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Original Paper

Technological Progress and Future of Kuznets Curve

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Abstract

This study considers the fluctuation in the degree of income inequality after the Kuznets curve completes a single inverted U-shaped curve. It ascertains that new-born technological inventions increase the degree of inequality; however, the degree of inequality declines as the technology disperses into the overall economy using OECD members' data. Assuming that technological progress takes place repetitively throughout long term economic growth, the Kuznets curve does not converge to a single inverted U-shaped curve. Rather, it fluctuates through technological progress where technology appears as an invention, but with time it becomes common knowledge.

Keywords

Kuznets curve, income inequality, cubic hypothesis, technological progress

1. Introduction

This study considers the fluctuation in the degree of income inequality after the Kuznets curve hypothesized that the relationship between income inequality and income level would follow a single inverted U-shaped curve. It is known that the level of inequality is generally extended at the beginning phase of economic growth; however, it gradually declines as economic growth matures. If the hypothesis of the Kuznets curve is correct, after one cycle of an inverted U, the degree of inequality should be permanently converged and stable with economic growth.

The Gini index, which is the most commonly used measure of income inequality, begins to increase again in some developed countries. The literature demonstrates that since the 1970s, the Gini index in the United States has started to increase again (e.g., Weinberg, 1996; Jones & Weinberg, 2000; DeNavas-Walt & Cleveland, 2002). Observing that Gini indexes in several developed countries have started to increase again after completing a single inverted U-pattern, Amos (1988) with the United State Gini index and Tachibanaki (2005) with the Japan Gini index, proposed another hypothesis: the cubic hypothesis of income inequality. The crucial idea of the cubic hypothesis is that there is another increasing trend in income inequality found in a mature postindustrial society. Weil (2005) suggested three reasons to explain such a phenomenon: (i) Technological advances, (ii) Increase in international trade, and (iii) Superstar dynamics.

This study confirms that the Kuznets curve can recur multiple times. What happens to the Gini index after Kuznets curve does not converge to a single inverted U-shaped pattern and starts to increase again following the cubic hypothesis? It would be necessary to converge to a specific number as "A" in Figure 1 or decrease again as "B" in Figure 1 since the Gini index is measured between 0 and 1. Moreover, if it decreases again after the peak of another cycle, a study on income and inequality would extend to a biquadratic hypothesis. What happens thereafter if a Gini index does not converge but moves somewhere? It would be related then to a multidimensional hypothesis.

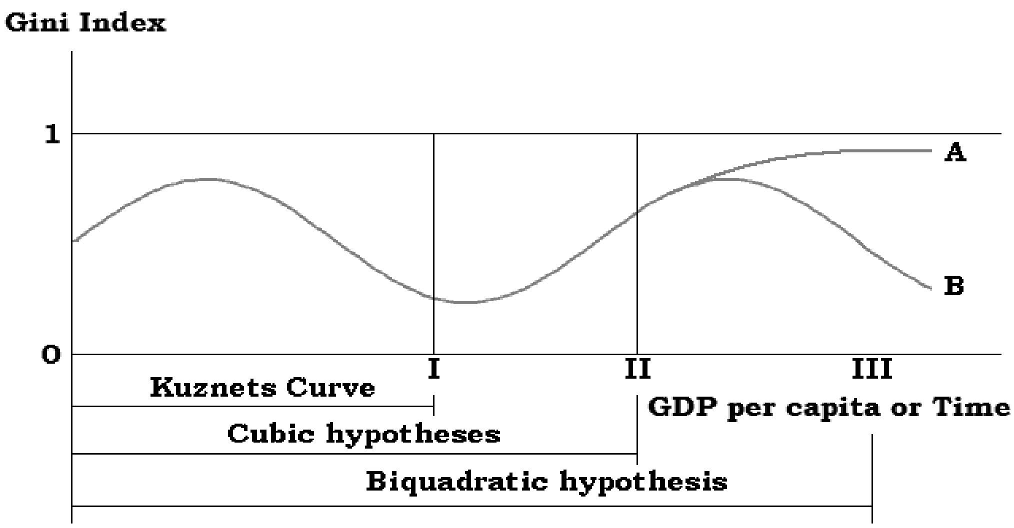

Figure 1. Biquadratic Hypothesis

Source: This figure was drawn by the authors.

Contrary to many reports, including that of Kuznets (1955) that focused on the relationship between the Gini index and income (economic growth phase or time), we relate the Gini index to technological progress, which Weil (2005) regarded as a source for increasing the Gini index. We estimate the future of Kuznets curve considering how the Gini index changes with technological progress. Using an Over Lapping Generation (OLG) model, Galor and Tsiddon (1997) proposed that the degree of inequality increases with new-born technology (i.e., invention periods); however, as it disperses to the overall economy (i.e., periods of technological innovations), the inequality decreases. Weil (2005) also mentioned that if a new technological revolution increases the degree of inequality and then that new technology is dissipated to the economy, the level of inequality that has been increased would be turn back to its initial level before the new technology arrived.

Therefore, assuming that technological progress occurs repetitively throughout long-term economic growth such as the Kondratiev wave (Note 1), we develop a conceptual graph of the future of Kuznets curve as in Figure 2.

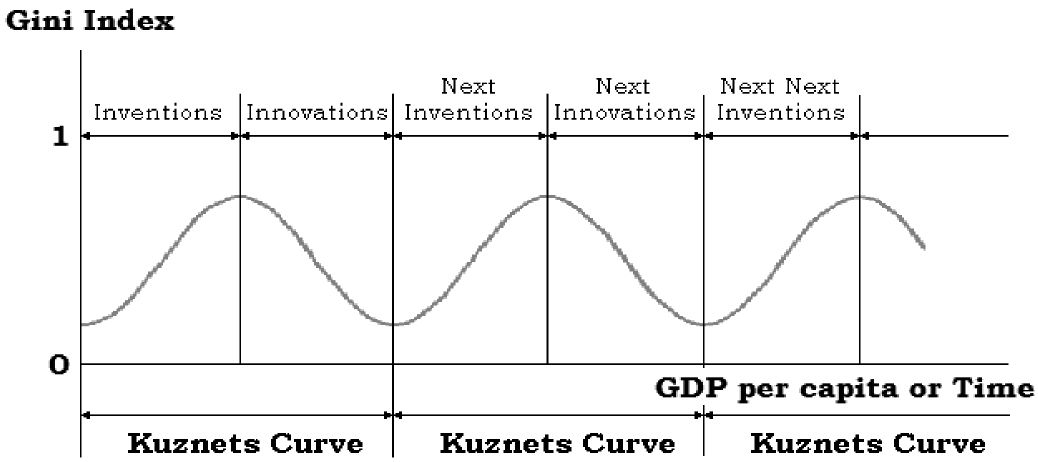

Figure 2. Conceptual Graph

Source: This figure was drawn by the authors.

In this study, using OECD members' data, we aim to confirm the above as Galor and Tsiddon (1997) and Weil (2005) mentioned, which is the co-movement between technological progress and income inequality. Galor and Tsiddon (1997) and Weil (2005) referred to how inequality changes with the process of inventions and innovations. However, they do not mention the future of the Kuznets curve in the long term. This study, we believe, is the first to consider the future of the Kuznets curve with technological progress.

Our study is the first to confirm these hypotheses using data. As a consequence, we affirm that for most OECD members, the Gini index temporarily increases and decreases, taking an inverted U-shaped, during the process of technological invention and diffused innovation. We reconfirm the above relationship between the Gini index and technological progress. With all of the results derived from the OECD members' data, we forecast the future shapes of Kuznets curve as follows. Since the Gini index goes through the inverted U-shaped pattern during the processing of each new born technology and its diffusion, the Kuznets curve does not converge to a single inverted U-shaped curve. Moreover, it can repeat the inverted U-shaped curve several times, depending on how many times new technologies emerge.

It is important to highlight that in this study, we do not address the possible mechanisms behind the obtained results theoretically. The purpose of this study was to make note of the empirical results; the possible mechanisms will be studied in future research papers.

This paper is organized as follows. In section 2, we describe the relationship between the rate of change of technological progress and the Gini index based on OECD members' data. We then propose a conclusion in Section 3.

2. Technological Progress and Gini index

To investigate how income inequality changes under the process of new born technology and its diffusion, we first employed OECD members' data to establish the relationship between the two rates of change related to technological progress and the degree of income inequality. These two rates of change are derived from the Total Factor Productivity (TFP) and Gini index data, respectively. There may be doubts about whether TFP is the best satisfactory measure of invention. We believed that TFP was a good proxy for it. The rate of change of technological progress in time *t* was calculated by TFP as (TFP(*t*)-TFP(*t*-1))/TFP(*t*-1), and the rate of the Gini index change in time *t* was obtained by Gini index as (Gini(*t*)-Gini(*t*-1))/Gini(*t*-1). The TFP data was obtained from Miketa 2004 at the International Institute for Applied Systems Analysis (IIASA) homepage (Note 2). The TFP data for 73 countries were calculated by the author (Note 3). The Gini index data was from World Income Inequality Database, Version 2.0b (2007) in the United Nations University-World Institute for Development Economics Research (UNU-WIDER) homepage (Note 4). According to UNU-WIDER, Gini indexes were coded in 2004, thus meeting the rigorous standards set forth in Deininger and Squire (1996). Both TFP and Gini indexes are annual data collections.

We investigated the time lag between the rate of change of technological progress and the rate of change of the Gini index and first calculated their time lag correlation coefficients. The time lag was extended to 10 periods. These outcomes are described in Figure 3 where the horizontal line indicates the time lag and the vertical line measures the correlation coefficients. The solid line indicates the autocorrelation with the time lag of the rate of change of technological progress and the dotted line is the time lag correlation of the rate of change of the Gini index with the rate of change of technological progress. Among the 25 OECD member countries, only 10 countries had data that could be collected for more than 12 years (Note 5). Therefore, we defined the 10-country data as in Table 1 where the countries and the periods to be analyzed are presented (Note 6).

Most countries, excluding New Zealand, show a sine curve such as the connection of the inverted U-shaped and the U-shaped curve on the time lag correlation of the rate of change of the Gini index with the change rate of technological progress in the dotted line (Note 7). More specifically, we found that the rate of change of the Gini index has a positive correlation with the rate of change of technological progress in the range of the inverted U-shape and a negative correlation in the range of the U-shape curve. That is, it indicates that technological progress has an effect on the high increase in the Gini index during the beginning phase. However, the effect shrinks over time and then declines the

Gini index as well as the rate of change. Thus, it can be easily ascertained that some propositions referred to in the paper of Galor and Tsiddon (1997) using the OLG model are applicable to the OECD data.

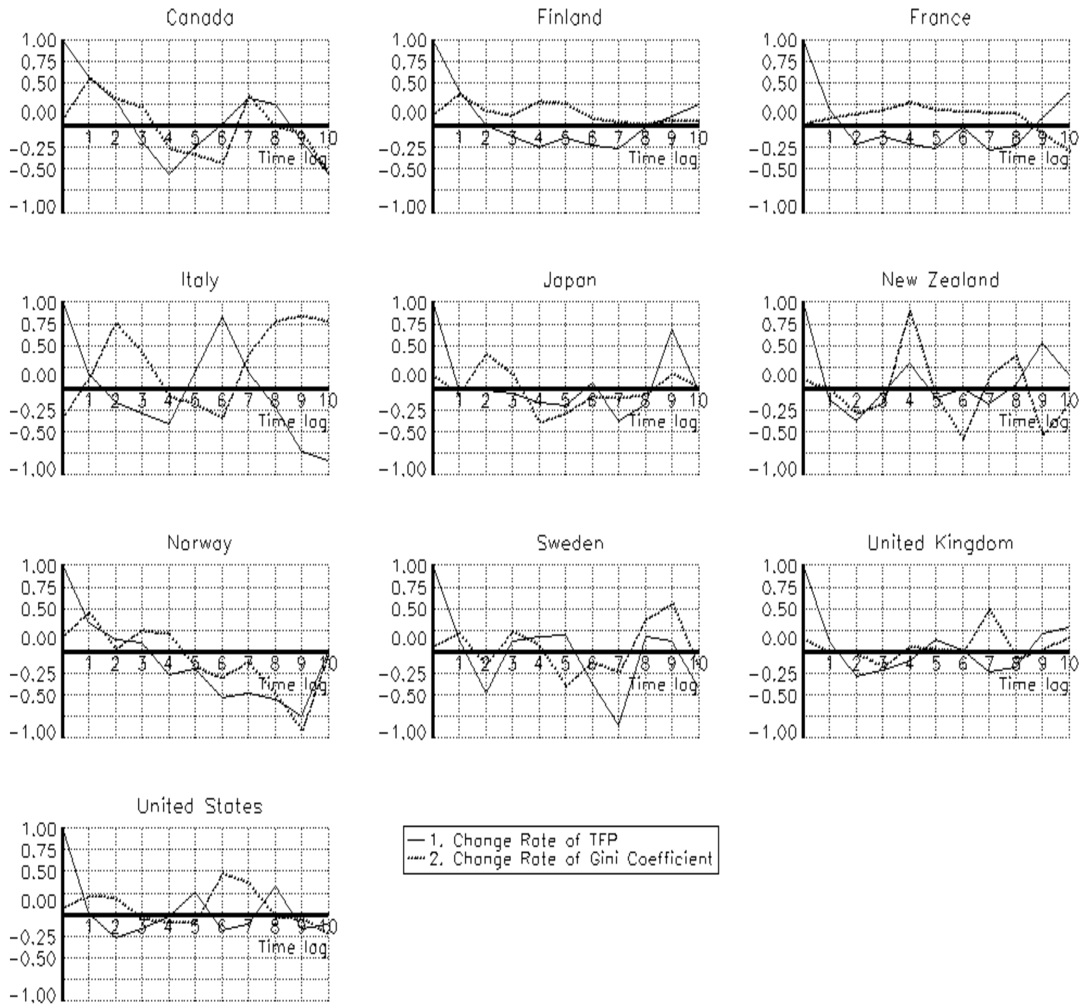

Figure 3. Time Lag Correlation Coefficient

Source: This figure was drawn by the authors using the open data.

Table 1. Countries and Periods for Analysis

Country	Time Periods	Country	Time Periods
Canada	1987-2000	Finland	1966-2002
France	1970-1999	Italy	1987-2000
Japan	1962-1990	New Zealand	1973-1990
Norway	1986-2002	Sweden	1976-1992
United Kingdom	1961-2002	United States	1967-1997

In the United States, for example, new born technological inventions increased the Gini index for three years (from 0 to 3 period), after which the index stayed negative for two years (from 3 to 5 period). Following Galor and Tsiddon (1997)'s phase, the first three years after the emergence of new technology were regarded as the periods of invention, while the next two years were the periods of innovation. By the end, a single Kuznets curve appeared in this period.

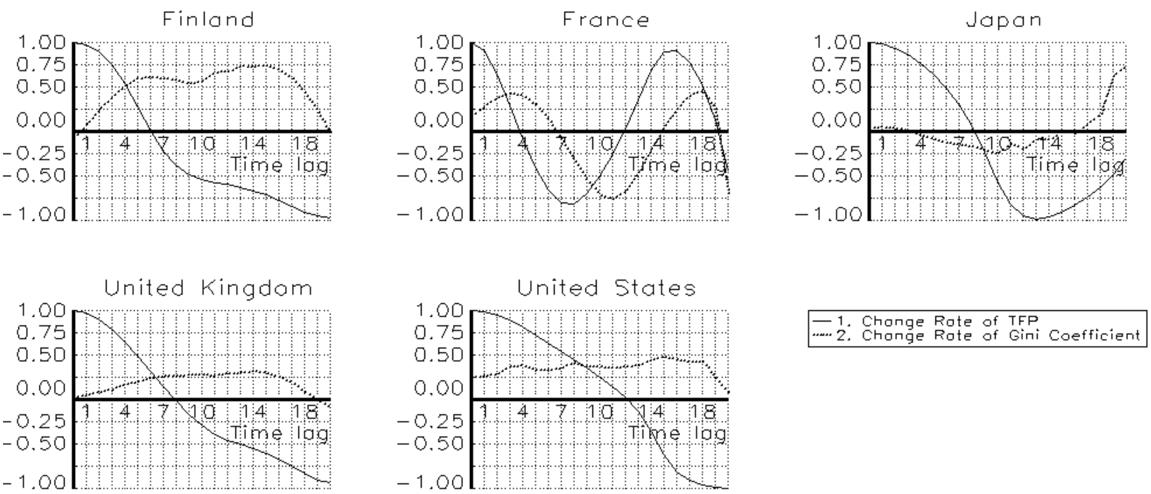

Figure 4. Time Lag Correlation Coefficient Controlled by Short-Term Noise

Source: This figure was drawn by the authors using the open data.

Based on the results in Figure 3, we estimated that a single cycle of the Kuznets curve (the inverted U) in the United States takes place every 5 years. However, it is known, as stated previously, that the Gini index data in the United States has kept increasing as a long-term trend since the 1970s, though with several small cycles within these periods. Thus, the cycle of the Gini index obtained in Figure 3 falls into the problem of a very short period of time compared to the real data of the Gini index. In this phenomenon, we developed an adequate explanation that some factors in the short term, such as noise, had an effect on the data. Therefore, we extracted the long-term trend of TFP to control factors related to the short-term factors in technological progress. We conducted the same analysis with the trend of TFP, removing small cycles by filtering out annual TFP data using the Hodrik-Prescott filter. Figure 4 describes the time lag correlation coefficient controlled by short-term noise for five countries where more than 22 years of data could be collected. The way to read Figure 4 is the same as that of Figure 3. In the case of the United States, the correlation coefficient had a positive relationship for more than 20 years. This outcome indicates that the introduction of new technology kept increasing the Gini index for more than 20 years, which indicates a long-term impact. Moreover, this long-term trend explains well the increasing trend for the Gini index in the United States, since we used United States data for 30 years (1967-1997).

3. Conclusion

This study considered the relationship between technological progress and the Gini index. Using OECD members' data, we reconfirmed that new-born technological inventions increase the degree of inequality; however, this impact declines as that technology disperses across the overall economy (e.g., Galor & Tsiddon, 1997; Weil, 2005). From these results, we could predict the future of Kuznets curve. The complete Kuznets curve keeps fluctuating (increasing and decreasing) as long as technological progress occurs occasionally, but does not converge to a particular number. The cubic curve, which is the hypothesis of Amos (1988) and Tachibanaki (2005), might just be a new starting point for those fluctuations.

We developed conclusions simply by looking at several graphs. We did not perform any statistical inferences or address the possible mechanisms behind the obtained results theoretically. These were left as our next research topic.

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Notes

Note 1. Galor and Tsiddon (1997, footnote 21 (page 376)) implied that technological progress could be generated endogenously.

Note 2. International Institute for Applied Systems Analysis (IIASA). Retrieved from http://www.iiasa.ac.at

Note 3. Details about the calculation can be found in Miketa (2004).

Note 4. United Nations University-World Institute for Development Economics Research (UNU-WIDER). Retrieved from http://www.wider.unu.edu/research/Database/en-GB/database/

Note 5. We need more than 11 years of data to calculate 10-year lag correlation coefficients. Moreover, since we considered the rate of change of the TFP and the Gini index, we need at least 12 years of data for TFP and Gini index data. The missing values of the Gini coefficients have been imputed using linear interpolation.

Note 6. These periods that vary quite a bit by country are the longest possible periods.

Note 7. New Zealand has a contrary connection of the U-shaped and the inverted U-shape (like minus sine curve). This result for New Zealand is left as our next research topic.