0.979	174

Table 1: Results of the regression (Stanadard errors are in the parenthesis).

The advantage of our findings is its robustness, adapted to almost all countries during 1960-2001. Guilmi, Gaffeo, and Gallegati(2003) is the first study that has paid attention to the relation between GDP per capita and its rank order, where they have shown that the world income distribution between the 30th and the 85th percentiles approximately follows a Pareto distribution. Their strategy is to seek a range in which the Log GDP and

[2]However, we can also notice that the coefficient of regression is stable for the recent decade.

the logarithm of its rank show linear property, i.e., the property known as Zipf's rule[3]. However, we point out that the Log GDP against its rank (instead of Log rank) displays a more significant relation: It clearly fits a line even for the richest and poorest country groups. Like the stylized facts in Kaldor(1963) which provoked a great deal of work on economic growth[4], we believe that the facts shown in this paper will also provide a new view enabling us to understand further the world income distribution.

3. Discussion

There are plenty of studies focusing on income differences between countries, and whose goals are to capture a descriptive image of how the world income distribution might look now, or in the future. Some studies empirically examine whether there are evidences for convergence of poor countries toward rich countries. Other studies seek statistical evidences that give us the key to understand the nature of world income distribution. Since the study of Baumol(1986), several studies including Mankiw, Romer, and Weil(1992) and Sala-i-Martin(1996) have confirmed the existence of convergence when conditioned to country-inherent properties. Jones(1997) points out that growth miracles are occurring more frequently than growth disasters and that the relative frequency of miracles has increased in the last 30 years. On the other hand, quite a large proportion of studies including well known studies such as Pritchett(1997) and Quah(1993, 1996) discuss that the divergence is a law for the income distribution[5].

As suggested in the previous section, we believe that the degree of inequality among countries is likely to be decreasing gradually. In fact, many statistical evidences point towards the world's income inequality being delicate, in the sense that their implication often changes according largely to how we treat data. For example, straight forward statistics such as a variance of GDP or a rich/poor type indexes, do not work well. Figure 2 and Figure 3 point out this fact. Though variance of cross-country GDP per capita is

[3]A distribution where Zipf's rule holds has been collected some attentions in economics. The size of companies and cities are famous two examples where Zipf's rule is observed to fit very well. See Stanley *et all.*(1995) and Krugman(1996) for each of the discussion.

[4]Kaldor(1963) has shown several stylized facts seen for the past 100 year in United States, including a constant return to real capital etc.

[5]See also Quah and Durlauf(1998), Sinclair(2000), and Sinclair(2001) for more recent surveys on statistical evidences on world income distribution.

increasing continuously, it is rather stable if we use the coefficient of variation instead during 1960-2001 as seen in Figure 2[6]. Meanwhile, it is often tried to make indexes as for the relative comparison between rich countries and poor countries (which we denote as rich/poor type index) to examine cross-country convergence. However, Figure 3 tells us how a rich/poor type indexes change their implications due to the definition of the index we suppose. The thick line shows the rich/poor type index during 1960-2001 defined as *(the real GDP per capita of the richest country)/(the real GDP per capita of the poorest country)*. On the other hand, the broken line shows the rich/poor type index for the same period, where we defined the index as *(the real GDP per capita of 25th percentiles country)/ (the real GDP per capita of 75th percentiles country)*. We can notice that the movement of each index is quite opposite, providing us a different implication as for whether the world's income inequality is increasing.

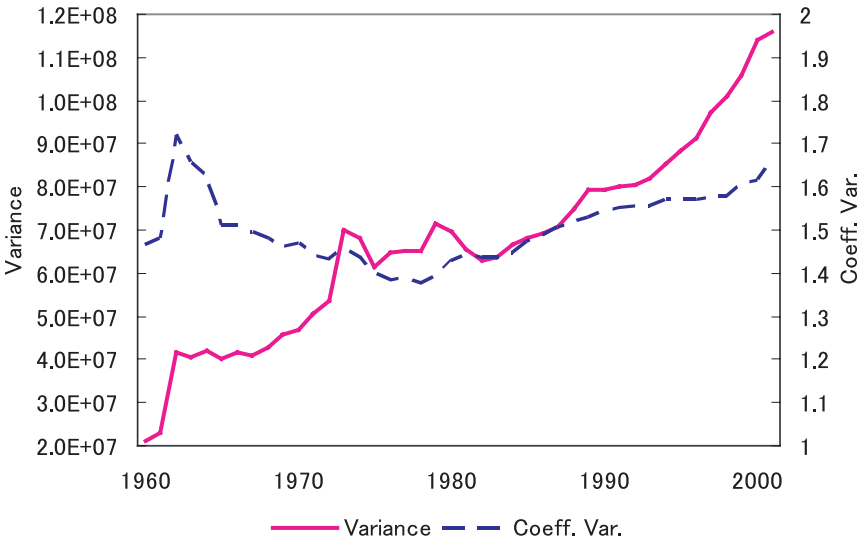

Figure 2. Variance and Coefficient of Variation.

[6]Apparently, the problem of using variance is that it does not consider continuous increase in real GDP as a whole, which, in result, overestimate the degree of inequality. The coefficient of variation somewhat clears this problem.

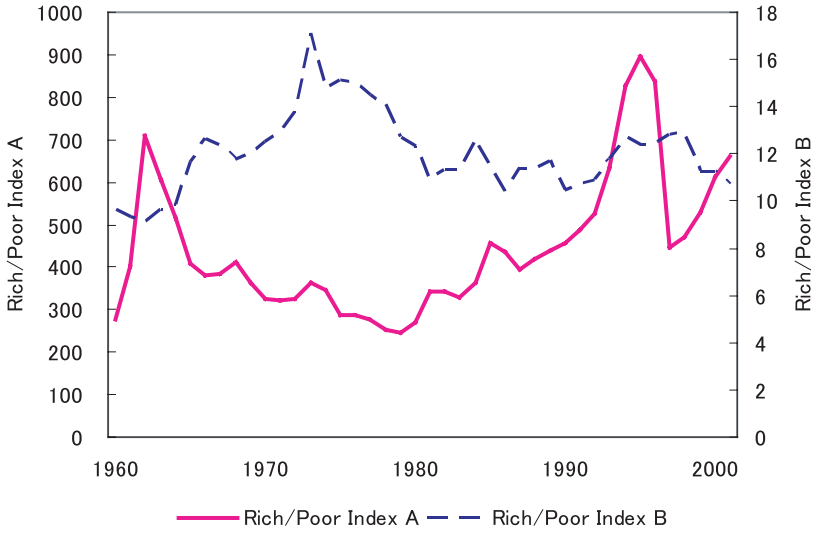

Figure 3. Two types of rich/poor indexes.
Rich/Poor Index A: (richest country)/(poorest country)
Rich/Poor Index B: (25th percentiles country)/ (75th percentiles country)

On the contrary, we believe that the statistical evidence presented in the previous section is more robust than existing indexes. Therefore, it seems rather natural that the inequality is not necessarily permanent in our economy. It must be noticed, however, that it does not mean that economists can dismiss cross-country income inequality, even though it may vanish *someday*. It is still important to consider how undeveloped countries can generate high growth in order to succeed in catching up with rich countries as quickly as possible[7]

4. Conclusion

Two empirical regularities are presented concerning the cross-country per capita GDP in this paper. 1.)They are significantly approximated to geometric sequence during 1960-2001. 2.)The common ratio of the geometric sequence is consistently declining for the period. We believe that this is in favor with the view that the world's income inequality is decreasing gradually, even though the convergence speed is very slow. However, why Log

[7]Salai-i-Martin(1997) makes a calculation, finding that the speed of convergence is around 2%, which is in fact extremely small.

GDP and its rank is linearly maintained, even though each country changes its rank of per capita GDP so often, remains an unsettled question.

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