# DIVERGENCE AND MORE DIVERGENCE (NOT CONVERGING TO CONVERGENCE)

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Inter-country convergence of incomes, whether unconditional or conditional, is usually studied by examining the evidence from the start year of a sample to the sample's end-year. A recent study instead examines evidence for every decade starting from 1960 to that decade's end. It finds divergence during the 1960s, 1970s, and 1980s, neither during the 1990s, and convergence during the 2000s and 2010s. It calls the said finding Converging to Convergence. We highlight that the said paper shows converging to relative convergence or convergence in income ratio, not in income levels. Using the recently available Penn World Tables, version 11.0 data for 128 countries from 1960 to 2023, and the growth rate of the income gap, we show that there has been a divergence in income levels in each decade. This result is not driven by countries grouped in any income quartile or any geographical region of the world. It remains unaltered when we consider conditional convergence using augmented Solow fundamentals (population growth rate, investment share, and human capital) as control variables. The explanation lies in the evidence that incomes rarely grow in a linear path over more than a decade and that there are systematic differences among countries other than in the augmented Solow fundamentals.

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**(Not Converging to Convergence)**

## 1. Introduction and Literature Review

Convergence, of per capita incomes or per worker product of countries/regions/states get closer overtime is one of the most widely studied topics in economics. The first author who used the word convergence to examine this question is Easterlin (1957, 1960). He examined historical data from 1880 to 1949-51 on personal per capita income of states of the US grouped in nine regions. Defining convergence as a decrease in average absolute percentage deviation of regional income from the national average, he found convergence.[1] However, the study of convergence really takes off after the publication of Maddison's data in 1982 on productivity from 1860-1979 in 16 industrialized countries. Not only was convergence debated, but a specific convergence hypothesis was emphasized/formulated that poorer countries tend to reduce their income gap from the richer ones.

Two prominent works that examine Maddison (1982) data for convergence are Baumol (1986) and Abramovitz (1986). Baumol (1986) was the first author to identify convergence with a negative coefficient of regressing growth rate of per capita income/productivity on countries' initial income. He found convergence for the 16 Maddison countries and found the explanation in Gerschenkron (1952)'s advantage of "relative backwardness" hypothesis - applicable to industrial countries and given in the context of Russia vs. Britain. Under Gerschenkron's (1952) view the late comers to industrialization can, with active role of governments and banks, purchase machinery from early developers and emphasizing capital goods/capital-intensive and large-scale

[1] However, Roberts (1979) demonstrated that once personal incomes are adjusted for urban-rural price differences, the convergence found by Easterlin (1957, 1960) disappears.

production, need not go through the same linear path of growth as the leaders, Performing similar exercise using the Summers and Heston (1984) data for 1950-80 for a wider group (72) of countries, Baumol (1986) did not find negative relationship between initial income and its growth rate – although he found it for data restricted to centrally planned economies. He refrained from discussing why the poorer countries have not benefited from the public goods properties of innovations and investments by other countries.

Rather than regression, Abramovitz (1986) used rank correlation and found the same sign (negative) of the rank correlation coefficient between growth of productivity and its initial level. There is "catch-up" growth –poorer countries' productivity grows faster. Greater the initial back log, greater is the "catch-up" growth rate and productivity differences decrease. But there is little "forging ahead" – countries' productivity ranks remain the same. The "catch-up" growth is feasible only for countries that have "social capability" to benefit from technological spillovers from the leader – while admitting "no one knows just what it ("social capability") means or how to measure it," p. 388. Further, he recognizes that the convergence rate is not uniform and varies from period to period. He limits his study to the data of productivity for 16 industrialized countries for 1860-1979 provided by Maddison (1982).

The convergence hypothesis received a big boost with the works of Barro (1989) and Barro and Sala-i-Martin (1990. They made two major innovations: a) They derived convergence as a corollary of the neo-classical single country closed economy growth model of Solow (1956); b) They redefined the balanced growth path of Solow (1956) as "steady state" path to which all countries converge – the initially poorer countries by growing faster than the average and the initially richer countries by growing slower than the average. Fundamental to this derivation was the concave production function of Solow (1956) between capital-labor ratio, $k$, and labor

productivity (taken as a proxy for per capita income). The poorer countries with a low $k$ had higher marginal product of capital and would *ipso facto* experience a greater increase in per capita income. Vice versa for the richer countries. All countries would reach the same steady state, and incomes would become equal (full convergence of Kant [2019, 2025]).

In Barro and Sala-i-Martin (1991 and 1992), they allow for steady state income, $y^{h*}$, and exogenous labor-augmenting technological progress, $x$, to differ among countries and make convergence conditional on $y^{h*}$ and $x$. Implicitly, the convergence defined in their 1990 paper was unconditional. Whether unconditional or conditional, empirical tests of convergence center on regressing growth rate of income on initial income. Calling the slope coefficient as β, β-convergence means a statistically significant negative estimated β. For conditional convergence, the additional assumption of the same $x$ and $y^*$ must be made.

Mankiw, Romer, and Weil (1992) emphasize that the Solow (1956) model does not predict convergence to the same steady state income for all countries. It predicts a country reaches its own steady state income. They augment the Solow (1956) model with human capital and demonstrate convergence conditional on human capital, physical capital accumulation and population growth rate.

Next development relevant to this paper is defining the concept of relative convergence and distinguishing it from absolute convergence by Kant (2019). Relative convergence means income-ratio convergence, while absolute convergence means income-level convergence. Kant (2025) calls income-level convergence simply as convergence and that usage is adopted here.[2]

[2] He does so since some authors, including Barro and Sala-i-Martin (1990) and Kremer, Willis, and You (2022), use absolute convergence to mean unconditional convergence.

Kant (2019) also shows that β-convergence means income-ratio convergence and does not imply income-level convergence.

Two major papers in this subject over the last five years are Patel, Sandefur, and Subramanian (2021), and Kremer, Willis, and You (2022). Both overlook Kant (2019), the concept of relative convergence and the results derived in that paper. They both use data since 1960, primarily analyzing unconditional β (income-ratio)-convergence, but mistakenly state as if they analyze income-level convergence. Patel, Sandefur, and Subramanian (2021) examine β (income-ratio)-convergence to 2019 when the start years rolls forward from 1960 to 2010. They do not find β (income-ratio)-convergence for the start years from 1960 to 1995 but find it for the start year 2000 – although at a very modest pace. Kremer, Willis, and You (2022) examine β (income-ratio)-convergence for each ten-year period starting from 1960 to 2007. They do not find any such convergence when the start year is from 1960, to mid-1990s but find it for the years starting from 2000. They label this result as "converging to convergence."

Kant (2025) proves the relationship between relative convergence and convergence for continuous changes and for log incomes too (neither done in Kant [2019]). He also defines convergence rate, develops a test of the convergence hypothesis (that poorer countries reduce their income gap from the rich countries) using the convergence rate and proves that β- convergence does not imply that income differences between any two countries in the regression decrease. Employing three sets of data starting from 1950/1960 to 2019/2022/2024, he shows there has been both unconditional and conditional divergence for the 1950/1960 to 2019/2022/2024 period from the largest to the smallest group of countries (OECD). Furthermore, the divergence is explained by the divergence of TFP from the world technological frontier.

The purpose of this paper is to examine whether the divergence for the entire period shown in Kant (2025) is due to divergence from 1960 to 1990 or whether divergence has continued since 1990 too. For this purpose, it studies, like Kremer, Willis, and You (2022), convergence by decades but examines income-level convergence rather than β (income-ratio)-convergence studied by them. The objective is to examine whether divergence in decades from 1960 to 2000 has continued in this century (divergence and more divergence) or whether it has come to a stop and changed to convergence.

Section 2 discusses the still relatively unknown distinction between relative convergence and convergence, shows β-convergence, or faster growth of the poorer country, means income-ratio convergence, defines the convergence rate and develops tests for the convergence hypothesis using it. Empirical estimation of decadal convergence is performed in Section 3 and contrasted from decadal β (income-ratio)-convergence studied by Kremer, Willis, and You (2022). Section 4 concludes.

## 2. Convergence, Relative Convergence, β convergence, Convergence Rate

This section discusses the little understood distinction between relative convergence and convergence, shows β-convergence, or faster growth of the poorer country, means income-ratio convergence, (not income level convergence) defines convergence rate and develops tests for the convergence hypothesis using it.

Consider any two closed countries, Rich and Poor, *R* and *P*, characterized by neo-classical assumptions, particularly a concave production function. Let $y_{Rt}$ and $y_{Pt}$ represent their per-capita incomes/outputs at time *t*, where $y_{Rt} > y_{Pt}$,. Let $\varphi_{tu}$ represent the poor country's income ratio and $\Delta_{Pt}$ the poor country's income difference from the rich country in year *t*. Then

$$\varphi_{Put} = y_{Pt}/y_{Rt} < 1 \qquad \text{and} \qquad \Delta_{Pt} = (y_{Pt} - y_{Rt}) < 0 \tag{1}$$

Following Kant (2019, 2025), relative convergence, relative divergence or neither means

$$\text{sign } (d\varphi_{Pt}/dt) > < = 0 \text{ (relative convergence, relative divergence, neither).} \quad (2)$$

Similarly, convergence, divergence or neither means

$$\text{sign } (d\Delta_P/dt) = (dy_P/dt) - (dy_R/dt) > < = 0 \text{ (convergence, divergence, neither)} \quad (3)$$

Let $g_P$ and $g_R$ represent the income growth rates from time 0 to time $T$, $(1/y_P)(dy_P/dt) = (d\log y_P/dt)$ and $(1/y_R)(dy_R/dt) - (d\log y_R/dt)$, of the two countries. Then,

$$(d\varphi_P/dt) = \varphi_P\,[(1/y_P)(dy_P/dt) - (1/y_R)(dy_R/dt)] = \varphi_P\,[(d\log y_P/dt) - (d\log y_R/dt)] \quad (4)$$

and

$$\text{sign } (d\varphi_P/dt) = \text{sign } (g_P - g_R) = \text{sign } [(d\log y_P/dt) - (d\log y_R/dt)] \quad (4\hat{})$$

(2) and (4') are combined in the following Lemma:

**Lemma 1**: Relative convergence, relative divergence and neither is synonymous with a poorer country's income growing faster, slower or equal to a richer country's income and/or its income ratio to the richer country increasing, decreasing or remaining unchanged.

From (3), convergence, divergence and neither mean

$$[(dy_P/dt)/(dy_R/dt)] > 1 \text{ (convergence); } < 1 \text{ (divergence); } = 1 \text{ (neither).} \quad (5).$$

Consider that the poorer country is growing faster, i.e., relative convergence. Then, we get from (4)

$$[(dy_P/dt)/(dy_R/dt)] > (y_P/y_R) < 1 \quad (6)$$

(6) has no implication for whether the magnitude of $[(dy_P/dt)/(dy_R/dt)]$ is greater than one, less than one, or equal to one. That is, whether a poorer country's income level grows more than a richer country's income level. Relative convergence is not sufficient for convergence and does not imply convergence.

Now, consider country *i, i* = 1 . . . *I*. Let $g_i$ represent the average annual growth rate of its income/productivity from time 0 to time *T,* and consider the regression equation

$$g_i = \alpha + \beta \log y_{i0} + \epsilon_i \quad (7)$$

where $E(\epsilon_i) = 0$. A negative statistically significant OLS estimated value, $\beta^h$ of the coefficient β is called β-convergence.[3] A negative regression coefficient means lower the initial income $y_{i0}$ of country *i,* greater is its growth rate. That is, a poorer country's income grows at a faster rate than a richer country's income. However, by (6), that does not imply that its income level grows more than a richer country's income level. From Lemma 1, a poorer country's income growing faster means the ratio of its income to the richer country increases. β-convergence means relative convergence or income-ratio convergence. It does not imply income level convergence.

**Convergence Rate and Convergence Hypothesis:**

(3) defines convergence between any pair of countries. In most situations, we would be interested in not just a pair wise comparison but whether one country has converged more than another (and more than hundreds of others). Then, it is more meaningful to compare convergence to the same reference or benchmark country. Let $\Delta_{bmit} = (y_{bmt} - y_{it})$ be the excess of the income of the Benchmark Country, *bm*, from Country *i*'s, in year *t,* where the Benchmark Country is the highest income country in the initial year, 0, and for half or more years of the sample period, *T.* Then, the convergence between periods 0 and *T* is:

$$(\Delta_{bmiT} - \Delta_{bmi0}) < 0 \quad (8)$$

[3] Such convergence, termed unconditional convergence, is distinguished from conditional convergence where the negative coefficient is conditional on a set of exogenous variables. It is not necessary to consider control variables for our argument here.

For ease of interpretation, we redefine convergence, divergence or neither as:

$$(\Delta_{\text{bmi0}} - \Delta_{\text{bmiT}}) > < = 0 \quad \text{(convergence, divergence, or neither)} \qquad (8').$$

The convergence rate for Country $i$ between year 0 and $T$, $cr_{iT}$, is defined as

$$cr_{iT} = T^{-1}(\log \Delta_{\text{bmi0}}) - \log \Delta_{\text{bmiT}}) \qquad (9)$$

If $cr_{iT} > 0$, (9) gives the convergence rate, and if it is < 0, it gives the divergence rate.

The convergence rate is the growth rate of the difference in the two countries' per capita income. It is not equal to the difference in the growth rates of the two countries' income.[4]

This paper emphasizes that the convergence rate given by (9), should be used to examine convergence. Using the income growth rate, as in (7) or as in β-convergence, examines relative convergence or income-ratio convergence.

The unconditional convergence hypothesis states a poorer country reduces its per capita income gap from the richer country. [5] It involves the following steps:

1. Poorer countries' incomes grow faster.
2. Growing faster decreases their income gap from the richer countries.
3. Incomes of poorer countries converge to those of richer countries.

We have shown above that faster growth of the poor country's income does not imply a reduction of its income gap from the rich country. With 2. not true (and its antecedent 1. therefore

[4] Log of a difference (or sum) is not equal to the difference (or sum) of the two logs.

[5]This is the weaker form of the convergence hypothesis - in contrast to the stronger form that asserts that the poorer country eliminates its income gap from the rich country. In what follows, we will only be working with the weaker convergence hypothesis.

irrelevant), the convergence hypothesis simply devolves to 3. and its test must be direct. We use the following regression to test for unconditional convergence:

$$T^{-1}(\log \Delta_{bmi0)} - \log \Delta_{bmiT}) = \gamma + \delta \log y_{i0} + \epsilon_i \qquad (10)^6$$

where $E(\epsilon_i) = 0$. Our hypothesis (assuming that the convergence rate is positive), is that lower is the initial income, the higher the convergence rate (given by (9)). That is, a negative significant estimated value, $\delta^h$ of the coefficient $\delta$ means convergence. If we find the relationship between the initial income and the convergence rate to be statistically significant and positive, it means the lower the initial income is the lower (algebraically or higher in absolute number) the divergence rate –the country diverges at a higher rate,

For conditional convergence/divergence, we estimate

$$T^{-1}(\log \Delta_{bmi0)} - \log \Delta_{bmiT}) = \gamma + \delta y_{i0} + \boldsymbol{X\Gamma} + \epsilon_i \qquad (11)$$

where $\boldsymbol{X}$ is a $I$ x $k$ matrix of control or conditioning variables and $\boldsymbol{\Gamma}$ is a $k$ x 1 vector of parameters.

## 3. Empirical Evidence

We use Penn World Tables (PWT) version 11.0 data in this study. PWT provides "a cross-country dataset that is closely linked to the theoretical concepts of welfare and production, more consistent over time and more transparent in its methods." Feenstra, et al (2015, p. 38).[7] This data is available to the year 2023. The start year varies for countries with that since 1950 available for more established countries, that for many African countries since 1960, for many other

[6] As explained in Kant (2025), taking initial income in logs is not essential - taking initial income in natural numbers will yield the same sign and p-value.

[7] Johnson and Papageorgiou (2020), call PWT the gold standard of cross-country data sets and report that about 70 percent of cross-country empirical work on growth is based on PWT.

countries since 1970, and for ex-socialist countries since 1990. To include a wider range of countries, we use 1960 as the start year for our study. PWT data were accessed on November 17, 2025 and are available at http://www.rug.nl/ggdc/productivity/pwt,

We use the following data series from PWT11.0: for convergence rate (i.e., the growth rate of income difference) - real GDP at constant national prices, and for output levels - output-side real GDP at chained PPPs - as recommended by the PWT (8.0) user guide, population, human capital index based on years of schooling and returns to education, and share of gross capital formation at current PPPs.[8] The sample of countries is governed by the availability of human capital data in PWT since no other source gives comparable data on human capital. Excluding the large oil exporters and countries with populations of less than one million, there are 129 countries in the sample. Switzerland has the highest income in 1960 and higher than USA for all years. We use it as the benchmark country, leaving 128 countries in the estimating sample

Table 1 reports the results from regressing the convergence rate by decades/period on the log income per capita in the initial year without considering any control variables (but including the year fixed effects). Then $\gamma$ in (10) is the year fixed effect and $T$ in (10) equals 10 years from the decadal start year 0. Since the data goes until 2023, the last two periods are 2000-2012 and

[8] The new generation of PWT (since its version 8.0) provides data on the following additional measures of real GDP, a) expenditure-side real GDP at chained PPPs, b) Output-side real GDP at current PPPs, and c) Expenditure-side real GDP at current PPPs. For an explanation and comparison these measures, see Feenstra, Inklaar and Timmer (2015), 0. For details on the human capital measure, see Human Capital in PWT 9.0 available at http://www.rug.nl/ggdc/productivity/pwt.

2012-2023. We find strong unconditional divergence for each decade/period.[9] The slope coefficient is positive, i.e., poorer the country is initially, the lower is the convergence rate/higher is the divergence rate. This pattern continues decade after decade. There is divergence in every decade and more divergence in the following decades. Figure 1 gives the scatter plots for each decade/period of the convergence rate against initial log income. The 1960s had no country with a positive convergence rate – in the subsequent decades only a few do. Although the slope of the trend line fluctuates, it is positive for each decade or period.[10]

< Insert Table 1 and Figure 1 here >

Before we turn to examining conditional convergence/divergence, we examine both trend in convergence/divergence each year starting from 1960 and i) robustness of the unconditional divergence to inclusion of new countries in the sample overtime, ii) whether a quartile of income-group of countries or iii in one of the regions of the world is behind the results. For this purpose, we estimate (10) each year from 1960 to 2013 and plot the slope coefficient, Delta, against time for both all and different groups of countries. Figure 2 is for all countries. It shows the trend in the delta coefficient overtime. It shows the coefficient is always positive – the poorer countries have a lower rate of convergence/higher rate of divergence, year after year from 1960 to 2013.

Figures 3, 4, and 5 are for specified groups of countries. In Figure 3, countries are separated by the same start year. There are three same samples: only countries with data from 1960 to 2023,

[9] Table 1 reports the significance levels using clustered standard errors. With usual standard errors, the coefficient of the slope coefficient for the 1990s is also significant at the 5% level (and its significance level is not any lower for any other period).

[10] In this Figure, cr60yn means convergence rate of income during the decade of 1960s, etc.

only countries with data from 1970 to 2023, and only countries with data from 1990 to 2023. Delta is separately computed each year only using data for countries belonging to the same sample. The three curves overlap. Divergence and more divergence is not due to the inclusion of new countries overtime.

Figure 4 shows four plots of the slope coefficient over time. Each plot is when countries with income in a quartile of income are excluded from the regression with the first quartile being the poorest. It examines if divergence and more divergence is driven by a quartile of countries by income. It is not so driven. Irrespective of the quartile of income countries excluded, Delta remains positive throughout for the remaining three-quarters of countries. However, the magnitude of delta is the lowest when the richest quartile is excluded – meaning it is the richest quartile of countries which are responsible for the higher rates of divergence shown by the other three curves. Similarly, the magnitude of delta is the highest when the poorest quartile is excluded – meaning it is the poorest quartile of countries which are responsible for the lower rates of divergence shown by the other three curves. Richer countries tend to increase the whole-sample rates of divergence, and the poorer countries tend to decrease the rates of divergence. This confirms the information given in decadal scatter plots shown in Figure 1 – the steepness of slopes of the scatter plots primarily depends on richer countries.

Figure 5 shows divergence and more divergence is also not driven by any geographical region of the world. The coefficient remains positive irrespective of the world region excluded. When Europe, C. Asia and N. America region is excluded, the coefficient is mostly lower – implying this region tends to keep the divergence rate higher. When any of the other three regions is excluded, the time-paths of the coefficient generally overlap except for the following. When the S. and E. Asia region is excluded, the other three regions do not experience the sharp spike in

divergence rate from 2000 to 2003 implying the said spike was due to S. and E. Asia region. Also, when Europe, C. Asia and N. America are excluded, the other three regions do not experience the sharp fall in the divergence rate from 2003 to 2005 implying the said fall was due to Europe, C. Asia and N. America region.

Now we discuss conditional convergence. Following Mankiw, Romer, and Weil (1992) and Kant (2025), we use three control or conditioning variables. These are averages over each decade of i) annual growth rate of population, ii) gross investment as a share of GDP, and iii) human capital. PWT is the source of this data too. Estimation results with the first two conditioning variables are presented in Table 2. Population growth has the expected negative effect even though many countries had negative population growth in the last three periods.[11] Investment proportion always has the expected positive and mostly statistically significant effect. Yet, divergence and more divergence continues. Although the coefficient on initial income is now negative for two periods, the negative coefficients almost equal zero with the average estimated positive coefficient 76 times the average estimated negative coefficient.

< Insert Table 2 here >

[11] The number of countries with negative population growth increased from one or two in the 70s (Cambodia) and 80s (Bulgaria & Hungry) to 17 in the 90s (Albania, Armenia, Bulgaria , Croatia, Czechia, Estonia, Hungry, Kazakhstan, Latvia, Lithuania, Moldova, Romania, Russia, Serbia, Slovenia, Ukraine), 15 in the 2000s (Albania, Armenia, Bulgaria, Croatia, Estonia, Germany, Hungry, Latvia, Lithuania, Moldova, Poland, Romania, Russia, Serbia, Ukraine), and 15 in the 2010s (Albania, Bulgaria, Croatia, Greece, Italy, Japan, Latvia, Lithuania, Mauritius, Moldova, Portugal, Romania, Serbia, Ukraine, Venezuela).

Table 3 presents the estimation results when human capital is added as a conditioning variable. Population growth and investment ratio have almost the same effects as without human capital. Human capital always has the expected positive effect. Divergence and more divergence continues even after controlling for human capital. The negative coefficients on initial income again equal almost zero with the average estimated positive coefficient now 11 times the average estimated negative coefficient. In the last three periods, the ratio is 21 times.

< Insert Table 3 here >

**Discussion:**

Our work is most closely related to Kremer, Willis, and You, (2022). They find converging to unconditional convergence (see, their Table 1 and Figure 1, p. 350 and 348). We demonstrate the completely opposite result: unconditional divergence and more unconditional divergence. The difference arises for two reasons: a) Kremer, Willis, and You, (2022) mistake an increase in income ratio as a reduction in income gap; and b) we use the most recent data that is available. We also find richer countries tend to increase the rates of divergence and the poorer countries tend to decrease rates of divergence. Kremer, Willis, and You, (2022) instead find β- (income ratio) convergence, at least in 2010s is driven by richer countries while poorer countries have been a drag on β-(income ratio) convergence. They also find β- (income ratio) convergence is strengthened in the last two decades when Sub-Saharan Africa is excluded. We do not find income divergence gets reduced upon excluding Sub-Saharan Africa.

We analyze convergence conditional on Solow fundamentals for each decade; they analyze it for two select periods, 1985-1995 and 2005-2015 and using a different measure of human capital, namely average years of schooling of population of 20–60-year age from Barro and Lee, (2021).

Their Table 5 shows using the three augmented Solow fundamentals does not change the unconditional income-ratio convergence results for these two periods.

What is remarkable about the results in our Table 3 is that even after we account for differing population growth rates, gross capital formation proportions and human capital accumulations among countries, there has been divergence and more divergence since 1960. Table 3 suggests divergence and more divergence in income must be due to mostly in non-measurable variables. The empirical tests of, e.g., the augmented Solow (1956) model given by Mankiw, Romer, and Weil (1992), are valid only if countries are in their steady state or if deviations from steady state are random. This is because the steady state value of $k^*$ (e.g., that given by (5) in Mankiw, Romer, and Weil (1992)) is substituted in the production function to derive the time-path of per-capita income - which hence is the steady state path.

In the steady state, (called balanced growth by Solow (1956)), with a given saving proportion, capital, labor and output all increase at the steady rate of exponential growth rate of labor. However, it has been known since 1993 that output and incomes rarely grow in a linear path. Easterly et al. (1993) examined correlations of decadal income growth rates (for 1960-69, 1970-79, and 1980-88) in a sample of 115 countries, finding them to be quite low (0.1 - 0.3). Easterly and Levine (2001) report that growth is highly unstable over time. Using data from PWT for 135 countries, per capita income growth during 1977-92 had a correlation of only 0.018 with growth during 1960-76. For 119 countries with data over 20 years between 1960-97, a break point can be found for 48 countries where the per capita income growth was 5 percentage points lower or higher in the decade following the break point than in the previous decade. Using long-term historical data for 25 countries from Maddison (1995), the correlation between 1820-70 and 1870-1929 in per capita income growth was only 0.097.

Pritchett (2000, 2003) finds that annual income growth rates of a country vary over time, and this variation is even stronger across countries. He identifies six distinct patterns of growth based on growth before and after statistically chosen structural breaks, classifying each country into one of these six groups: steep hills (growth of more than 3% in both periods), hills (growth of more than 1.5% in both periods), plateaus (growth of more than 1.5% before the break and less than 1.5% after the break), mountains (growth of more than 1.5% before the break and negative after the break), plains (growth of less than 1.5% in both periods), and accelerators or "Denver" (growth of less than 1.5% before the break and more than 1.5% after the break).

Hausmann et al. (2005) report that few countries experience consistently high growth over several decades and instead look for growth acceleration episodes (where the income growth rate increases by at least two points for eight years). They define a sustained episode as when, for two years after the episode, income growth is at least 3.5%. Countries can have multiple episodes if they are five years apart. Although they find that 37 of their 69 episodes were sustained, 25 out of these sustained episodes had negative or poor growth before the start of the acceleration period.

Building on Pritchett (2000), Jerzmanowski (2006) highlights that identical average growth rates can mask very distinct growth paths and classifies variation over time in income growth within a country into four distinct regimes. These are stable growth (at 2% rate per year), stagnation (on average, zero to slightly negative growth), crises (highly volatile growth ranging from double-digit negative to double-digit growth), and miracle-growth (at 6% annually). He first estimates a Markov-switching regression to characterize these regimes, then determines the probabilities of countries switching/transitioning between them and of ignition and termination of growth episodes. Kerekes (2012) extends this by grouping countries based on similar transition probabilities into three clusters. These clusters are a successful growth cluster (countries growing

at 2% most of the time), a moderately successful growth cluster (growing at 2% for 45% and stagnating for 37% of the time), and a growth failures cluster (stagnating for most of the time).

Jones and Olken (2008) examine ten to fifteen-year country growth periods relative to the US, finding that growth miracles and failures are common across countries. They report that 86% of all countries, 92% of the poorest one-third countries (in 1960) and 76% of Sub-Saharan countries have experienced higher growth than the US over at least one ten-year period. Cuberes and Jerzmanowski (2009) find that rather than frequent shocks, most countries experience trend volatility over the medium-term – periods of exceptionally high growths are followed by low or even negative growth and vice versa. They conclude "from the policy makers_ point of view, lessons about medium-term growth are likely much more relevant than those about the long run." (p. 1296).

The above literature establishes that incomes rarely grow in a steady path. That itself throws considerable doubt on the convergence hypothesis. But we find divergence and more divergence. What explains that?

The steady state path of per capita income (e.g., (6) in in Mankiw, Romer, and Weil (1992)) also depends on the initial value *A, A*(0). *A*(0) is not just the initial level of technology but non-augmentable "resource endowments, climate, institutions, and so on; it may therefore differ across countries." Mankiw, Romer, and Weil (1992, p. 411). They assume ln *A (O)* = $a + \varepsilon$, where *a* is a constant and ε is a country-specific shock. That is, they assume there are no systemic differences between countries. The analysis and explanation of divergence then amounts to an analysis and explanation of the hard task of systematic initial differences among countries.

Some of the limitations of our analysis may be noted. Durlauf, Johnson and Temple (2005), in their Appendix B, list hundreds of right-hand variables that have been found statistically

significant in cross-country growth (not convergence) regressions. We have not examined which of these explain divergence and more divergence since 1960 (and attempted to tackle their estimation problems). We cannot use a country after its income exceeds the benchmark country's income (because its log will be undefined). However, according to our data, there are only three such countries - out of a total of 128. Further, the objective is to compare the convergence rates **to** the benchmark country's income (not to exceed it). Another limitation is that we have not used alternative human capital data. The convergence rate is the annual compound rate. The starting date of data for some countries for the 1960s decade is later than 1960 – it is the first year since 1960 when data became available for a country.

## 4. Conclusions

This paper first summarizes the not so well understood difference between relative convergence and convergence from Kant (2019, 2025) and that faster growth or β-convergence means an increase in income ratio – not a reduction in income gap. We define convergence rate as the rate of growth of the income gap (not of income - as instead used in β-convergence) and use it to test the convergence hypothesis. Using the recently available PWT data from 1960 to 2023, we find unconditional divergence decade after decade – not converging to convergence as found Kremer, Willis, and You, (2022). That is, the lower the initial income, the lower is the convergence rate or higher is the divergence rate. We demonstrate that global divergence and more divergence in subsequent decades neither depends on countries in an income quartile nor in any major geographical region of the world. It holds even after controlling for population growth rates, investment proportions, and human capital. Only three (Norway, Ireland, and Singapore) out of 128 countries converge to the Swiss income during 1960 to 2023 – Norway during the 1990s and Ireland, and Singapore during the 2010s. All these countries, as well as Switzerland, are small

economies throwing doubt on the scale-economies based endogenous growth theory of Romer (1986).

The task ahead is to undertake the difficult task of why there has been divergence decade after decade since 1960 and why Divergence, Big Time (Pritchett, 1997) has continued. Anecdotal evidence suggests that there has been a spread of modernization, communications and information across the world since 1950/1960 as compared to the pre-War world. The question is why these positive developments have not put a stop to divergence.

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**Table 1**
**Divergence and More Divergence, Unconditional**
**Average Annual Divergence in Next Decade**

| | Coeff. | Std. Err. | N | Y.F.E. |
|---|---|---|---|---|
| 1960 ln GDPpc X ln 1960 | 0.018*** | [0.007] | 100 | Yes |
| ln 1960 | -0.544*** | [0.054] | | |
| 1970 ln GDPpc X ln 1970 | 0.067*** | [0.016] | 112 | Yes |
| ln 1970 | -0.634*** | [0.112] | | |
| 1980 ln GDPpc X ln 1980 | 0.023*** | [0.010] | 112 | Yes |
| ln 1980 | -0.406*** | [0.083] | | |
| 1990 ln GDPpc X ln 1990 | 0.070*** | [0.015] | 127 | Yes |
| ln 1990 | -0.620*** | [0.125] | | |
| 2000 ln GDPpc X ln 2000 | 0.074 | [0.058] | 127 | Yes |
| ln 2000 | -0.684 | [0.471] | | |
| 2012 ln GDPpc X ln 2012 | 0.023*** | [0.007] | 125 | Yes |
| ln 2012 | -0.299*** | [0.061] | | |

Note: Divergence and more divergence is shown by the positive slope coeffieicnt throughout. The rates for the start years 2000 and 2012 are for the 2000-2012 and 2012-2023 periods, respectively. Clustered standard errors are used. Y.F.E. stands for year fixed effects. The following countries are deleted from the sample as they reach the Swiss per capita income during the stated and later periods: Norway from the 1990s and Ireland and Singapore in the 2010s.

**Table 2**
**Divergence and More Divergence, Conditional**
**Average Annual Convergence/Divergence in Next Decade**

| | Coeff. | Std. Err. | N | Y.F.E. |
|---|---|---|---|---|
| 1960 ln GDPpc X ln 1960 | -0.001 | [0.007] | 100 | Yes |
| ln Pop. Growth Rate, 1960s | -1.935*** | [0.351] | | |
| ln Inv./GDP, 1960s | 0.121** | [0.052] | | |
| 1970 ln GDPpc X ln 1970 | 0.048*** | [0.013] | 112 | Yes |
| ln Pop. Growth Rate, 1970s | -1.420 | [0.901] | | |
| ln Inv./GDP, 1970s | 0.132 | [0.105] | | |
| 1980 ln GDPpc X ln 1980 | -0.002 | [0.011] | 112 | Yes |
| ln Pop. Growth Rate, 1980s | -1.576*** | [0.475] | | |
| ln Inv./GDP, 1980s | 0.177** | [0.088] | | |
| 1990 ln GDPpc X ln 1990 | 0.084*** | [0.018] | 127 | Yes |
| ln Pop. Growth Rate, 1990s | 1.813*** | [0.540] | | |
| ln Inv./GDP, 1990s | 0.428* | [0.179] | | |
| 2000 ln GDPpc X ln 2000 | 0.092 | [0.092] | 127 | Yes |
| ln Pop. Growth Rate, 2000-2012 | 2.693 | [3.960] | | |
| ln Inv./GDP, 2000-2012 | 0.693 | [0.602] | | |
| 2012 ln GDPpc X ln 2012 | 0.003 | [0.009] | 125 | Yes |
| ln Pop. Growth Rate, 2012-2023 | -0.986*** | [0.347] | | |
| ln Inv./GDP, 2012-2023 | 0.447*** | [0.124] | | |

Note: Divergence and more divergence, conditional, is shown by the mostly positive and statistically significant coeffieicnt on initial income (where the negative coefficients are about zero) with controls of population growth and gross capital formation. 0.05 is added to the population growth rates for labor-augmenting technical progress and depreciation. Clustered standard errors are used. Y.F.E. stands for year fixed effects. The following countries are deleted from the sample as they reach the Swiss per capita income during the stated and later periods. Norway from the 1990s and Ireland and Singapore in the 2010s.

**Table 3**
**Divergence and More Divergence, Conditional With Human Capital**
**Average Annual Convergence/Divergence in Next Decade**

| | Coeff. | Std. Err. | N | Y.F.E. |
|---|---|---|---|---|
| 1960 ln GDPpc X ln 1960 | -0.008 | [0.010] | 100 | Yes |
| ln Pop. Growth Rate, 1960s | -1.791*** | [0.402] | | |
| ln Inv./GDP, 1960s | 0.111** | [0.053] | | |
| ln Human Capital | 0.237 | [0.336] | | |
| 1970 ln GDPpc X ln 1970 | 0.029* | [0.015] | 112 | Yes |
| ln Pop. Growth Rate, 1970s | -1.041 | [0.768] | | |
| ln Inv./GDP, 1970s | 0.120 | [0.098] | | |
| ln Human Capital | 0.671 | [0.509] | | |
| 1980 ln GDPpc X ln 1980 | -0.005 | [0.017] | 112 | Yes |
| ln Pop. Growth Rate, 1980s | -1.476*** | [0.400] | | |
| ln Inv./GDP, 1980s | 0.176** | [0.088] | | |
| ln Human Capital | 0.133 | [0.372] | | |
| 1990 ln GDPpc X ln 1990 | 0.082*** | [0.021] | 127 | Yes |
| ln Pop. Growth Rate, 1990s | 1.846*** | [0.520] | | |
| ln Inv./GDP, 1990s | 0.423** | [0.189] | | |
| ln Human Capital | 0.082 | [0.384] | | |
| 2000 ln GDPpc X ln 2000 | 0.083 | [0.095] | 127 | Yes |
| ln Pop. Growth Rate, 2000-2012 | 2.928 | [3.936] | | |
| ln Inv./GDP, 2000-2012 | 0.697 | [0.602] | | |
| ln Human Capital | 0.440 | [0.407] | | |
| 2012 ln GDPpc X ln 2012 | -0.004 | [0.010] | 125 | Yes |
| ln Pop. Growth Rate, 2012-2023 | -0.881** | [0.354] | | |
| ln Inv./GDP, 2012-2023 | 0.452*** | [0.125] | | |
| ln Human Capital | 0.320* | [0.186] | | |

Note: Divergence and more divergence, conditional, is shown by the mostly positive and statistically significant coeffieicnt on initial income (where the negative coefficients are about zero) with controls of population growth, gross capital formation, and human capital. 0.05 is added to the population growth rates for labor-augmenting technical progress and depreciation. Clustered standard errors are used. Y.F.E. stands for year fixed effects. The following countries are deleted from the sample as they reach the Swiss per capita income during the stated and later periods: Norway from the 1990s and Ireland and Singapore in the 2010s.

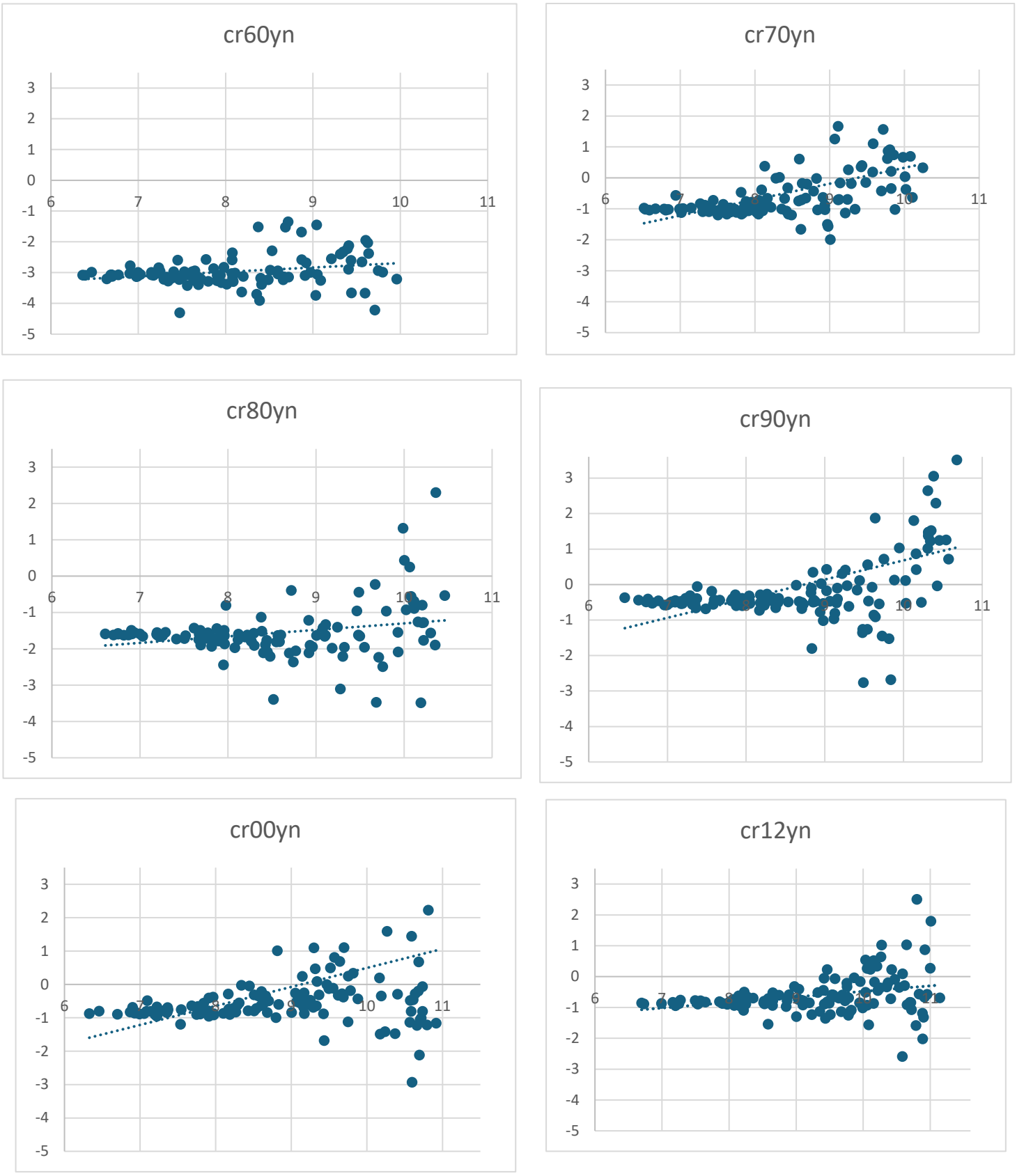



Figure 1
Divergence and More Divergence, 128 Countries

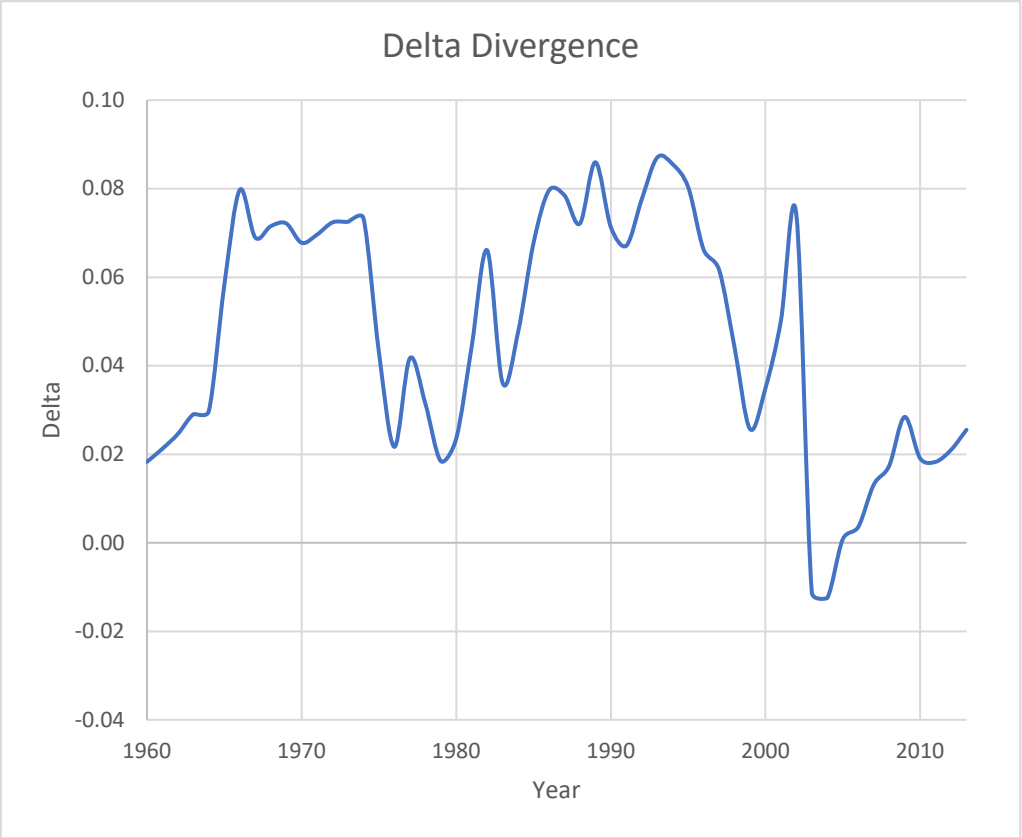



Fig. 2. Treand in income divergence, 1960-2013.

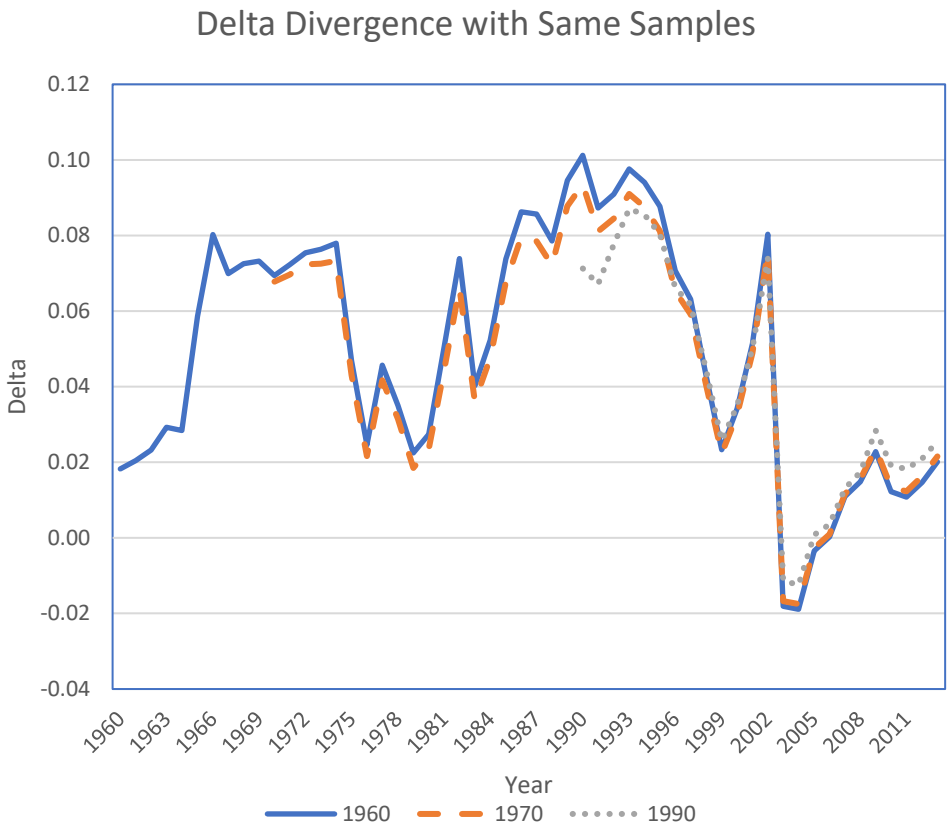



Fig. 3. Robustness of income divergence to same samples

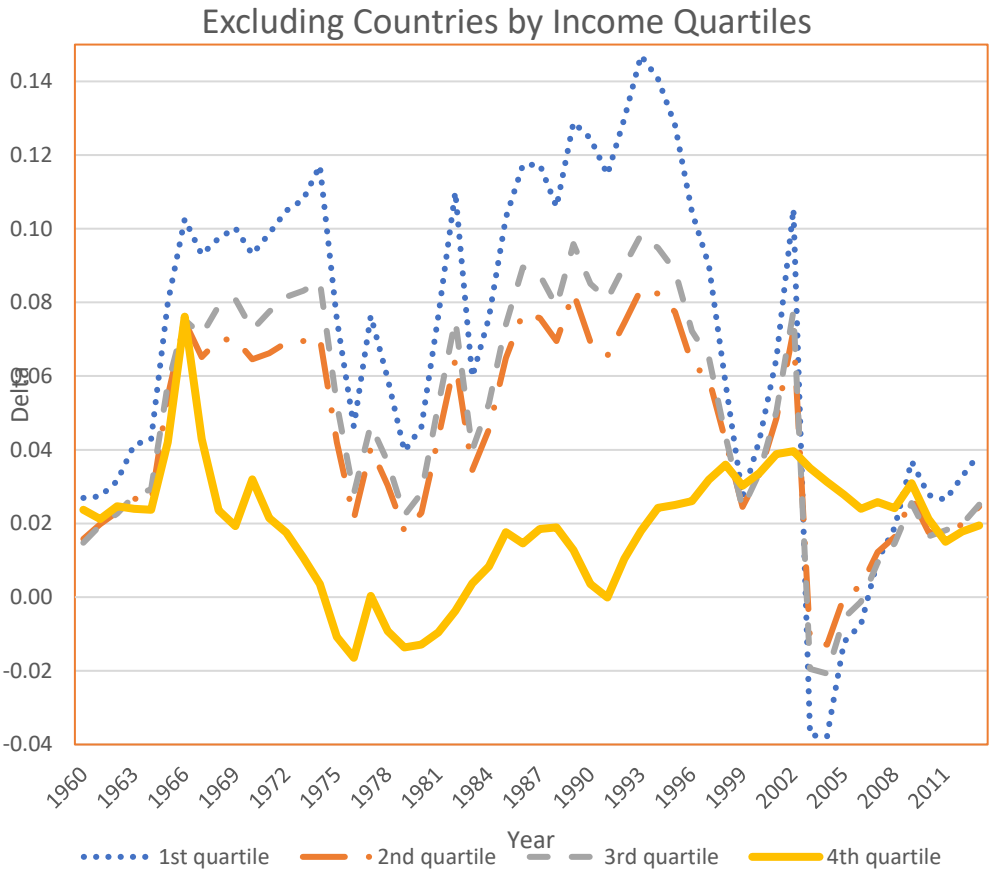



Fig. 4. Income divergence when excluding countries by income quartiles, where the first quartile is the poorest

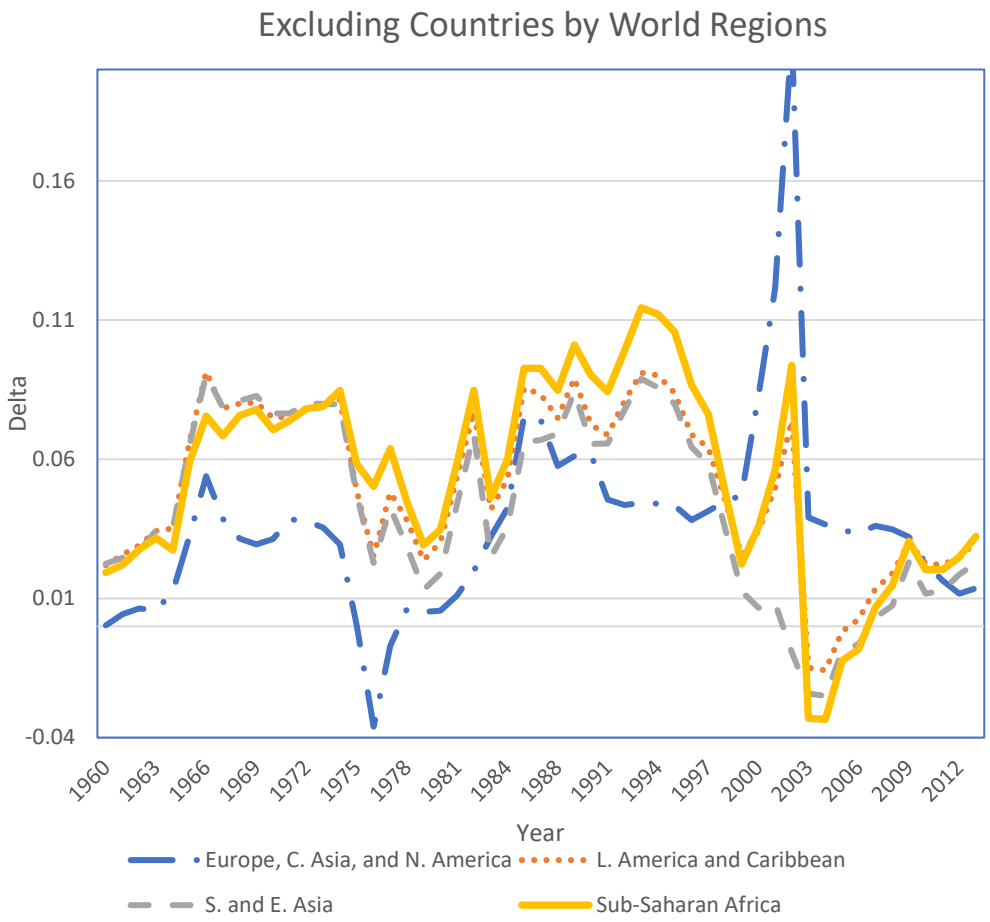



Fig. 5. Income divergence when excluding countries by world regions