Review of Income and Wealth
Series 51, Number 3, September 2005

GROWTH AND CONVERGENCE: A SOCIAL WELFARE FRAMEWORK

BY QUENTIN WODON

AND

SHLOMO YITZHAKI*

World Bank and Hebrew University

This paper proposes a social welfare framework in which to analyze the relationships between growth, trends in inequality, mobility, and social welfare. An application of the framework to worldwide and regional data on per capita GDP suggests a lack of convergence at the world level, opposite trends in convergence in various regions of the world, and a fairly low level of mobility or re-ranking between countries over time.

1. INTRODUCTION

Two main concepts of convergence have been used in the literature: β-convergence and σ-convergence. There is σ-convergence if the dispersion of per capita income, as expressed by the variance of the logarithms, between countries or regions falls over time. According to Sala-i-Martin (1996, p. 1327), "there is β-convergence . . . if we find a negative relationship between the growth rate of income per capita and the level of initial level of income." The idea of β-convergence has emerged from assumptions of the neo-classical growth model, and it has been observed in several empirical studies, starting with Barro (1991) and Barro and Sala-i-Martin (1992). However, a number of authors (e.g. Friedman, 1992; Quah, 1993, 1996; Caselli *et al.*, 1996; Bliss, 1999; Cannon and Duck, 2000) have argued that there may have been measurement errors in estimates of β-convergence, and that the concept of β-convergence itself may be less important than σ-convergence, since in the end the main interest is whether the world distribution of income becomes more equal over time.

In this paper, we focus on σ-convergence, but we also discuss the issue of mobility, which is related to β-convergence. A key issue is that whether σ-convergence is actually observed or not may depend on the measure of dispersion or inequality used. For example, using GDP per worker data for 121 countries, Dalgaard and Vastrup (2001) show that the coefficient of variation and the variance of the logarithm suggest different trends in inequality. It could then be a matter of judgment as to which measure of inequality to use. However, the problem with such an approach is that not all measures of inequality are equally attractive. While most empirical studies on σ-convergence rely on the variance of the logarithm of per capita GDP, this measure does not respect basic properties expected from an

*Correspondence to: Shlomo Yitzhaki, Department of Economics, Hebrew University, Jerusalem, 91905, Israel (shlomo.yitzhaki@huji.ac.il).

inequality measure, such as being consistent with the Lorenz ordering (Foster and Ok, 1999). In order to deal with the choice of inequality measure in the analysis of growth and convergence, we propose to use a social welfare framework.

The reason for using a social welfare framework is that from a policy point of view, growth and convergence matter only to the extent that they affect the welfare of populations. But the question then is how to choose a specific welfare framework. As noted by Wodon and Yitzhaki (2002), social welfare functions tend to have three fundamental properties: they weight the welfare of various individuals (or in our case countries) differently in a reasonable way, for example according to per capita GDP or the rank of the country in the world distribution of income; they respect Pareto's principle, so that a gain in a country obtained without decreasing well-being elsewhere leads to higher overall welfare; and they assume (at some order of stochastic dominance) that an income transfer from a richer country to a poorer one is believed to increase social welfare.

While these three principles restrict the admissible set of social welfare functions, many alternatives remain. In order to obtain a complete ordering of states of the world, we must assume that the marginal utility of per capita GDP is derived from a specific inequality measure. Then, social welfare W can be written as the product of mean income μ times one minus the inequality measure. If the Gini index is used, this yields $W = \mu(1 - G)$. The advantage of using the Gini is that it has attractive properties. Firstly, the Gini respects properties of welfare dominance, which correspond to the three basic principles outlined above. Secondly, the welfare function $W = \mu(1 - G)$ is consistent with the Relative Deprivation Theory put forward by Runciman (1966) according to which individuals (or countries) care not only about their own income, but also about how they compare to others (which is a reasonable assumption in the age of globalization). Thirdly, the Gini and associated parameters have attractive statistical properties, including empirical robustness to outliers, and an ability to place more or less weight on comparatively poorer countries, which is useful to account for various preferences, while keeping the properties of the Gini related to welfare dominance and relative deprivation theory. Fourthly, because the Gini is based on a covariance formula, one can use the properties of the covariance, to make direct links between growth, inequality, and welfare.

An additional advantage in our suggested framework is the use of the decomposition technique. The framework used details the relationship between all concepts used so that they have to fulfill a basic identity, which is the value of the social welfare function that is decomposed. In this sense, they form sufficient statistics for describing the social welfare function. As a result, there is no danger of double counting or omitting an important concept. The weakness of our approach is that it is a static framework. It describes the starting and the final values of the social welfare function. Unlike β-convergence, which is rooted in growth theory, our suggested method does not offer explanations. It serves as an accounting method that shows the differences between the starting and final periods.

Our multi-period social welfare framework is presented in Section 2. For convenience, social welfare is defined as average welfare over two (or more) periods of time, so that it depends on first period income, economic growth, inequality in each period, and mobility from one period to the next. We interpret σ-convergence as a reduction in instantaneous inequality over time, as measured by the Gini (or extended Gini) index of inequality, and we replace the concept of β-convergence with the Gini index of mobility in per capita income over time, showing that there need not be any binding connection between the two concepts.

The framework is then illustrated empirically in Section 3 using data on country per capita GDP from 1960 and 1998. The main finding is a lack of convergence at the world level, opposite trends in convergence in various regions of the world, and a fairly low level of mobility or re-ranking between countries over time. A brief conclusion follows.

2. Social Welfare Framework

Many empirical studies on convergence rely on the variance of the logarithm of per capita GDP as the measure of dispersion or inequality. A reasonable requirement from an inequality measure is to be sensitive to the Dalton criterion, which says that a transfer from a rich person or country to a poor one that does not affect their rankings should reduce inequality. Unfortunately, as shown by Hart (1975), the variance of the logarithm fails to meet this criterion. Furthermore, Foster and Ok (1999) show that the variance of the logarithm is not Lorenz-consistent and that the probability of a failure to meet the criterion is not negligible. The Gini index used here does not have these weaknesses, and it benefits from solid theoretical foundations.

Consider a group of countries living for two periods and earning income in both periods. The generalization to n periods will be straightforward. The wealth of each country h over the two periods is defined as $w_h = (Y_{1h} + \beta Y_{2h})$, where β is a discounting factor and Y_{ih} is the income per capita of country h in period $i = 1, 2$. To measure the satisfaction derived from income, we assume that a global social planner (say, a multilateral organization) has the following social welfare function:

$$W(w_1, \ldots, w_H) = \mu_w (1 - G_w), \tag{1}$$

where G_w is the Gini index of inequality in wealth w, and μ_w is the world's mean wealth. This social welfare function was originally suggested and interpreted by Sen (1976) and empirically used in Klasen (1994) and Park and Brat (1995). It can also be interpreted as derived from the theory of relative deprivation (Runciman, 1966), which is a sociological theory explaining the feelings of deprivation among individuals in the society (Yitzhaki, 1979, 1982). It can be extended to country-level deprivation in a world subject to globalization (Wodon and Yitzhaki, 2004). The Gini can also be derived as an inequality measure from axioms on social justice (Ebert and Moyes, 2000). The concepts leading to equation (1) can be also traced to Atkinson's (1970) idea of Equally Distributed Equivalent income, so that the value of the social welfare function is equal to mean income minus the premium subtracted for having an unequal income distribution.[1]

In our social welfare framework, assuming that countries assess their level of well-being not only in absolute terms (i.e. how much income per capita they have),

[1]An anonymous referee has pointed out that the elasticity of welfare with respect to μ is 1, while the elasticity with respect to inequality is $G_w/(1 - G_w)$. The latter approaches infinity when inequality approaches one. This is so because when inequality approaches one, welfare converges to zero.

but also in relative terms (i.e. how much do they have in comparison to other countries), then a between-country Gini index of 0.5 combined with a mean per capita GDP in the world of \$1,000 generates a level of social welfare of \$500. This would be higher than the level of welfare obtained, say, with a world average per capita GDP of \$800 and a Gini index of 0.40, yielding a social welfare of \$480. While this type of comparison depends on the distributional weighting structure implicit in the use of the Gini, it can be generalized to other weighting structures by using the "extended" Gini (Yitzhaki, 1983), instead of the standard Gini.

Now, denote by μ_i the mean income of the world in period i, by $g = \mu_2/\mu_1$ the rate of growth of world income between the two periods, by G_i the Gini index of inequality in period i, and by $s_1 = \mu_1/\mu_w$ and $s_2 = \beta\mu_2/\mu_w$ the shares of average income in each period. β is a discounting factor assumed to be equal to one. While G_i gives a snap-shot of income inequality, G_w is the inequality in average (or permanent) income, or wealth. Assuming that Y_1, Y_2, and w are exchangeable up to a linear transformation, it is shown in Appendix 1 that the following holds:

$$\mu_w(1-G_w) = \mu_1(1+\beta g)\frac{1-(s_1G_1+s_2G_2)^2+2s_1s_2G_1G_2(1-\Gamma)}{1+G_w}, \tag{2}$$

where Γ is the Gini correlation coefficient between the incomes of the two periods (defined in appendix 1).

Equation (2) enables us to see the role played by three different components: growth, instantaneous inequality, and mobility. Growth is measured by g. The higher the growth, the higher the level of welfare is. In general, growth needs not be related to inequality (G) or mobility ($1 - \Gamma$), but if there is such a relationship, and if this relationship is known, it can be handled by the analyst. For example, if it is believed that growth leads to higher inequality, a functional form for the inequality in the second period as a function of the growth rate could be proposed.

Convergence occurs if G_2 is smaller than G_1. Since a lower inequality in the second period improves average welfare, convergence is obviously a good thing. But in equation (2), no a priori specific assumption is made about convergence.

Mobility is measured by $1 - \Gamma$, which is the Gini mobility index (Yitzhaki and Wodon, 2004). Since the Gini correlation Γ is bounded by minus one and one, the Gini index of mobility is always non-negative, and the higher the mobility, the higher average welfare is.

Assuming that the ranking of each country is identical in the two periods (i.e. $1 - \Gamma = 0$), equation (2) becomes:

$$\mu_w(1-G_w) = \mu_1(1+\beta g)(1-(s_1G_1+s_2G_2)). \tag{3}$$

In equation (3), the Gini of wealth is simply the average of the Ginis for the two periods. An absence of re-ranking over time is observed (among other possibilities) if, for example, country growth rates are monotonic increasing functions of initial income levels. Growth rates can also be a decreasing function of initial income, provided that the initial differences in incomes are sufficiently large to prevent re-ranking. Even if there is no mobility ($\Gamma = 1$), there may be an increase or decrease in inequality over time. By contrast, when $\Gamma < 1$, growth is not a monotonic function of initial income and growth is large enough for countries to switch ranks. If $\Gamma = 0$, then first and second period incomes are statistically independent.

$\Gamma < 0$ implies that countries with high income tend to change ranks with those with low income. $\Gamma = -1$ is the perfect switching of positions. That is, the richest country becomes the poorest, the second from top becomes the second from bottom, etc.

To derive equation (2) we have assumed that the distributions of Y_1, Y_2 and w are exchangeable up to a linear transformation. Exchangeability between two variables y_1 and y_2 means that the joint cumulative distribution has the property that $H(y_1, y_2) = H(y_2, y_1)$. Exchangeability up to linear transformation means that the initial distribution y_1 can be of any shape, but y_2 has to have a distribution, which deviates in its shape from y_1 by a linear transformation only. An example of such distributions is the multi-normal, or the lognormal provided that the variances of the logarithm in both periods are equal. Countries can switch positions in the distribution, which means that the correlation between the two periods can be of any magnitude. Since the shape of the world income distribution in each year tends to be stable, exchangeability seems to be a reasonable assumption to start with. However, it may be violated in the data, in which case it can be used as an approximation only. The symmetry required by exchangeability is needed to avoid an index number problem. That is, the choice of the base period, whether it is the initial year or the final year, will not affect our findings if the variables are exchangeable (this yields $\Gamma_{21} = \Gamma_{12} = \Gamma$).

As shown in Appendix 1, three exchangeability assumptions are needed to derive equation (2). The assumptions are related to the equality of the Gini correlations: (a) between Y_1 and w; (b) between Y_2 and w; and (c) between Y_1 and Y_2. For example, if (Y_1, Y_2) are not exchangeable, then the two Gini correlation Γ_{12} and Γ_{21} are not equal. In this case, we must substitute Γ in equation (2) by $(\Gamma_{12} + \Gamma_{12})/2$ for the equation to continue to hold. A failure to meet the other two exchangeability (up to linear transformation) assumptions, for (Y_1, w) and (Y_2, w), require the addition of terms to equation (2), which becomes:

$$(4) \quad \mu_w(1-G_w) = (\mu_1/2)(1+\beta g)\frac{1-(s_1G_1+s_2G_2)^2 + s_1s_2G_1G_2(2-(\Gamma_{12}+\Gamma_{21})+V_2)}{1+G_w}.$$

In this equation, the term V_2 accounts for the violation of the exchangeability assumptions between Y_1 and w, as well as Y_2 and w, and the subscript 2 refers to the fact that we are dealing with two periods. The exact specification of V_2 is given in Appendix 1.

Finally, it should be emphasized that equations (2) and (4) are statistical "accounting" identities that are not derived by an economic theory. As far as we can see, it is an organization of the changes in the facts that are relevant the measurement of welfare that occurred over a given period of time. Conjectures that are derived from economic growth theory can offer relationships among the components of these accounting identities.

3. Empirical Illustration

In our framework, social welfare, defined as average welfare over two (or more) periods of time, depends on first period income, growth, inequality in each period, and mobility from one period to the next. In this section, we estimate all the parameters of the decomposition (4) using data on per capita income from the

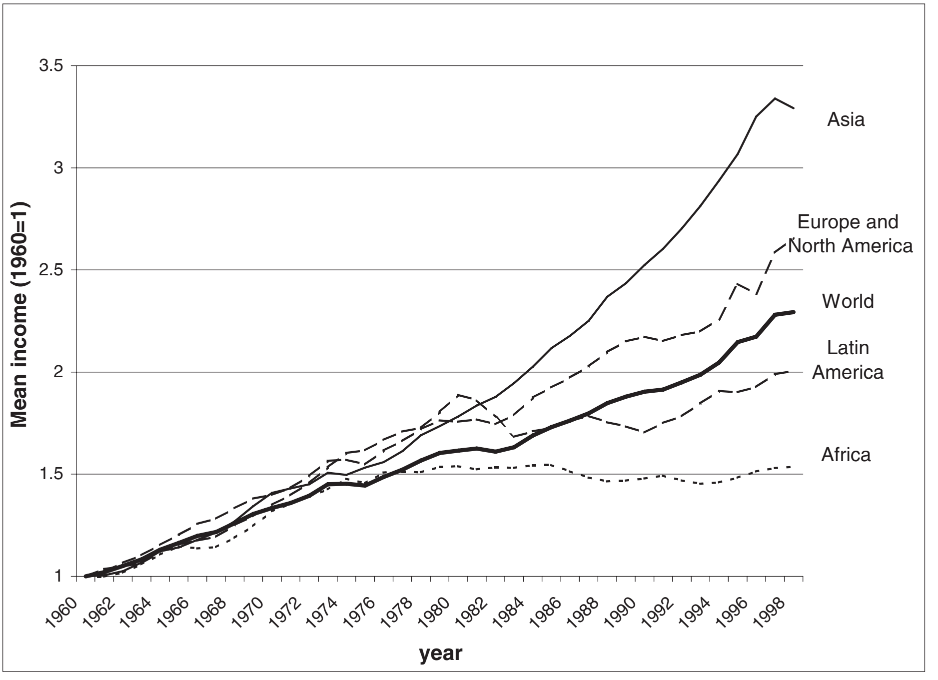

Figure 1. Mean Income by Region, 1960–1998

6th release of the Penn World Tables. Our analysis is based on a sample of 103 countries (list given in Appendix 2), which are allocated to four regions (Africa, Asia, Europe and North America, and Latin America). Those are the countries for which we have data from 1960 to 1998. A different set of countries could have been used, and this could have generated different results, but since our purpose is mainly methodological, we will not test systematically for the impact of including or deleting some countries from the sample. We use real per capita GDP based on the chain method, in 1996 prices. The weights are based on country population (with the correction proposed by Lerman and Yitzhaki, 1989).

Figure 1 provides the trend in mean per capita income for the world as a whole and the various regions, with 1960 as the reference period. That is, the figure provides the value of g in equation (4). As is well known, Asia has the best, and Africa the worst performance, especially since the mid 1980s. Figure 2 provides the trend in inequality as measured by the Gini index of inequality. At the world level, with our sample of countries, there was an increase in inequality from 1960 to the mid 1970s, and a decrease thereafter. In Figure 2, one can hardly speak of convergence. Whether inequality has fallen or not depends on the periods chosen for the comparison, and overall, the changes in inequality tend to be small. The picture is different at the regional level. In Europe and North America, and in Latin America, between-country inequality has been reduced over time, while in Africa and in Asia (at least until the 1980s), it has been increased.

The components of the decomposition (4) are given in Table 1 for the average welfare over two periods, 1960 and 1998. While in Figures 1 and 2 we allowed the

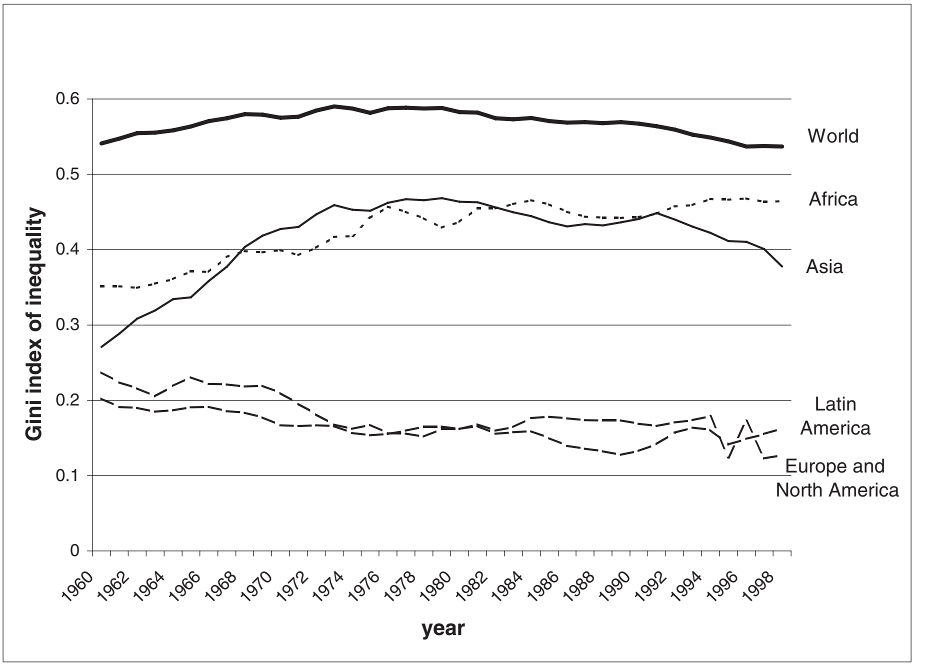

Figure 2. Between-country Inequality, by Region, 1960–1998

population weights to change over time, in Tables 1 and 2, we use the same population weights for both periods. Table 1 gives the decomposition for the world as a whole, with the initial population weights, the final population weights, and equal weights for all countries. The treatment of the weights affects the conclusions as to whether inequality has increased or not over time. For example, if the data were to be used in a regression setting, where weights tend not to be taken into account, inequality might be found to increase dramatically over time, from a Gini of 0.45 at the beginning of the period to a Gini of 0.546. But this is not the case to any large extent with the initial or final population weights which report a small increase and a small decrease in Gini. Also note that the Gini correlations between 1960 and 1998 are very high, suggesting that there is fairly little re-ranking between countries at the world level, even over a period of almost 40 years (in general, a longer period leads to more re-ranking, and thereby a smaller Gini correlation).

The bottom part of Table 1 presents the decomposition in a different format in order to see the impact of growth, changes in inequality, and mobility on social welfare. The idea is to compute the ratio of average welfare over initial welfare, and to highlight the gains in welfare from three factors: the impact of growth, the impact of changes in inequality, and the impact of mobility or re-ranking. For this, we use the following formula:[2]

[2]Equation (5) can also be viewed as a variation of a way to introduce distribution-sensitive growth rates (Klasen, 1994, p. 259, referred to as Gini 1, and also used in Grün and Klasen, 2003, p. 623). The contribution of (5) is by also addressing the role of mobility.

TABLE 1

DECOMPOSITION OF SOCIAL WELFARE, CROSS-COUNTRY, 1960 AND 1998, WORLDWIDE

	Initial Population Weights (1960)	Final Population Weights (1998)	Equal Weights for All Countries
Gini indices of inequality			
G_{1960}	0.5411	0.5229	0.4526
G_{1998}	0.5351	0.5369	0.5464
G_w	0.5314	0.5265	0.5071
Mean income			
1960	3,082	2,582	3,419
1998	8,594	7,067	8,572
Average income *w*	5,838	4,825	5,996
Gini correlations			
1960 and 1998	0.9479	0.9381	0.8700
1998 and 1960	0.9457	0.9233	0.8384
1960 and average	0.9718	0.9617	0.9270
Average and 1960	0.9697	0.9552	0.9003
1998 and average	0.9968	0.9968	0.9920
Average and 1998	0.9960	0.9961	0.9917
Decomposition eq. (5)			
Growth effect	1.8943	1.8685	1.7537
Inequality effect	1.0211	0.9924	1.2300
Convergence effect	1.0131	0.9828	0.8848
Mobility effect	0.0080	0.0096	0.3452
Total effect	1.9343	1.8542	2.1571

Source: Authors' estimation from Penn World Table, version 6. Total of 103 countries (Africa 45, Asia 18, Latin America 21, Europe and North America 19.)

$$(5) \qquad \frac{\mu_w(1-G_w)}{\mu_1(1-G_1)} = (1+\beta g)\left(\frac{1-(s_1G_1+s_2G_2)^2}{(1-G_1)(1+G_w)} + \frac{2s_1s_2G_1G_2(1-\Gamma)}{(1-G_1)(1+G_w)}\right),$$

The growth effect, at 1.8–1.9 depending on the weights used for the computation, is large. By contrast, there is little convergence-related effect since G_2 does not differ very much from G_1 when population weights are used, suggesting little or no positive contribution to welfare from reduction in inequality over time. The impact of mobility on welfare is necessarily positive (since mobility means that previously poorer countries do better than previously richer countries, thereby equalizing welfare over time), but it is also very small when population weights are used, simply because mobility is limited ($1 - \Gamma$ close to zero). Hence the main contribution of growth on world social welfare is in its effect on the growth of incomes. The impacts of convergence and mobility are negligible.

Since much of the work on convergence has taken place at the regional level, results for four regions are provided in Table 2 using initial population weights (the results do not change very much using final weights). As already mentioned, inequality between countries decreased in Europe/North America and in Latin America, and increased in Africa and in Asia. The Gini correlations are lower in Latin America and Africa, perhaps because countries in these two regions have been more affected by aggregate income shocks than countries in the other regions.

TABLE 2

Decomposition of Social Welfare, Cross-Country, 1960 and 1998, by Region

	Africa	Asia	Latin America	Europe and North America
Gini indices of inequality				
G_{1960}	0.3517	0.2709	0.2371	0.2021
G_{1998}	0.4624	0.4157	0.1669	0.1264
G_w	0.4084	0.3801	0.1786	0.1449
Mean income				
1960	1,701	1,297	3,511	9,523
1998	2,706	4,759	7,248	25,055
Average income	2,203	3,028	5,379	17,289
Gini correlations				
1960 and 1998	0.8805	0.8968	0.7573	0.9375
1998 and 1960	0.8361	0.9191	0.6045	0.9490
1960 and average	0.9415	0.9222	0.9079	0.9719
Average and 1960	0.9135	0.9427	0.8137	0.9836
1998 and average	0.9884	0.9996	0.9639	0.9920
Average and 1998	0.9878	0.9965	0.9575	0.9918
Decomposition eq. (5)				
Growth effect	1.2954	2.3339	1.5321	1.8156
Inequality effect	0.9125	0.8503	1.0766	1.0717
Convergence effect	0.9023	0.8468	1.0720	1.0710
Mobility effect	0.0102	0.0035	0.0046	0.0007
Total effect	1.1820	1.9845	1.6494	1.9457

Source: Authors' estimation from Penn World Table, version 6. Total of 103 countries (Africa 45, Asia 18, Latin America 21, Europe and North America 19.) Based on initial 1960 weights.

Yet overall, the impact of mobility and changes in inequality, on social welfare remain very small in comparison to the impact of growth.

4. Conclusion

This paper has proposed an alternative yet simple social welfare framework with which to analyze the relationships between growth, inequality, and mobility. The framework relies on the Gini indices of inequality and mobility, and it allows the analyst to assess the impact of growth, σ-convergence, and mobility on average social welfare over time. An application of the framework to worldwide and regional data on per capita GDP suggests a lack of convergence at the world level, opposite trends in convergence in various regions of the world, and a fairly low level of mobility or re-ranking between countries over time.

One weakness in the methodology used in this paper is the reliance on a specific measure of inequality, the Gini index. Further research is needed in order to extend the same methodology to include alternative measures of inequality so that a sensitivity analysis with respect to the choice of the measure of inequality can be performed. A first step in this direction is offered in Schechtman and Yitzhaki (2003), who applied the basic decomposition that is used in this paper, to the extended Gini inequality index.

Appendix 1: Proof of Equations (2), (3), and (4)

Wodon and Yitzhaki (2003) have proved the following proposition with respect to the decomposition of the Gini coefficient of a sum of random variables.

Let (Y_1, Y_2) be drawn from a bivariate continuous distribution, where Y_i is the income distribution in period i. Let $w = \beta_1 Y_1 + \beta_2 Y_2$, where $\beta_i > 0$ ($i = 1, 2$) is a constant. Denoting by $F(Y_i)$ the cumulative distribution and μ_i the expected income, the Gini coefficient (Pyatt *et al.*, 1980; Lerman and Yitzhaki, 1989) is:

$$G_i = 2\operatorname{cov}(Y_i, F(Y_i))/\mu_i . \tag{A1}$$

Denote by $\Gamma_{ij} = \dfrac{\operatorname{cov}(Y_i, F(Y_j))}{\operatorname{cov}(Y_i, F(Y_i))}$, $i, j = w, 1, 2$, the Gini correlation between incomes from periods Y_i and Y_j, or between income from one period and average income. As discussed in Schechtman and Yitzhaki (1987), the properties of the Gini correlations are a mixture of Pearson's and Spearman's correlation coefficients. In particular, Γ_{ij} is bounded by minus one and one, but Γ_{ij} is not necessarily equal to Γ_{ji}. Define also $D_{iw} = \Gamma_{iw} - \Gamma_{wi}$, for $i = 1, 2$ (here, the Gini correlations are taken between the income in each of the two periods and the average income over time), and $s_i = \beta_i (\mu_i/\mu_0)$, where $\mu_i > 0$ and $\beta_1 = 1$.

Proposition

(a) The following identity holds:

$$G_w^2 - [s_1 D_{1w} G_1 + s_2 D_{2w} G_2] G_w = s_1^2 G_1^2 + s_2^2 G_2^2 + s_1 s_2 G_1 G_2 (\Gamma_{12} + \Gamma_{12}). \tag{A2}$$

(b) Provided that $D_{iw} = 0$, for $i = 1, 2$, and $\Gamma_{12} = \Gamma_{21} = \Gamma$, which corresponds to exchangeability, then:

$$G_w^2 = s_1^2 G_1^2 + s_2^2 G_2^2 + 2 s_1 s_2 G_1 G_2 \Gamma. \tag{A3}$$

The extension of equations (A2) and (A3) to k periods is trivial. If $w = \Sigma_{i=1}^{k} s_i Y_i$, then:

$$G_w^2 - G_w \sum_{i=1}^{k} s_i D_{iw} G_i = \sum_{i=1}^{k} s_i^2 G_i^2 + \sum_{i=1} \sum_{i \neq j} s_i s_j G_i G_j \Gamma_{ij}. \tag{A4}$$

If $D_{iw} = 0$, for $i = 1, \ldots, k$ and $\Gamma_{ij} = \Gamma_{ji}$, then:

$$G_w^2 = \sum_{i=1}^{k} s_i^2 G_i^2 + 2 \sum_{i=1}^{k} \sum_{i<j} s_i s_j G_i G_j \Gamma_{ij}. \tag{A5}$$

Using the proposition, proving equations (2), (3), and (4) is trivial. For equation (2), we must show that under exchangeability:

$$\begin{aligned} \mu_w (1 - G_w)(1 + G_w) &= \mu_1 (1 + \beta g)(1 - s_1^2 G_1^2 - s_2^2 G_2^2 - 2 s_1 s_2 G_1 G_2 \Gamma) \\ &= \mu_1 (1 + \beta g)[(1 - (s_1 G_1 + s_2 G_2)^2 + 2 s_1 s_2 G_1 G_2 (1 - \Gamma)], \end{aligned}$$

where $\mu_w = \mu_1 + \beta\mu_2 = \mu_1(1 + \beta g)$. This result is obtained directly from equation (A3).

Equation (11) is obtained with $\Gamma = 1$, in which case:

$$\mu_w(1-G_w)=\mu_1(1+\beta g)[(1-(s_1G_1+s_2G_2)].$$

In equation (4), the term V is derived from (A2) as:

$$V=G_w\sum_{i=1}^{2}s_iD_{iw}G_i$$

Appendix 2: List of Countries Used in the Estimation

Algeria
Angola
Argentina
Australia
Austria
Bangladesh
Belgium
Benin
Bolivia
Botswana
Brazil
Burkina Faso
Burundi
Cameroon
Canada
Cape Verde
Central African Republic
Chile
China
Colombia
Comoros
Congo
Costa Rica
Cote d'Ivoire
Denmark
Dominican Republic
Ecuador
Egypt
El Salvador
Equatorial Guinea
Ethiopia
Finland
France
Gabon
Gambia
Ghana
Greece
Guatemala
Guinea
Guinea-Bissau
Guyana
Honduras
Hong Kong
Iceland
India
Indonesia
Iran
Ireland
Israel
Italy
Jamaica
Japan
Jordan
Kenya
Korea, Rep.
Lesotho
Luxembourg
Madagascar
Malawi
Malaysia
Mali
Mauritania
Mauritius
Mexico
Morocco
Mozambique
Namibia
Nepal
Netherlands
Nicaragua
Niger
Nigeria
Norway
Pakistan
Panama
Papua New Guinea
Paraguay
Peru
Philippines
Romania
Rwanda
Senegal
Seychelles
Singapore
South Africa
Spain
Sri Lanka
Sweden
Switzerland
Syrian Arab Republic
Taiwan, China
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Togo
Trinidad and Tobago
Turkey
Uganda
United Kingdom
United States
Uruguay
Venezuela
Zambia
Zimbabwe

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