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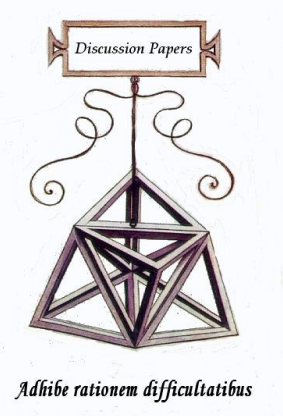

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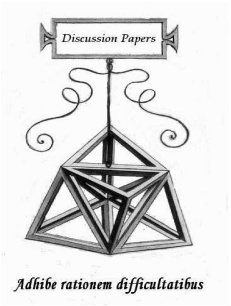

Michele Battisti - Tamara Fioroni - Andrea Mario Lavezzi

World Interest Rates, Inequality and Growth: an Empirical Analysis of the Galor - Zeira Model

Abstract

Following Galor and Zeira (1993), we study the effect of the world interest rate on inequality and growth for the period 1985-2005, characterized by falling world interest rates and cross-country income polarization. We argue that the two phenomena are related on the basis of the following findings, which are in accordance with the predictions of the Galor and Zeira model: 1) a reduction of the world interest rates increases inequality in rich countries and decreases inequality in poor countries; 2) inequality has a negative (and significant) effect on human capital accumulation in rich countries and a positive (but mostly not significant) effect in poor countries; 3) human capital positively affects GDP in both group of countries, in particular with a higher marginal effect in poor countries. The overall effect of these facts is polarization in the world income distribution.

Classificazione JEL: C33, O15, O16, O47
Keywords: Inequality, Human Capital, Economic Growth, Multiple Equilibria, World Interest Rates

Contents

I. Introduction

This paper is a contribution to the literature on income inequality and economic growth (see Galor, 2011, for an exhaustive survey). In particular, we study an aspect of the seminal model of Galor and Zeira (1993) (GZ henceforth) not considered so far: the consequences for within-country and cross-country income inequality of a decrease in the world interest rate, when the main channel connecting inequality and growth is human capital accumulation. The reduction of the world interest rate in the recent decades is a well-documented fact related to the globalization of capital markets (see e.g., Ahrend et al. 2006 and Desroches and Francis, 2010). However, its relationship with within-country income inequality and with the increase in the same period in world income polarization (see, e.g. Quah, 1997) has not been studied so far.[1]

The insights on such relationships provided by the GZ model are the following. Agents can invest in human capital at a fixed cost. Given the decision to invest in human capital, agents can be borrowers or lenders of funds, depending on the level of bequest they receive. Credit markets are imperfect: the borrowers' interest rate is proportionally higher than lenders' interest rate, given by the world interest rate. The dynamics of the model, for a given level of the world interest rate, features multiple equilibria in the level of bequest. The world interest rate impacts on the income of both borrowers and lenders: lenders are affected because their income includes interests; borrowers, instead, are affected in their capacity to invest in human capital and earn higher wages. The resulting level of within-country inequality determines the share of population investing in human capital, the level of production of the economy and, ultimately, the degree of cross-country income

[1]Another strand of the literature, as for example Beaudry and Collard (2006), identifies as the principal cause of the increase in income inequality across countries another aspect of the process of globalization, i.e. the increase in international trade. The basic idea is that capital-abundant countries specialize in high-capital/high-wage industries and therefore disproportionately gain from globalization relative to poor countries that increase employment in less capital-intensive industries.

inequality.

With multiple equilibria, the initial conditions of the within-country income distribution, i.e. its mean (determining if a country is "poor" or "rich"), and its dispersion, are crucial for the long-run dynamics. As shown by Galor (2011), in particular, inequality can be "good for growth" in poor countries, as it allows some agents to escape the the low-bequest equilibrium to invest in human capital, but it can be "bad for growth" in rich countries, because agents outside the basin of attraction of the high-bequest equilibrium cannot accumulate human capital. When the world interest rate changes, therefore, it may have different effects in poor and rich countries.

In this paper we test the empirical predictions of the GZ model on a large sample of countries for the period 1985-2005, a period characterized by falling world interest rate and cross-country income polarization. The main contributions of the paper are the following.

On the theoretical side, we demonstrate that when the world interest rate is sufficiently high, the GZ model features one globally stable equilibrium, but when the world interest rate decreases, multiple equilibria appear. On the empirical side we show that: 1) a reduction of the world interest rates has a different impact on inequality in rich and poor countries: it increases inequality in rich countries, and reduces inequality in poor countries; 2) inequality has a different impact on the accumulation of human capital (specifically in the form of tertiary education) in rich and poor countries. In particular, inequality has a negative and significant effect on human capital accumulation in rich countries, and a positive (but mostly not significant) effect in poor countries. Overall, in the period we study, inequality reduced human capital accumulation in both group of countries below their potential. We show that the net effect is, however, nonconvergence in human capital between the groups. 3) Human capital has positive effect on GDP in both rich and poor countries, but its marginal effect is much higher in poor countries. This supports the claim that the lack of convergence in human capital contributes to the observed lack of convergence in per capita GDP. This facts are in line with the predictions of the

GZ model.

The paper is organized as follows. In Section II. we discuss the existing literature on growth and income distribution; in Section III. we summarize the GZ model and show how a decrease in the world interest rates may cause the appearance of multiple equilibria, and how this can have asymmetric effects on inequality depending on the initial distribution of income. In Section IV. we present the empirical analysis: a set of stylized fact on world interest rates, within-country and cross-country inequality for the period 1985-2005 (Section IV.A.), and the econometric analysis of the relationships of interest (Section IV.B.); in Section V. we consider an alternative channel that may explain our stylized facts based on the "directed technical change" hypothesis (Acemoglu, 2002); Section VI. concludes.

II. Related Literature

The relationship between inequality and economic growth has been analyzed by a large body of literature. The classical approach, based on the Kaldor (1955)'s assumption that the marginal propensity to save of the rich is higher than that of the poor, suggests that inequality is growth-enhancing since it positively affects aggregate savings and therefore physical capital accumulation (Stiglitz, 1969, Bourguignon, 1981).

In the last two decades, the view that inequality is growth-enhancing has been challenged by a a number of theoretical and empirical studies. In particular the literature which emerged since the nineties can be classified into two broad approaches: the credit market imperfection approach and the political economy approach (see Galor, 2011).

The Galor and Zeira (1993) article is the seminal contribution of the first approach. In particular, Galor and Zeira (1993) develop a model based on two fundamental assumptions: i) the presence of credit market imperfections, so that the borrowing interest rate is higher than the lending interest rate for agents wishing to borrow

to invest in human capital, ii) the existence of fixed costs associated to investment in education. These assumptions imply a multiple equilibria dynamics in which the initial distribution of income can affect the level of investment in human capital, the level of skilled and unskilled labor of the economy and aggregate output. In this setting, as noted: "inequality in the distribution of income may have an adverse effect on the growth process in a non-poor economy, whereas inequality may have a beneficial effect on the growth process in poor economies" (Galor, 2011, p. 19)

The Galor and Zeira paper has given rise to a vast literature, as for example Banerjee and Newman (1993), Benabou (1996), Durlauf (1996), Piketty (1997), Maoz and Moav (1999) and Mookherjee and Ray (2003), which based their models on the two fundamental assumptions of the Galor and Zeira model (that is, credit constraints combined with fixed costs for individual investment projects), and provided theoretical support for a positive correlation between equality and economic growth and for a critical role of the initial income distribution on the long-run steady-state equilibrium.[2]

Moreover, in accordance with this approach, Aghion et al. (1999), following Benabou (1996), argue that, in presence of imperfect capital markets, inequality negatively affects economic growth for at least three reasons: it reduces investment opportunities for poor agents, it decreases the effort of the borrowers to accumulate wealth since they must share a fraction of the marginal returns of their effort with lenders, it generates macro-economic volatility because an unequal access to investment opportunities leads to a separation between investors and savers.[3] Finally, the recent paper by Papa-

[2]In the model developed by Piketty (1997), for example, it is the effort level, rather than capital investment, that is indivisible. Mookherjee and Ray (2003), on the other hand prove that multiple equilibria arise from the indivisibility of the returns to education. Banerjee and Newman (1993) assume that fixed costs are associated with entrepreneurial activities rather than to investment in human capital.

[3]This result is based on the assumption that only a fraction of savers can invest in more productive projects. This implies the lack of an equilibrium between supply and demand for investment in more productive technologies. Therefore, a fraction of savings accumulated during the periods of economic expansion becomes idle and has to be invested in a traditional technology, leading the economy into a low-productivity phase. This in turn allows a reduction of the interest rate, that implies a new increase in investment and therefore, a new boom.

georgiou and Razak (2010) exploits the GZ setup to analyze empirically the relationship between inequality and economic growth through the human capital channel. Using a two-stage specification, where the instruments for education are the gini index and a dummy variable for poor countries, they find strong evidence of a negative relationship between inequality and economic growth.

The political economy approach developed, among others, by Persson and Tabellini (1994), Alesina and Rodrik (1994) and Perotti (1996), further suggests the existence of an inverse relationship between inequality and economic growth. In particular, Persson and Tabellini (1994) and Alesina and Rodrik (1994) argue that a greater inequality leading to higher redistribution distorts investment decisions, and therefore negatively affects economic growth.[4]

Perotti (1996), using cross-country growth regressions, finds that a greater inequality leading to a higher political (rent-seeking activities) and social instability (violent protests, assassinations, and coups) reduces investment and growth. Moreover, he shows that a more equal income distribution favors the accumulation of human capital and that this relationships is reinforced by the consideration of fertility. That is, lower inequality is associated not only to higher rates of investment in education but also to lower fertility rates that further favor economic growth.

The recent literature has focused on other possible mechanisms through which inequality can influence the process of economic development. Galor et al. (2009), for example, focus on inequality in the distribution of landownership and suggest that it may adversely affect human capital accumulation. The basic assumption is that landowners have no economic incentives to support human capital accumulation because it decreases returns to land due to the migration of labor force to the industrial sector. Therefore, economies characterized by high inequality in landownership show a low level of human capital and slower growth, whereas the economies with

[4]The basic idea is that redistributive policies as, for example, transfer payments and the associated tax on labor income, discourage work effort reducing the investment in physical and human capital.

an equal distribution of land show a rapid process of development and the emergence of a skill-intensive industrial sector.

Galor and Weil (1996), Dahan and Tsiddon (1998) and De la Croix and Doepke (2003), instead, argue that the main channel by which inequality affects economic growth is the fertility rate. In particular they show that higher inequality, by increasing the fertility differential between rich and poor families, lowers average education and therefore growth.

Other studies such as Barro (2000) and Chen (2003), have deviated from the examination of the channels through which inequality may affect growth, and restricted their attention to the reduced-form relationship between inequality and growth. They show that inequality can be harmful for growth only when countries are poor, restoring the classical Kuznets curve results.[5]

Finally the recent paper by Halter et al. (2014) argues that inequality has a positive effect on economic growth in the short run while it has a negative effect on economic performance in the long run. The basic idea is that the positive effects of inequality on economic growth, as for example a higher aggregate saving as suggested by Kaldor (1955), or the fact that with capital market imperfections a more concentrated distribution of income may favor high-return projects, tend to appear in the short run. On the other hand, the negative effects which rely on the political economy approach as the rise in the socio political instability or the change of institutions, tend to operate only on the long run.

III. The Galor and Zeira Model

In this section we describe the theoretical background of the paper. In particular: in Section III.A. we summarize the model of Galor and Zeira (1993), highlighting the conditions for the existence of multiple equilibria, while in Section III.B. we analyze the

[5]A related strand of research regards the question of whether growth is good or not for the poor, where the hypothesis usually tested is whether economic growth reduces or increases inequality. For instance, Kraay (2006), using decomposition methods, finds correlation among poverty reduction and determinants of growth in average incomes.

consequences of a decrease in the world interest rate for the long-run dynamics of inequality and growth.[6]

III.A. Bequest Dynamics and Multiple Equilibria

In the GZ model, the economy is populated by overlapping generations of individuals living for two periods: childhood and adulthood. Agents can either work as unskilled in both periods or acquire human capital in childhood and work as skilled in adulthood. Their utility depends on consumption in the second period and on the bequest left to their offspring. Population is constant. Production is carried out by firms that can use two technologies: one that utilizes skilled labor and capital, and one using unskilled labor only.

In the first period agents receive an inheritance x from their parents. If the inheritance is sufficiently high, i.e. it is greater than or equal to the fixed cost of education h, agents can acquire human capital without borrowing money. On the contrary, if $x < h$ agents can choose either to borrow at interest rate i or, otherwise, not to invest in education and work as unskilled in both periods. Agents who choose to work as unskilled in both periods earn a wage w_n in both periods, whereas agents choosing to acquire education in childhood earn the skilled wage w_s in their adulthood.

A fundamental assumption of the GZ model is the presence of credit markets' imperfections, so that $i > r$, where r is the lending interest rate, which is assumed to be given by the world interest rate.[7] The assumption depends on the hypothesis that borrowers may evade repayment, and therefore lenders must monitor them at a cost.[8]

Galor and Zeira (1993) show that the borrowing interest rate for individuals is given by:

$$i = \frac{1 + \beta r}{\beta - 1}, \tag{1}$$

[6]The main references are Galor and Zeira (1993) and Galor (2011).

[7]That is, the model is designed for a small open economy.

[8]In the model this assumption holds only for individuals wishing to borrow money. Firms, on the contrary, can borrow at the world interest rate r to finance investment in capital on the assumption that evading the repayment is more difficult for them.

where $\beta > 1$ is an "evasion cost", that is the cost that the borrowers incur to evade debt payments.

The first order conditions, when some restrictions hold (see below), yield the following optimal choices of bequests. Agents with inheritance $x > h$ invest in human capital and are lenders leaving a bequest:

$$b_s^l = (1-\alpha)\left[w_s + (x-h)(1+r)\right], \tag{2}$$

where $\alpha < 1$ is the parameter of the utility function measuring the weight of consumption on utility.

Agents receiving $x < h$ can be lenders or borrowers. An agent deciding to work as unskilled and not to invest in human capital is a lender leaving a bequest:

$$b_n = (1-\alpha)[(x+w_n)(1+r) + w_n]. \tag{3}$$

On the other hand, agents receiving $x < h$ that invest in human capital are borrowers who leave a bequest:

$$b_s^b = (1-\alpha)\left[w_s + (x-h)(1+i)\right]. \tag{4}$$

A condition, based on comparison of indirect utilities, rules out the case that agents always prefer to work as unskilled [9]. In particular, the skilled wage should be sufficiently high, i.e.:

$$\frac{w_s - w_n(2+r)}{(1+r)} \geq h. \tag{5}$$

This ensures that lenders, i.e. agents with inheritance $x > h$, will invest. Borrowers, i.e. agents with $x < h$, instead invest in human capital if the following condition holds:

$$x > f = \frac{1}{(i-r)}[w_n(2+r) + h(1+i) - w_s]. \tag{6}$$

Eq. (6) implies that: "individuals who inherit an amount smaller than f would prefer not to invest in human capital but work as unskilled" (Galor and Zeira, 1993, p. 40).

[9] That is $b_s^l > b^n$.

The bequests dynamics is summarized in Eq. (7). To focus on the effect of changes in the world interest rate on the evolution of income distribution we substitute Eq. (1) into Eq. (4) and obtain:[10]

$$x_{t+1} = \begin{cases} b_n = (1-\alpha)[(x_t + w_n)(1+r) + w_n] & x_t < f \\ b_s^b = (1-\alpha)\left[w_s - (h - x_t)\beta\left(\frac{1+r}{\beta-1}\right)\right] & f \leq x_t < h \\ b_s^l = (1-\alpha)\left[w_s + (x_t - h)(1+r)\right] & h \leq x_t \end{cases} \tag{7}$$

The graphical representation of the bequest dynamics is in Figure 1.

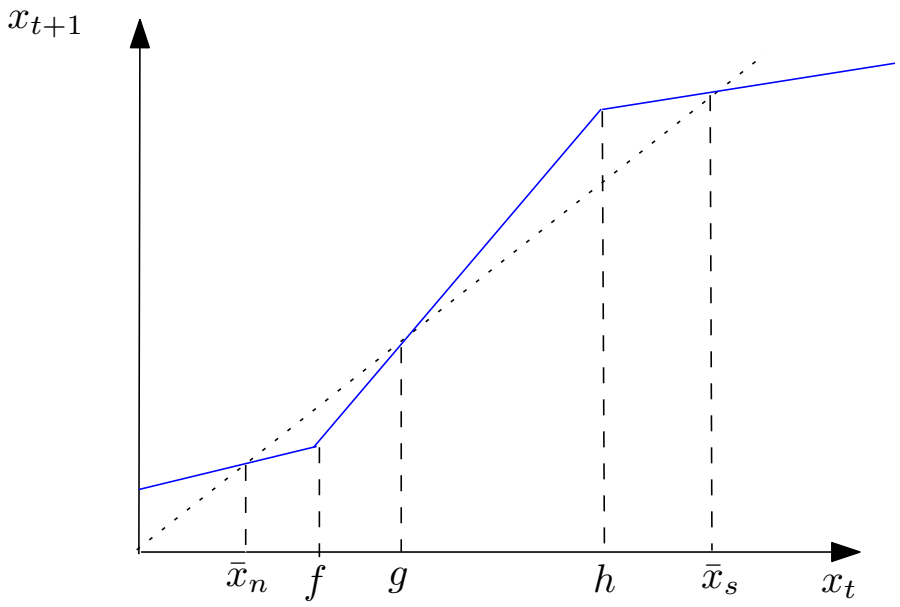

Figure 1: Bequest dynamics and multiple equilibria

Figure 1 shows three equilibria, two of which are stable, $\bar{x}_n$ and $\bar{x}_s$, while g is unstable. The values of the three equilibria are presented in Eqq. (8)-(10).

[10]Literally, bequest should belong to the category of wealth, but from the way the model is formulated, it corresponds to income that can be spent by individuals in the first period to acquire human capital or added to w_n and transferred to the second period of their life. For this reason, in the discussion of the model and in the empirical analysis we consider the distribution of *income* as the relevant distribution to study inequality and human capital accumulation, as also suggested by Galor (2011, pp. 16-17).

$$\bar{x}_n = \frac{(1-\alpha)\, w_n\, (2+r)}{1-(1-\alpha)\,(1+r)}, \tag{8}$$

$$g = \frac{(1-\alpha)\,[h\beta\,(1+r) - w_s\,(\beta-1)]}{\beta\,(1+r)\,(1-\alpha) - (\beta-1)}, \tag{9}$$

$$\bar{x}_s = \frac{(1-\alpha)\,[w_s - h\,(1+r)]}{1-(1-\alpha)\,(1+r)}. \tag{10}$$

The existence of three equilibria requires two additional assumptions on the slopes of the functions in Eq. (7), in addition to the conditions in Eqq. (5) and (6), that is:

Assumption 1

$$(1-\alpha)(1+r) < 1 \Rightarrow r < r_{max} = \frac{\alpha}{1-\alpha}$$

Assumption 2

$$(1-\alpha)(1+i) > 1 \Rightarrow \frac{\beta}{\beta-1}\,(1+r)\,(1-\alpha) > 1 \Rightarrow r > r_{min} = \frac{\alpha\beta - 1}{\beta(1-\alpha).}$$

Assumptions 1 and 2, as indicated, imply that the world interest rate r must be bounded from above and below, that is:

$$r_{min} < r < r_{max}. \tag{11}$$

The conditions in Eqq. (5) and (6), therefore, must hold for this range of interest rates.

From Figure 1 we see that if $x_t < g$, the transfers across generations diminish over time and the system converges to the steady state equilibrium $\bar{x}_n$ which can be defined a poverty trap. When $x_t > g$ the bequest across generations converges to the stable equilibrium value of $\bar{x}_s$.[11]

[11] The value of g expressed as a function of the borrowing interest rate i (see Galor and Zeira, 1993, p. 41), is:

$$g = \frac{(1-\alpha)\,[h(1+i) - w_s]}{(1+i)\,(1-\alpha) - 1},$$

We gather the previous results in the following proposition which will be useful for the analysis of the effects of changes in the world interest rate on the model's dynamics.

Proposition 1 *Under Assumptions 1 and 2 and the conditions in Eqq. (5) and (6), the dynamics displays multiple equilibria if the following conditions hold:*

$$x_{t+1}(x_t = h) > h$$
$$x_{t+1}(x_t = f) < f.$$

The crucial implication of the model is that initial inequality can become persistent. The bequest of the generations starting below the threshold value g will converge to $\bar{x}_n$, while the bequest of the generations starting above g will converge to $\bar{x}_s$. Members of the former will be unable to accumulate human capital in the long run and will remain poor, while members of the latter will accumulate human capital and become rich. This has implications for the aggregate output of the economy because in this model the larger is the fraction of individuals investing in human capital, the larger is aggregate output (Galor and Zeira, 1993, p. 42).

In the context of cross-country comparisons, the model can therefore account for the persistence of income differences (or non-convergence, see e.g. Quah 1993 and 1997), that can depend on: "differences in investment in human capital, due to credit market imperfection" (Galor and Zeira, 1993, p. 37). That is, countries with larger fractions of skilled individuals will be richer.

Finally, the model provides different predictions for the effect of inequality on growth that depend on whether the economy is initially "poor" or "rich". We summarize these predictions in Figures 2 and 3, from Galor (2011, pp. 19-21).

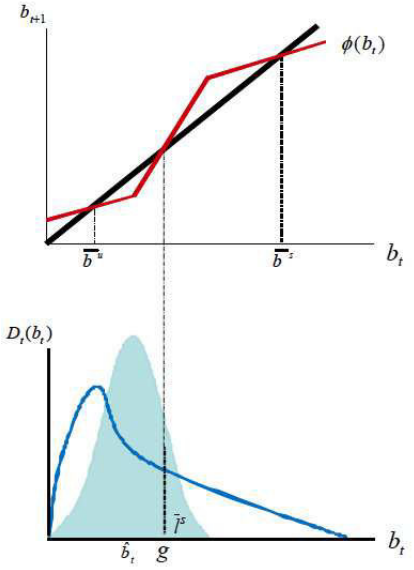

Figure 2: Poor countries: inequality is good for growth

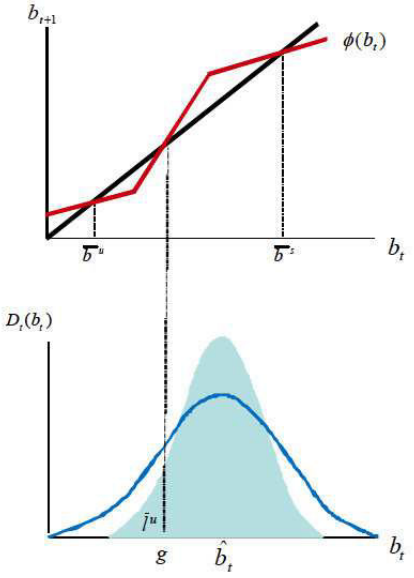

Figure 3: Rich countries: inequality is bad for growth

Figures 2 and 3 show that initially "poor" economies, i.e. economies with initial average bequest below the threshold, higher inequality may imply that more agents are rich enough to invest in human capital and, therefore, *inequality is good for growth.* On the contrary, for initially "rich" economies, i.e. economies with initial average bequest above the threshold, higher inequality may imply that more agents fall in the basin of attraction of $\bar{x}_n$ and, therefore, *inequality is bad for growth.*

In the following section we discuss the effects of changes in the world interest rate on the dynamics of the model.

III.B. The World Interest Rate and the Long-Run Dynamics of Inequality and Growth

In the previous section we highlighted the effect of initial inequality on the long-run distribution of the population among skilled and unskilled and on the level of aggregate output, for a given set of parameters. In this section, instead, we study the consequences for the long-run dynamics of a change in one parameter, the world interest

rate r, for a given initial income distribution.

In particular we show that, under some restrictions,[12] there exists a threshold level of r, $r_{min} < \bar{r} < r_{max}$, such that if $r > \bar{r}$, the economy is characterized only by the globally stable equilibrium $\bar{x}_s$. If the interest rate is below this threshold, i.e. $r_{min} < r < \bar{r}$, with a supplementary assumption of the cost of education, the economy displays multiple equilibria including a poverty trap.

We can, therefore, state the following proposition.

Proposition 2 *Under Assumptions 1 - 2 and the conditions in Eqq. (5) and (6), if the world interest rate r is above $\bar{r}$, then the dynamical system in Eq. (7) displays a unique globally stable equilibrium, $\bar{x}_s$. If the interest rate falls below $\bar{r}$, and the following condition holds: $\frac{F_1(r)}{F_2(r)} < h < w_s(1-\alpha)$, then the dynamical system in Equation 7 displays multiple equilibria.*

Proof. see Appendix A ■

Figure 4 shows the consequences of a reduction in r following Proposition 2. The dynamical system undergoes a qualitative change switching from a system characterized by a unique equilibrium (thick red line), to a multiple equilibria system (thin blue line).[13]

[12] See Appendix A for details.

[13] Galor (1996, p. 1067), discusses the case in which, in a similar framework, technological progress may qualitatively change the dynamics, by turning a multiple equilibria dynamics into a dynamics characterized by a unique globally stable equilibrium. Fiaschi and Lavezzi (2007) argue that the oil shocks of the seventies contributed to shift the cross-country nonlinear growth path downwards, providing a prediction similar to the one presented in this paper: a dynamics featuring one globally stable equilibrium becomes a multiple equilibria dynamics. The explanation provided is based on the diffusion of technologies across countries which may have become more difficult as countries started to converge to different equilibria, as suggested by the theory of appropriate technology (see, e.g. Basu and Weil, 1998).

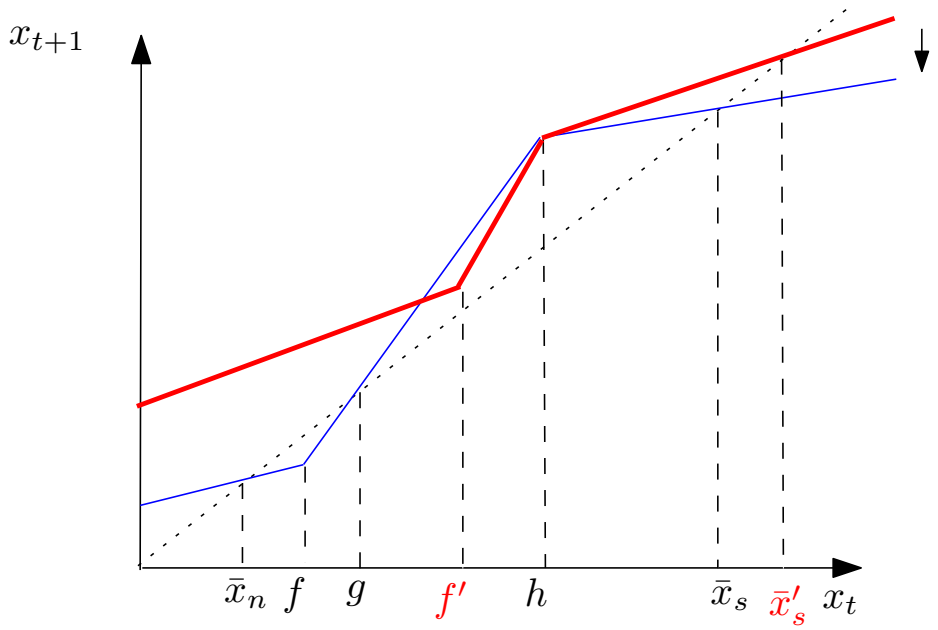

Figure 4: Effects of a reduction in the world interest rate on the model dynamics.

In particular, when the dynamical system becomes characterized by multiple equilibria, following the intuition of Galor (2011), the crucial issue is whether a country is initially "poor" or "rich", i.e. whether the average of the income distribution is located to the left or to the right of g, and how much dispersed the distribution is. In other words the *location* in the graph and the *dispersion* of the initial income distribution are crucial determinants of the long-run dynamics. Specifically, these two characteristics would allow to predict the direction of change of income inequality within a country, its capacity to accumulate human capital, and its long-run aggregate output level. For example, an initially poor country with most of the income distribution mass concentrated on the left of g would experience a reduction in inequality (as the distribution will shrink around $\bar{x}_n$), and low growth, as a small fraction of individuals will accumulate human capital in the long run.

IV. Empirical Analysis

In this section we present the empirical analysis.[14] In particular we aim at showing that a reduction of the world interest rate in the period 1985-2005 contributes to the explanation of the lack of cross-country convergence in per-capita GDP observed in the same period. The relevant channels are: the effect of world interest rate on income inequality within countries, the effect of inequality on human capital accumulation and the effect of human capital on GDP. First of all we describe the dataset, while in Sections IV.A. and IV.B. we present, respectively, the relevant stylized facts and the econometric analysis.

Table 1 describes the main variables used in the empirical analysis.[15] To compute the world interest rate we follow Barro and Sala-I-Martin (1990) by building a global measure as a GDP-weighted average of national real interest rates on long-term government bonds of eight large-GDP countries (we use the US interest rate as an alternative measure).[16]

To measure inequality we use Gini indices of gross and net incomes from the database of Solt (2010), that reports standardized values for a large set of countries.[17] Finally, data on real GDP per worker (RGDPCH) are from the Penn World Table 7.1 (Heston *et al.*, 2011), while data on human capital are from the new Barro and Lee (2011) enlarged education dataset.

[14]Data and codes are available at: `http://www.unipa.it/ mario.lavezzi/research.html`.

[15]The sources of other variables used as controls in the econometric analysis are reported in Section IV.B..

[16]Specifically, data on interest rates are from the IMF's *International Financial Statistics*. The eight countries considered are: Belgium, Canada, Japan, France, Netherlands, UK, US, Sweden. With respect to Barro and Sala-I-Martin (1990) we do not consider Italy and Germany for lack of data on the relevant period. The eight countries account for 48.2% of world GDP in 1985, computed considering 190 countries, while the ten countries of Barro and Sala-I-Martin (1990) account for approximately 65% of world GDP, computed on a total of 144 countries. Adding Italy and Germany, for the available years, i.e. 1992-2006, generates a value of the world interest rate that is correlated at 99% to the one used in the paper. The consideration of Italy and Germany would make the sample of 10 countries account for 56.75% of world GDP in 1985.

[17]The measure of income adopted is: "income per capita, household adult equivalent". For simplicity in the paper we will often define the indices "Gini gross" and "Gini net".

	Description	Coverage	Source
World Interest rate	GDP-Weighted rates for 8 large-GDP countries	1960-2005	Barro and Sala-I-Martin (1990), IMF
Human Capital	Average schooling years, share of population with completed education for population aged 15-99	1950-2010	Barro and Lee (2011)
GDP per capita	Real per capita GDP constant prices, chain series	1950-2011	P.W.T. 7.1
Income inequality	Gini index of gross and net incomes	1963-2009	Solt (2010)

Table 1: Sources for the main variables used in the empirical analysis

In the next section we present the relevant stylized facts on these variables.

IV.A. Stylized facts for the period 1985-2005

In this section we present some stylized facts on world interest rate, economic growth, inequality and human capital accumulation for a large sample of countries for the period 1985-2005. We choose this period because it is characterized by a clear downward tendency of the world interest rate, while the previous period was characterized by strong instability caused by the oil shocks of the seventies.[18] Taking this into account, we selected a sample of 75 countries in order to have the largest possible balanced panel of data on GDP and inequality at 5-year intervals.[19]

Figure 5 shows the dynamics of the world interest rate (along with that for the US interest rate): a clear declining pattern for both rates characterizes the period 1985-2005. Interest rates, in particular, decrease from a value around 6% to less than 2% in 20 years.

[18] In Figure 17 in Appendix D we report the dynamics of the world interest rate in the period 1970-1985.

[19] For each country, therefore, we will utilize five observations in the econometric analysis. Appendix E contains the country list.

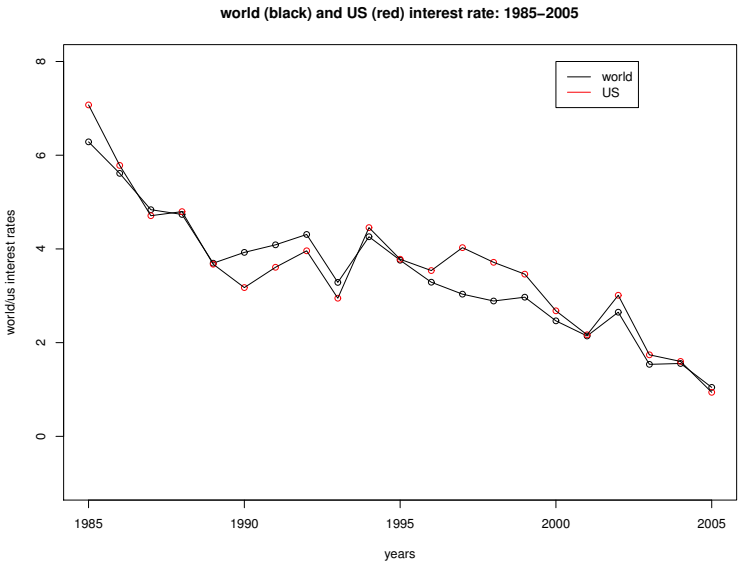

Figure 5: World and US interest rates 1985-2005

In the same period, we can observe a tendency for polarization in cross-country GDP for our sample of 75 countries, as shown in Figures 6 and 7.

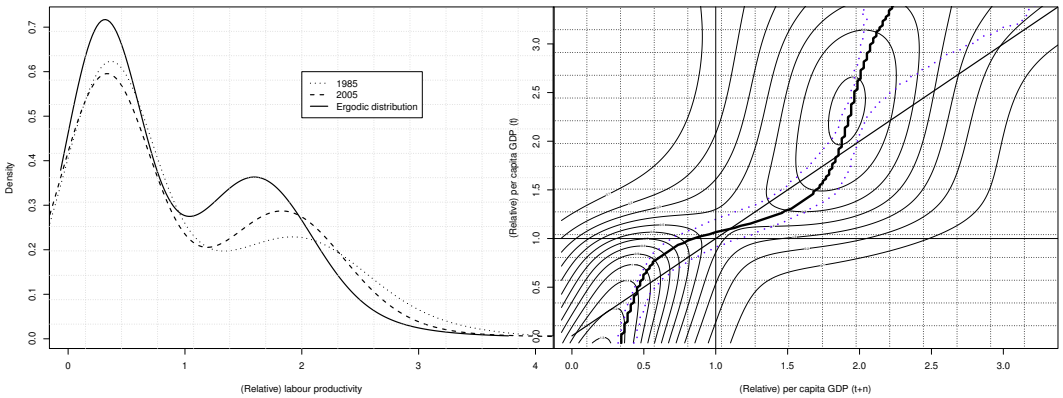

Figure 6: Distribution dynamics of per capita GDP: 1985-2005. 75 countries

Figure 7: Stochastic Kernel: 1985-2005, 75 countries, $\tau = 21$. Thick line: median of the stochastic kernel; dotted lines: 95% confidence bands.

In particular, in Figure 6 we show the density of incomes in 1985, in 2005 and the ergodic distribution, which represents the long-run tendency implied by the distribution dynamics between

1985 and 2005. The ergodic distribution is obtained from the estimated stochastic kernel (see e. g. Quah, 1997) showed in Figure 7, mapping the initial distribution of GDP in the final distribution.[20] Figure 6 highlights that the distribution dynamics is characterized by increasing polarization: the mass in the middle of the distribution tends to vanish as two peaks at low and high income levels appear.[21] The two peaks are located at a value of approximately 0.5 and 1.8. This tendency is also clear from examination of the estimated stochastic kernel in Figure 7. The probability mass is concentrated around the 45° line and two peaks are clearly visible. Moreover, the median of the stochastic kernel clearly shows a non-linear pattern highlighting the tendency for countries around the two peaks to converge.[22] Finally, note that the value of 1, i.e. the average GDP of the sample, seems to be a fairly good dividing line between the two basins of attraction.[23]

Now we consider the dynamics of income inequality and growth for subsamples of countries. The analysis of Section III. suggests that there might be differences between poor and rich countries in the dynamics of inequality, human capital accumulation and growth. We partition our sample of countries in poor and rich according to a simple criterion: a country is poor (rich) if its per capita GDP

[20]The values of GDP are normalized with respect to the sample average in every year, to take into account the possible presence of global trends. The densities in 1985 and 2005 are the *adaptive kernel estimators* of true densities, in which the bandwidth of the kernel (Gaussian in our case) decreases when the density of observations increases (see Silverman, 1986, pp. 100-110). The ergodic distribution is computed by utilizing a stochastic kernel estimated following the procedure proposed by Johnson (2005). A stochastic kernel is an operator mapping the density of a variable at time t into its density at time $t+\tau$, $\tau > 0$, and indicates for each level of the variable in period t its probability distribution in period $t+\tau$ over the possible values of the variable. The relation between the densities and the stochastic kernel is: $f_{t+\tau}(z) = \int_0^\infty \phi_\tau(z|x) f_t(x)\, dx$, where z and x are values of the variable, and $\phi_\tau(z|x)$ is the stochastic kernel. To estimate the stochastic kernel $\phi_\tau(z|x) = \phi_\tau(z,x)/f(x)$ we estimated the joint density of z and x, $\phi_\tau(z,x)$, and the marginal density of x, $f(x)$. In the estimation of $\phi_\tau(z,x)$ we followed Johnson (2005), who used Silverman's adaptive kernel estimator.

[21]The recent increase in income polarization is documented in a number of works. See, among others, Quah (1993 and 1997), Fiaschi and Lavezzi (2003), Battisti and Parmeter (2013).

[22]In Figure 7 we also report confidence bands estimated by the bootstrap procedure based on Bowman and Azzalini (1997, p. 44) and described in Fiaschi et al. (2013, pp. 39-40).

[23]Evidence similar to the one in Figures 6 and 7 can be observed for a larger sample of countries. See Appendix C. In Appendix D we present the results on the distribution dynamics in the period 1970-1985, and show that the tendency for polarization was much less evident.

is below (above) the sample average in at least three of the five observations we use for the econometric analysis.

	poor	rich
number of countries	45	30
per capita GDP 1985	3999.45 (0.38)	20519.98 (1.93)
per capita GDP 2005	5936.19 (0.35)	33736.54 (1.98)
annual average growth rate	0.017	0.025
Gini (net) 1985	44.25	29.59
Gini (net) 2005	43.20	31.74
% countries with ΔGini> 0	0.51	0.73
% countries with ΔGini<0	0.49	0.27
Gini (gross) 1985	47.46	40.91
Gini (gross) 2005	45.45	46.10
% countries with ΔGini >0	0.49	0.80
% countries with ΔGini <0	0.51	0.20
higher ed. (nr. years) 1985	0.17 (0.64)	0.41 (1.53)
higher ed. (nr. years) 2005	0.30 (0.65)	0.71 (1.53)
higher ed. (share pop.) 1985	3.02 (0.64)	7.29 (1.54)
higher ed. (share pop.) 2005	5.27 (0.64)	12.7 (1.54)
total ed. (nr. years) 1985	5.35 (0.79)	8.82 (1.31)
total ed. (nr. years) 2005	7.43 (0.86)	10.44 (1.21)
total ed. (share pop.) 1985	33.16 (0.77)	57.77 (1.34)
total ed. (share pop.) 2005	45.38 (0.89)	59.51 (1.17)

Table 2: Dynamics of economic growth, inequality and human capital accumulation in poor and rich countries: 1985-2005. Within-group average values are reported. Numbers in parenthesis indicate averages of values normalized with respect to sample average.

Table 2 shows the following facts about the two groups of countries: i) there is confirmation of no convergence in per capita GDP. In particular, the average growth rate of rich countries is higher than the one of poor countries;[24] ii) the dynamics of income inequality is remarkably different across the two groups. Inequality was initially higher for the poor and, on average, slightly declined, while it strongly increased in rich countries (see also the differences in the percentage of countries that experienced an increase or a decrease of

[24]Note that the average relative GDP of the two groups is approximately 0.4 and 1.9, in line with the values highlighted by the graphical representation of the distribution dynamics. The fact that, on average, GDP increased in rich countries, is apparently in contradiction with the dynamics implied by Figure 4 which suggests that the long-run level of bequest (and income) should decrease. However, as we discuss in Appendix V., if we add to the picture an increase of the skilled/unskilled wage ratio, the equilibrium level of $\bar{x}_s$ may shift to the right.

the Gini index).[25] iii) There is convergence in human capital across the two groups when we consider total education, but there is no convergence when we consider higher (tertiary) education only.

To highlight the relationship between income and the variation of the Gini index between 1985 and 2005 without partitioning the sample, in Figure 8 we report a nonparametric estimation of such relation, in particular utilizing the average per capita GDP over the period to measure income.

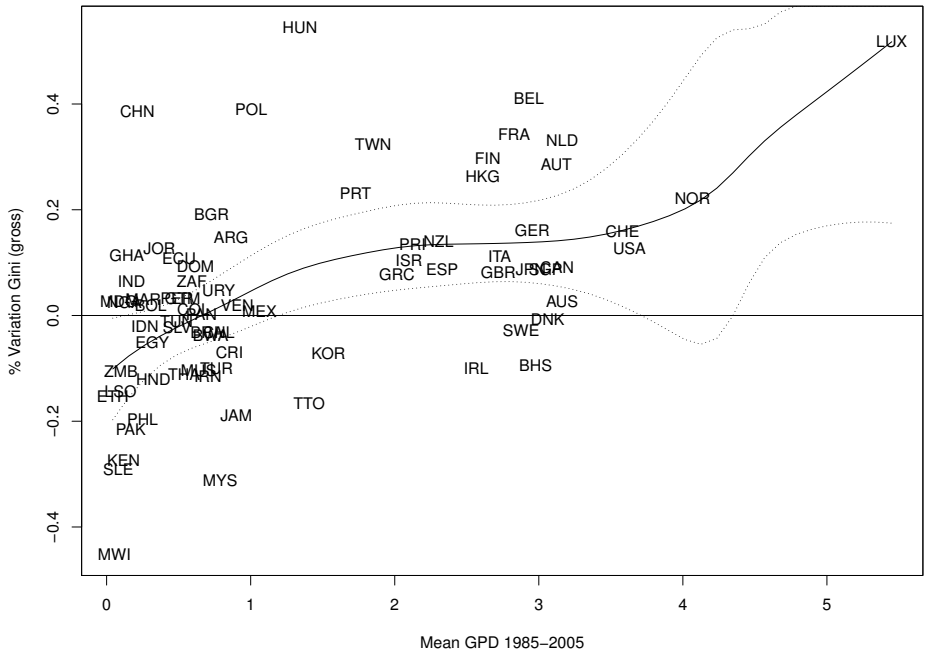

Figure 8: Variation of the Gini (gross) index and GDP

We can observe that, as GDP increases, the relationship is increasing, moving from negative to positive values.[26] Notable ex-

[25]Our sample of 75 countries is obtained after excluding Rwanda, Nepal and Bangladesh from the analysis as outliers because they show positive variations of the Gini index between 60% and 80%. In the period of interest, however, Rwanda was plagued by the genocide of 1994, Bangladesh experienced a switch from military regime to democracy in the early nineties, while Nepal switched from monarchy to democracy in the same period. These massive events are likely to have conditioned the recorded values of the Gini indices which display the most anomalous changes with respect to the other countries in the sample.

[26]A very similar picture is obtained considering the Gini index of net incomes. The estimation

ceptions at low GDP levels are China, Poland and Hungary, e.g. countries that in the period of interest moved towards more market-oriented institutional arrangements.

In the light of the theoretical background discussed in Section III., we propose the following interpretation of the stylized facts presented in this section. The reduction of the world interest rate caused the appearance of multiple equilibria. Poor countries found themselves in the basin of attraction of the low-income equilibrium,[27] while rich countries were in the basin of attraction of the high-income equilibrium. This explains the lack of convergence documented in Table 2. The income distribution of poor countries, therefore, was attracted towards the low-income equilibrium. The income distribution of rich countries, on the contrary, was split in two parts, belonging to the two different basins of attraction. This explains the tendency for a reduction of inequality (or stability of inequality) in poor countries and for an increase of income inequality in rich countries. At the root of the different growth performances lies the accumulation of human capital. We find that it was in particular human capital in the form of higher (i.e. tertiary) education that did not converge.[28] It is true that human capital accumulation was reduced with respect to its initially potential level in rich countries, because inequality increased, but since inequality did not increase in poor countries, the latter were unable to accumulate enough human capital to catch up with the rich.[29]

Figures 9 and 10 offer a graphical representation of this hypoth-

is not affected by removing Luxembourg from the sample. The estimation is performed using a Gaussian kernel, with bandwidth corresponding to its standard deviation. We report *variability bands* corresponding to two standard errors above and below the estimated function. See Bowman and Azzalini (1997, pp.50-51 and 76) for details.

[27]Literally, in the theoretical model the equilibria correspond to levels of bequest. Being the bequest a part of income, we consider bequests as proxies for income levels.

[28]The theoretical model, indeed, suggests that the cost of human capital is faced by the households as if it was referred to private education. Tertiary education seems to fit better with this feature, as primary and secondary education are largely provided by the State. Moreover, human capital in the model is the cause for the difference between being skilled and unskilled, a distinction usually made between college- and non-college educated individuals (see, e.g. Philippon and Reshef, 2013, p. 80).

[29]In Section IV.B. we show that in the period of interest the marginal effect of human capital on GDP is higher in poor countries, a finding that reinforces this claim.

esis: the color red refers to initial conditions, and black to the subsequent period in which the world interest rate decreased.

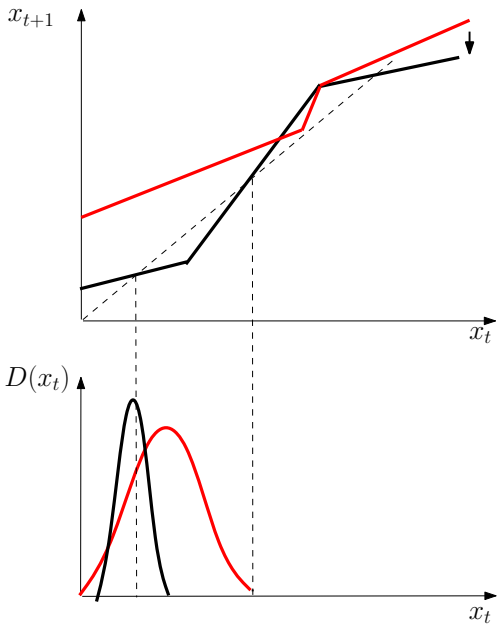

Figure 9: Poor countries: dynamics of income and inequality after a decrease of the world interest rate

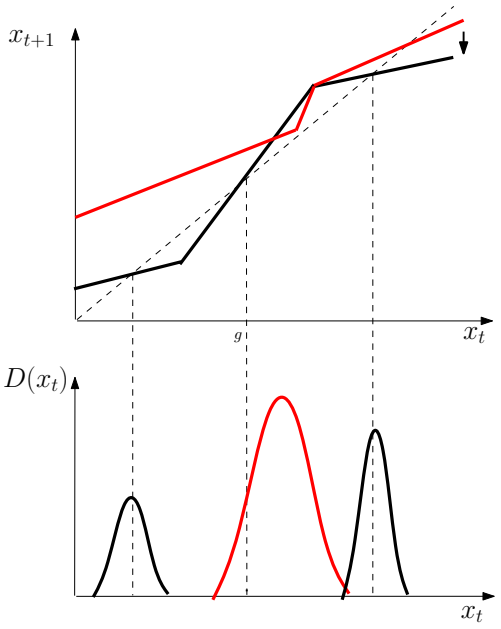

Figure 10: Rich countries: dynamics of income and inequality after a decrease of the world interest rate

In the next section we present the results of the econometric analysis aiming at testing rigorously these hypotheses.[30]

IV.B. Econometric analysis

The aim of the econometric analysis is to test the predictions of the GZ model discussed so far. In particular, we wish to test the following hypotheses: 1) a reduction in the world interest rate has a different impact on inequality in the two groups of poor and rich countries: it should decrease inequality in the former and increase inequality in the latter.[31] 2) Inequality has a differential impact

[30] In Appendix B we discuss a possible alternative scenario, in which the initial state of the system also features multiple equilibria, and argue that it appears less empirically plausible than the one described here.

[31] The GZ model of within-country inequality can be interpreted as focused on income *polarization* within a country. The validity of the Gini index as a measure of inequality could be limited when the distribution is not unimodal. Duclos *et al.* (2004) examine several shapes

on human capital accumulation: it should increase human capital accumulation in poor countries and decrease human capital accumulation in rich countries. 3) Human capital has a positive effect on GDP in both groups.

Therefore, indexing country and time by, respectively, j and t, we propose a three-step procedure based on the following relations to be estimated:

(I) $\text{inequality}_{j,t} = \alpha_0 + \alpha_1 r_t + ... + \epsilon_{j,t}$

where we expect $\hat{\alpha}_1 > 0$ in poor countries and $\hat{\alpha}_1 < 0$ in rich countries;

(II) $\text{human capital}_{j,t} = \beta_0 + \beta_1 \text{inequality}_{j,t} + ... + \upsilon_{j,t}$

where we expect $\hat{\beta}_1 > 0$ in poor countries and $\hat{\beta}_1 < 0$ in rich countries;

(III) $\text{GDP}_{j,t} = \gamma_0 + \gamma_1 \text{human capital}_{j,t} + ... + \eta_{j,t}$

where we expect $\hat{\gamma}_1 > 0$ in poor and rich countries.

---

of the distribution and possible modifications that can occur. They show that "squeezes" of the distribution could lead either to higher or to lower polarization, depending on the shape of the distribution (i.e. the number of modes, their location, etc.). On the other hand, in the identity-alienation framework of Duclos *et al.* (2004) it is highlighted that the Gini index is a good proxy for the polarization index, except for very high values of the α parameter, that is a polarization-sensitivity parameter, affecting the income distribution and polarization. Overall, we use the Gini index as our measure of inequality for two reasons. Firstly, it allows us to obtain a fairly large sample, while computing different indices of polarization across countries and time would significantly reduce the number of observations. Moreover, it allows consistent comparisons with previous literature aiming at testing the GZ model (see for example Papageorgiou and Razak, 2010), which considered the Gini index, as well as most of the literature on inequality and growth. However, in order to control for possible shortcomings, we computed the change of the ratio among the ninth and first decile of the income distribution for each country for which we have homogeneous observations from 1985 to 2005 (with at least the availability of the half of the period) in terms of source, income definition, unit of analysis and coverage (UNU-WIDER, 2008). This reduces the sample to 36 observations, 17 for the rich and 19 for the poor cluster (the list of countries is available upon request), and for these, we computed the correlation with the change of the Gini index in the same span of time for each country. The correlation is very high, equal to 0.67, and if we check for the changes in the Gini index as in Table 2 for rich and poor we have the same results, with an increase of 6 percentage points for the rich and a change of 0.03 percentage points for the poor. This suggests that the use of the Gini index seems to be acceptable, also to check how the difference across income groups changes over time.

Step I is also related to the literature on the Kutnetz curve (see, e. g., Milanovic, 1994, Barro, 2000) where inequality is nonlinearly influenced by income and by control variables such as human capital, trade openness and institutional quality.[32]

After partitioning the countries in rich and poor, to estimate the relation in Step I we run the following regression:[33]

$$Gini_{j,t} = \alpha_0 + \alpha_1 r_t + \alpha_1 \cdot Dr_t + \alpha_2 GDP_{j,t} + ... + \epsilon_{j,t} \qquad (12)$$

where $t = 1985, 1990, 1995, 2000, 2005$; D is a dummy variable such that $D = 1$ if country is rich and $D = 0$ otherwise, while r represents the world interest rate. The expectation, therefore, is that the effect given by α_1 is positive, while when the effect of world interest rate is measured by the interaction of α_1 with D, it is negative, significant, and greater in absolute value than the effect given by α_1 alone. We use GDP per capita as regressor in this benchmark specification to control for the initial "location" of the country and as a synthetic index of other possible determinants of inequality. We estimate this equation as a fixed effect (FE) panel regression with either balanced or unbalanced panel data,[34] considering lagged values of the regressors, on the assumption that the effects we study may take time to manifest, and to attenuate the issue of endogeneity.[35] Results are presented in Table 3.

[32]See also Kraay (2006) and Beck et al (2007) for related works on the determinants of inequality.

[33]To study the period 1985-2005, we consider a sample of 75 countries, for which we have a balanced panel of inequality and growth determinants data at 5-year intervals (in few cases we replace the initial observation, if not available, with the closest one, e. g. the observation for year 1986 instead of 1985). We consider this sample and a larger unbalanced sample (containing also countries that do not appear for all the periods for all the variables) including 128 countries. This list is available upon request.

[34]It is possible that, when we consider other regressors than GDP, a country does not have observations for the whole period.

[35]Results are not affected by considering contemporaneous values of the regressors.

	1	2	3	4	5	6	7	8
Dependent variable	Gini Net	Gini Gross	Gini Net	Gini Gross	Gini Net	Gini Gross	Gini Net	Gini Gross
GDP_{-5}	3.764***	3.384**	36.160***	22.775**	49.338***	37.160***	18.105***	28.021*
	(1.343)	(1.602)	(9.47)	(11.52)	(10.12)	(12.50)	(9.401)	(11.236)
GDP $squared_{-5}$			-1.9222***	-0.665	-2.702***	-2.020***	-0.92*	-1.488*
			(0.556)	(0.685)	(0.602)	(0.744)	(0.556)	(0.665)
World Interest $rate_{-5}$	0.559***	0.494***	0.552***	0.489**	0.536***	0.491**	0.410**	0.424*
	(0.172)	(0.205)	(0.168)	(0.204)	(0.168)	(0.208)	(0.191)	(0.228)
World Interest $rate_{-5}$*D	-0.602**	-1.096***	-1.247***	-1.482***	-1.358***	-1.485***	-1.072***	-1.609***
	(0.249)	(0.297)	(0.307)	(0.373)	(0.310)	(0.384)	(0.320)	(0.383)
Trade Openness % GDP_{-5}					0.014	0.022	-0.002	0.0151
					(0.012)	(0.015)	(0.012)	(0.150)
Public expenditure % GDP_{-5}					0.090	-0.075	-0.093	-0.036
					(0.112)	(0.138)	(0.106)	(0.126)
Institutional $quality_{-5}$					-0.241	-0.471	0.409	0.214
					(0.275)	(0.340)	(0.308)	(0.369)
Obs	300	300	300	300	287	287	467	467
Test coeffs WIR=-1*RICH	0.03	4.60	5.46	7.52	7.49	7.14	11.80	15.54
P-value	(0.85)	(0.03)	(0.02)	(0.01)	(0.01)	(0.01)	(0.001)	(0.001)
Balanced	Yes	Yes	Yes	Yes	Yes	Yes	No	No

Table 3: Regression of Inequality on World Interest rate, 1985-2005. Standard errors in parenthesis. ***,** ,* denote significant coefficients at 1%, 5% and 10%

Models 1 and 2 are estimations of Eq. (12) in which we only control for GDP. The estimates show that the documented decrease in the world interest rate had a positive effect on inequality in poor countries (i.e. inequality in those countries decreased as well) and a negative and significant effect in rich countries as shown by the coefficient of the interaction between the world interest rate and the dummy for "rich" countries. We can reject the hypothesis of equality of the estimated coefficients for the effect of the world interest rate.

In Models 3 and 4 we introduce a squared term for GDP to control for the possible presence of "Kuznets curve" effects. There is some evidence of such effects, in particular when we consider Gini net. The main results on the coefficients of interest are confirmed, and the differences in the effect in poor and rich countries increase.

Models 5-8 feature the introduction of other possible determinants of inequality considered in the literature.[36] In particular we considered: trade openness, as the latter may affect the internal demand of skills and impact on inequality through wage differentials; institutional quality, as institutions may affect inequality as they influence the allocation of factors and the overall functioning

[36]See, e.g., Barro (2000) and Beck et al. (2000).

of the economy; a measure of public expenditure on GDP, on the assumption that public sector intervention may reduce inequality.[37] Results show that these additional variables are scarcely significant. Our coefficients of interest, however, remain highly significant.

Another version of this test,[38] i.e. of whether the effect of the world interest rate is different for poor and rich countries, that utilizes a nonparametric estimation of Model 1 following Li and Racine (2007), allows to rank the coefficients of the effect of the world interest rate on inequality, at different GDP levels on the pooled sample. This allows us to avoid an ex-ante partition of the countries.

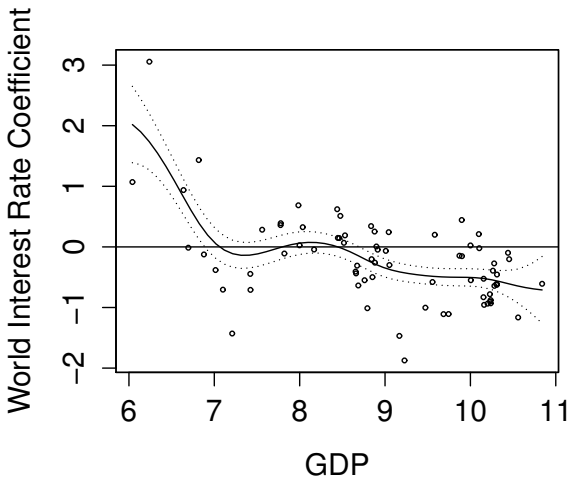

Figure 11: Nonparametric estimation of the effect of the world interest rate on inequality at different levels of log GDP per capita. We report the variabilty bands of the estimate (see Footnote 26)

As we see from Figure 11, where we report the country average of the world interest rate coefficients (gradients) on inequality, ranked

[37] The openness measure, given by the sum of export and import over GDP, and the percentage of public expenditures on GDP, come from PWT 7.1 (Heston *et al.*, 2012), while the ICRG82 is the score of Knack and Keefer (1995) in the available initial year for each country.

[38] We also tried separate fixed effects estimations for the groups of poor and rich countries, always obtaining positive and significant coefficients of the effect of world interest rate for poor countries and negative and significant coefficients for the rich ones. The alternative results are available upon request.

on the country mean GDP over the available periods, the estimated relation is decreasing. This confirms the results with FE estimation: as GDP increases, the marginal effect of the world interest rate on inequality decreases, moving from positive to negative values.

On the basis of this different results for rich and poor, we consider Steps II and III by means of a 3-stage least squares system in which in the first stage we study the effect of inequality on human capital, and in the second stage the effect of human capital on GDP. Results are presented in the two panels of Table 4: the upper panel contains the results of the estimation of the effect of human capital on GDP (our Step III), while the lower panel contains the results of our Step II, i.e. the estimated effects of inequality on human capital.[39] We use the average numbers of years of tertiary education in the population and shares of population with completed tertiary education as our human capital variables. In addition to this, we instrument investments with their past values.

Looking at the lower panel of Table 4 we first of all note that inequality has a significant negative effect on human capital accumulation only in rich countries (except in Models 5 and 9). In poor countries, the coefficient is generally positive but not significant, except for the specification of Model 10 in which the effect is positive and significant. This result does not seem affected by possible changes in the length of the lags. Considering the Gini net the signs are as expected, but the coefficients are not significant.[40]

Looking at the upper panel of Table 4 we notice that human capital has a positive and strongly significant effect on GDP in both subsets of countries. In particular, the estimated coefficient is al-

[39]The regression to evaluate the effect of human capital on GDP is estimated, following Mankiw et al. (1992) as an "augmented" Solow model. In the regression of human capital on inequality, we also control for lagged values of human capital itself, given the persistency of this variable, and as proxies of other determinants of human capital. We keep these specifications simple, as it is beyond the scope of this paper to identify the best selection of regressors (see Durlauf et al., 2005, on the issue of model specification of growth regressions).

[40]The other possible combinations of Gini (gross and net) with other human capital variables at 5- and 10-year lags give similar results. Considering the share of population with completed (total) education produces non significant results for the group of rich countries, as this variable changes a little in the period of interest.

ways higher in poor countries and, in comparison with the effect exerted by total education, the marginal effect of tertiary education seems particularly strong when measured by the average years of higher education in the population.[41] We argue that this result corroborates the claim that nonconvergence in tertiary education contributes to the explanation of nonconvergence in GDP.[42]

[41] This result suggests the presence of decreasing returns to human capital (see Mankiw et al., 1992).

[42] A more detailed evaluation of this effect with respect to other determinants of nonconvergence in GDP is left for future research.

dependent variable: GDP	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Rich	Poor	Rich	Poor	Rich	Poor	Rich	Poor	Rich	Poor
Higher education	0.362***	2.155***	0.381***	2.139***	0.400***	2.151***				
(years of schooling)	(0.111)	(0.300)	(0.111)	(0.300)	(0.112)	(0.300)				
Higher education							0.021***	0.094***		
(% pop. completed)							(0.006)	(0.016)		
Total education									0.083***	0.254***
(years of schooling)									(0.023)	(0.028)
Investment	0.003	0.013*	0.005	0.018**	0.006	0.017**	0.003	0.017***	0.002	0.005
	(0.008)	(0.007)	(0.008)	(0.007)	(0.008)	(0.007)	(0.008)	(0.007)	(0.008)	(0.006)
Population growth	-2.222**	-3.931***	-2.338**	-3.593***	-2.341***	-3.930***	-2.152***	-3.699***	-2.091***	-1.517
	(1.002)	(1.023)	(0.999)	(1.023)	(1.001)	(1.023)	(0.994)	(1.078)	(0.969)	(1.024)
Constant	10.049***	7.821***	9.987***	7.831***	9.948***	7.828***	10.038***	7.942***	9.461***	6.693***
	(0.206)	(0.215)	(0.206)	(0.215)	(0.208)	(0.215)	(0.211)	(0.224)	(0.322)	(0.272)
R^2	0.11	0.32	0.10	0.32	0.10	0.32	0.13	0.24	0.15	0.42
Dep. var. Human Capital										
Gini gross$_{-5}$	-0.381**	0.027					-0.056*	0.009	-0.540	0.856*
	(0.168)	(0.057)					(0.031)	(0.014)	(0.870)	(0.470)
Gini gross$_{-10}$			-0.469***	0.065						
			(0.159)	(0.055)						
Gini net$_{-10}$					-0.158	0.032				
					(0.181)	(0.055)				
Higher education	1.031***	1.158***	1.020***	1.162***	1.026***	1.159***				
(years schooling)$_{-10}$	(0.036)	(0.037)	(0.036)	(0.037)	(0.037)	(0.037)				
Higher education							1.052***	1.191***		
(% pop. completed)$_{-10}$							(0.038)	(0.041)		
Total education $_{-10}$									0.782***	0.949***
(years of schooling)									(0.029)	(0.023)
Constant	0.299***	0.023	0.337***	0.008	0.187***	0.025	4.750***	0.190	2.996***	0.869***
	(0.074)	(0.031)	(0.070)	(0.029)	(0.060)	(0.027)	(1.374)	(0.685)	(0.464)	(0.270)
R^2	0.88	0.86	0.88	0.86	0.88	0.86	0.88	0.86	0.87	0.92
Dep. var. Investment rates										
Investment$_{-5}$	0.697***	0.745***	0.697***	0.744***	0.691***	0.745***	0.697***	0.745***	0.700***	0.725***
	(0.056)	(0.046)	(0.056)	(0.046)	(0.056)	(0.046)	(0.056)	(0.046)	(0.055)	(0.045)
Constant	8.217***	6.211***	8.230***	6.215***	8.379***	6.211***	8.232***	6.197***	8.142***	6.662***
	(1.455)	(1.138)	(1.454)	(1.138)	(1.454)	(1.138)	(1.455)	(1.138)	(1.450)	(1.127)
R^2	0.58	0.61	0.58	0.61	0.58	0.61	0.58	0.61	0.58	0.61
Obs	112	168	112	168	112	168	112	168	112	168

Table 4: System of regressions: final dependent variable GDP. ***,** ,* represent significant coefficients at 1%, 5% and 10%. In the 3SLS estimations the endogenous variables are respectively human capital in the second system and human capital and investment in the third one. All variables are in logs. Standard errors in parenthesis.

To sum up, the econometric analysis provides support for the following picture. A decreasing world interest rate increases inequality in rich countries and decreases inequality in poor countries. Inequality reduces human capital accumulation in rich countries (and is therefore "bad for growth"), and has a positive (but mostly not significant) effect in poor countries. We cannot make the strong claim that it is therefore "good for growth", but it is clearly not "bad for growth" as in rich countries.

Our results are in contrast with Barro (2000) and Chen (2000) who argue that higher inequality retards growth in poor countries and encourages growth in rich countries. On the other hand, our results for rich countries are in accordance with the strand of the literature which suggests that inequality is harmful for economic growth that is, among others, Persson and Tabellini (1994), Alesina and Rodrik (1994), Perotti (1996), Galor and Weil (1996), Dahan and Tsiddon (1998) and De la Croix and Doepke (2003).[43]

The closest comparison is Papageorgiou and Razak (2010) that found a negative effect of inequality on growth through human capital. However, there are two major differences: i) they do not estimate a different relationship for rich and poor but just introduce a dummy for the poor[44] ii) they do not take into account, neither theoretically, nor empirically, the possibility of changes in the interest rate so that our first step does not appear in their work.

In the next section we explore an alternative theory that may account for our stylized facts.

V. A Possible Alternative Channel

Another channel through which inequality may affect economic growth could be based on the impact of the reduction in interest rate

[43]In a recent paper, Lin *et al.* (2014) find evidence of a positive effect of inequality (measured by the top 1% income share) on per capita income growth, above a given threshold. However, there are remarkable differences with respect to our study: first of all, they consider a reduced form equation (estimated as a threshold panel regression), and not a structural one (as we propose in this paper, by the two-step strategy with fixed effects and then 3SLS), so that there is no direct consideration of the effect of inequality on growth through the human capital channel (as suggested by the GZ model). In fact Lin *et al.* (2014) consider the channel suggested by Galor and Tsiddon (1997), focusing on technological innovation. Secondly, they use a sample of US States from 1945 to 2004, so that period is quite different (given that the global shocks analysed in our paper for instance go in opposite directions in '70s and '80s, a larger period as in Lin et al (2014) cannot allow to have the same prescription on the basis of GZ model) and, more importantly, they only consider "rich" countries (as US States are with respect to developing countries). Thirdly, the inequality measure is far different from ours. A comparable comparison of rich and poor countries' inequality like the one proposed here through the income share of the top 1% is still not feasible, given the available data (see the Alvaredo et al., 2014, database).

[44]The same holds for the model of De la Croix and Doepke (2003), which is also considered by Papageorgiou and Razak (2010).

on physical capital investment. Specifically, a reduction of interest rates should stimulate investment, but inequality and human capital can also be affected, as the following argument illustrates.[45]

Let us assume that: i) rich countries are endowed with both skilled and unskilled labor, while poor countries are endowed with unskilled labor only, and ii) capital is complementary to skilled labor, and a substitute for unskilled labour. This implies that in rich countries capital accumulation following a decrease in interest rates increases the demand for skilled labor leading to a higher wage differential and therefore to greater inequality,[46] while in poor countries inequality is not affected. This argument is in the line the theory of "directed technological change" (Acemoglu, 2002).

In this case the prediction is that the documented decrease in the world interest rate should increase investment in both rich and poor countries. Increase in investment in rich countries should increase inequality while it should have a non-significant effect in poor countries.[47]

Table 5 contains the results of regressions testing this hypothesis.

It can be observed that in all specifications, the effect of the world interest rate on investment is significant and has the predicted sign in both rich and poor countries, also taking into account individual countries' interest rate.[48] However, the effect of investment on inequality strongly depends on the inequality measure we adopt. In the Models 5-8, based on Gini net, the coefficients have the expected sign, but are significant only for rich countries. In the first four specifications, based on Gini gross, the sign of the effect of investments is opposite to what expected for rich countries, and is negative but not significant for poor countries.

Overall, we find mixed evidence that this alternative channel may

[45] We thank Costas Azariadis for suggesting us to explore this route.

[46] See, e.g. Atkinson (1997) for a discussion of wage differentials and inequality.

[47] For the same reasons we mentioned in the presentation of Tables 3 and 4, we present results where the values of the regressors are lagged. Also in this case, using simultaneous values of the variables does not affect the results.

[48] We considered the "real interest rate" from the World Bank Indicators. Interestingly, domestic interest rates have non-significant effects on investments. This is in line with the GZ model that argues that the relevant rate for firms' investment is the world interest rate.

	Gini gross				Gini net			
	1	2	3	4	5	6	7	8
	Rich	Poor	Rich	Poor	Rich	Poor	Rich	Poor
$Investment_{-5}$	-0.187**	-0.060	-0.113	-0.058	0.235**	-0.068	0.339***	-0.064
	(0.095)	(0.076)	(0.091)	(0.084)	(0.091)	(0.080)	(0.093)	(0.088)
GDP_{-5}	134.11**	-2.518	102.98	5.045	29.191	9.226	33.070	14.541
	(61.52)	(11.769)	(65.55)	(12.814)	(58.639)	(12.513)	(66.911)	(13.432)
GDP $squared_{-5}$	-6.501**	0.189	-4.963	-0.295	-1.659	-0.635	-1.811	-0.976
	(3.019)	(0.746)	(3.228)	(0.816)	(2.878)	(0.793)	(3.295)	(0.856)
Constant	-641.56**	55.71	-486.72	27.742	-99.582	13.644	-126.16	-5.703
	(313.52)	(45.66)	(332.94)	(49.467)	(298.86)	(48.544)	(339.86)	(51.855)
R^2	0.08	0.00	0.05	0.00	0.10	0.01	0.15	0.01
Dep. var. $Investment_{-5}$								
World Interest $Rate_{-10}$	-0.877***	-1.259***	-0.624**	-1.080**	-0.985***	-1.242***	-0.785***	-1.055**
	(0.229)	(0.340)	(0.265)	(0.469)	(0.228)	(0.341)	(0.265)	(0.470)
Country $interest\ rate_{-10}$			-0.056	0.011			-0.047	0.012
			(0.050)	(0.039)			(0.050)	(0.039)
$Investment_{-10}$	0.770***	0.715***	0.768***	0.747***	0.766***	0.715***	0.764***	0.747***
	(0.044)	(0.041)	(0.050)	(0.050)	(0.044)	(0.041)	(0.050)	(0.050)
Constant	9.477***	10.490***	8.859***	9.111***	10.024***	10.418***	9.558***	9.008***
	(1.456)	(1.634)	(1.676)	(2.181)	(1.454)	(1.638)	(1.674)	(2.187)
R^2	0.72	0.63	0.71	0.63	0.72	0.63	0.71	0.63
Obs	120	180	101	134	120	180	101	134

Table 5: 3SLS System of regressions. Final dependent variable: Inequality. Standard errrors in parenthesis. ***,** ,* represent significant coefficients at 1%, 5% and 10% In the 3SLS estimations the endogenous variable is the investment.

explain the relationship between the fall in world interest rate and the dynamics of inequality in rich and poor countries. Differently from our previous results, there appears a stronger dependence on the type of Gini index considered.[49]

VI. Conclusions

In this paper we studied the effects of the world interest rate on the dynamics of within- and cross-country income inequality, following the insights of the model of Galor and Zeira (1993). We found evidence of an effect of world interest rate on within-country income inequality, but this effect differs between rich and poor countries. Specifically, a decrease in the world interest rate, characterizing recent decades, caused an increase in inequality in rich countries, and

[49]The correlation among the two Gini measures (on net and gross incomes) is higher than 0.90 in our sample, but if we only consider rich countries it drops at 0.53. This is not surprising given the redistributive effects of fiscal policy in rich countries.

a decrease in poor countries.

The effect of inequality on human capital accumulation, and therefore on economic growth, also differs between poor and rich. Inequality is negatively associated to human capital accumulation in rich countries, while it has a positive (but, in our estimates, mostly not significant) impact in poor countries. Given that inequality did not increase in poor countries, they were constrained in their capacity of accumulating human capital and grow, an implication of the GZ model stressed by Galor (2011), that we corroborate, also on the basis of the estimated coefficients on the effect of human capital on GDP.

Hence, we added two novel elements in the discussion on income inequality, growth and cross-country convergence: the consideration of a global factor, such as the world interest rate, and the identification of a differential role that inequality may play in poor and rich countries in the process of human capital accumulation, a fundamental factor of economic growth.

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Appendix

A Proof of Proposition 2

From Eqq. (6) and (7), the condition for the existence of the equilibrium $\bar{x}_s$, i.e. $x_{t+1}(x_t = h) > h$, holds if:

$$h < w_s(1-\alpha), \tag{13}$$

and the condition for the existence of the equilibrium $\bar{x}_n$, i.e. $x_{t+1}(x_t = f) < f$, holds if:[50]

$$h > \frac{F_1(r)}{F_2(r)}, \tag{15}$$

where:

$$F_1(r) = w_n\left(\frac{2+r}{1+r}\right)[\beta(1+r)(1-\alpha)-(\beta-1)]+w_s\left(\frac{\beta-1}{1+r}\right)[1-(1-\alpha)(1+r)], \tag{16}$$

and:

$$F_2(r) = \beta[1-(1-\alpha)(1+r)]. \tag{17}$$

Therefore, from Eqq. (5), (13) and (15), the dynamical system in Eq. (7) shows multiple equilibria if there is a range of values for the interest rate r such that:

$$\frac{F_1(r)}{F_2(r)} < h < \min\left\{w_s(1-\alpha), \frac{w_s - w_n(2+r)}{(1+r)}\right\} \tag{18}$$

Some calculations show that:

$$\frac{F_1(r)}{F_2(r)} < w_s(1-\alpha) < \frac{w_s - w_n(2+r)}{(1+r)} \tag{19}$$

[50]Substituting Eq. (1) into Eq. (6) we obtain the threshold f as a function of r:

$$f = \frac{\beta-1}{1+r}\left[w_n(2+r) + \frac{\beta h(1+r)}{\beta-1} - w_s\right], \tag{14}$$

if the interest rate is sufficiently low, that is if:

$$r < \bar{r} = \frac{\alpha w_s - 2w_n}{w_s(1-\alpha) + w_n}. \tag{20}$$

where $\bar{r} < r_{max}$ for any value of parameters, and $\bar{r} > r_{min}$ if:

$$\frac{w_s}{w_n} > \frac{\beta(2-\alpha) - 1}{(1-\alpha)}. \tag{21}$$

Thus Eq. (19) implies that, for each $r_{min} < r < \bar{r}$ the interval in Eq. (18) exists. Therefore when $r_{min} < r < \bar{r}$ both Eqq. (13) and (15) can be satisfied for some values of h, and multiple equilibria exist.

On the other hand, when $\bar{r} < r < r_{max}$:

$$\frac{w_s - w_n(2+r)}{(1+r)} < w_s(1-\alpha) < \frac{F_1(r)}{F_2(r)}, \tag{22}$$

thus the interval in Equation (18) does not exist. Thus from Eq. (22) and Eq. (5), when $r > \bar{r}$, it follows that only the condition $h < w_s(1-\alpha)$ can be satisfied, that is the dynamics only features the equilibrium $\bar{x}_n$.

Are these conditions satisfied in the period we are observing? The assumption of this paper is that the period 1985-2005 is characterized by a world interest rate which, starting from high values, significantly declined over the period, causing the emergence of poverty traps. A complete set of data needed for a calibration of the model, however, are not available. For a necessarily partial evaluation of the fulfillment of the conditions stated in this appendix, we proceeded as follows.

We gathered the available data for the period of interest to proxy for the variables of the model. In particular, some values for parameter α, reflecting the degree of agents' "selfishness", can be computed from Nishiyama (2000, Table 10).[51] To estimate i we considered the

[51] Nishiyama (2000) estimated a parameter for parents' altruism towards future generations from calibrations based on US data covering different periods between the eighties and the nineties.

risk premium variable from the WBI, measuring the difference between the interest rate on banks' loans and the (short-term) treasury bill interest rate.[52] The measurement of w_s and w_n at cross-country level is made very difficult from the different definitions of skilled and unskilled wage (see Oostendorp, 2012). The largest comparable dataset, reporting dynamics of wage ratios by skill level only, is OECD (2007, Table A9.2a), reporting data for the period 1997-2005 for only 25 countries of our sample (22 rich and 3 poor).[53] Alternatively, if we assume to proxy wage levels by skill through income deciles, then UNU-WIDER (2008) contains data for the period 1985-2005 for 35 countries of our sample (17 rich and 18 poor).[54]

To provide an evaluation of the fulfillment of the conditions of this appendix, we proceeded as follows. We calculated sample averages for the available data, averaging in time and across countries, to obtain a single value for each relevant variable.[55] With respect to the world interest rate, for example, this implies considering an average value characterizing the whole period.[56]

The available data provide annual values of some relevant variables. The model, however, considers variables such as w_s, w_n, r, i, that apply to periods amounting to, approximately, half of the life of generations of individuals. For this reason, we compute "half-lifetime" values of wages, by cumulating annual wages on a given

[52]See `http://data.worldbank.org/indicator/FR.INR.RISK`.

[53]The countries covered are: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Korea, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, United States, Israel (rich); Hungary, Poland and Turkey (poor). In this case, and in the other that are mentioned in what follows, not all years are available for each country.

[54]The countries in this sample are: Austria, Belgium, Canada, Finland, Germany, Ireland, Israel, Italy, Luxembourg, Netherlands, New Zealand, Norway, Spain, Sweden, Taiwan, United Kingdom, United States (rich); Argentina, Bolivia, Brazil, Bulgaria, Chile, Costa Rica, Ghana, Guatemala, Hungary, Indonesia, Malaysia, Mexico, Pakistan, Panama, Philippines, Poland, Uruguay, Venezuela (poor).

[55]In the paper, indeed, the implicit assumption is that the parameters of the model hold "on average" for all countries and across the period, being poor and rich countries classified on the basis of initial income. In any case, the paucity of data prevents us from carrying out a more precise analysis, for example distinguishing between different sub-periods or sub-samples within the interval 1985-2005.

[56]In other words, we are assuming that the period 1985-2005 is characterized on average by a "low" world interest rate.

number of periods by a growth rate taken from the available evidence, and interest rates by simply compounding annual values on a given number of periods.[57]

We calibrate the model using the available data. In particular, we use the following values: i) $\alpha = 0.7$: this value is consistent with the values calculated by Nishiyama (2000) for high risk aversion;[58]. ii) $ra = 0.034$, and $ia = 0.105$: these values for the annual world interest rate and the interest rate for borrowers are consistent with the average of the value of the world interest rate used in this paper for the period 1985-2005 (3.4%), and the average value of the risk premium computed for the available countries, (7.1%).[59]. iii) annual unskilled wage, $w_{na} = 6100$ and annual skilled wage, $w_{sa} = 62000$, respectively growing at annual growth rates equal to $g_{wn} = 0.024$ and $g_{ws} = 0.026$;[60] iv) the first period of life of unskilled and skilled workers is assumed to last 15 years, while the second 35 years;[61]

[57]Specifically, given an initial annual wage of wa, a growth rate of g_{wa}, and a duration of a period of life of l years, the half-lifetime wage is computed summing the $l + 1$ values of annual wages, where each annual wage is given by $wa(1 + g_{wa})^l$. The interest rates appearing in the model, e.g. r, are instead computed from the following simple formula: $(1 + r) = (1 + ra)^l$, where ra is the annual value of the interest rate (the same applies to i).

[58]Nishiyama (2000, Tab. 10), shows that, for high risk aversion, his parameter of parental altruism per offspring is equal to 0.33. The average number of children in his calibration is 1.35. This returns a value of total parental altruism of 0.45. The interpretation of such number is that parents care about their children 55% less than they care about themselves. In the GZ model, α measures the weight of parents' consumption in utility. A value of $\alpha = 0.7$ and $1 - \alpha = 0.3$, therefore, implies that the weight they give to bequests is 45% of the weight they give to their own consumption.

[59]This value is computed for 73 out of the 75 countries of our sample (Germany and Taiwan are missing).

[60]The values of w_{na} and w_{sa} are calculated as follows: for the countries of our sample present in the UNU-WIDER (2008) dataset, which contains data on deciles' income shares for variable number of years, we assume that the per capita GDP of a year proxies for the average income of the fifth decile. Using the income shares as weights, we calculate the average income of all deciles. For each country we calculate the average value of each decile's average income in time. The values of w_{na} and w_{sa} correspond to the cross-section averages of the latter values, for the first and tenth decile, while the values of g_{wn} and g_{ws} correspond to the average yearly growth rate over the available years of the income of the first and tenth decile. The latter values are rather high, which can be explained, in addition to the small number of countries considered, by the relatively short period on which they are actually calculated: the average initial year is 1987 and the average number of years is 13.

[61]The assumption is that in the first period of life individuals work or acquire education, and work in the second. The model is silent on such values, so we simply assume that the first period is shorter than the second because it is the one in which education is acquired.

the values of w_n and w_s are calculated considering the duration of the second period of life, while the values of r and i are calculated using the duration of the first.[62] v) The value of h is calibrated to be around three times the value of w_n.[63]

With these assumptions, the conditions in Eqq. (19), (20) and (21) implying the existence of multiple equilibria in the period 1985-2005, are satisfied.[64] Given the lack of more precise indications from the model on many important parameters (such as duration of periods of life), the computed values of some variables such as w_n and w_s matter in particular for the definition of the proportions that should exist so that the conditions of this appendix are satisfied.[65] From many numerical simulations, the proportions satisfying the mentioned conditions are: $w_s/w_n \approx 10$, $i/r \approx 5$, $h/w_n \approx 3$. In other words, the gap between the skilled and unskilled wage should be relatively high,[66] as well as the gap between i and r.

The numerical value of the threshold defined in Eq. (20) is 1.31, while the computed value of r is 0.65. *Ceteris paribus*, a value of ra greater than 0.057 is sufficient generate a value of $r > \bar{r}$. As remarked, a fuller comparison with the period before 1985 is not possible. Let us just note that the level of the world interest rate in 1984 was 6.68%.[67]

[62] In the model, the interest rate on loans applies in the first period only, so we used the same criterion for the calculation of r.

[63] This implies that the correct value of h to be taken into account should also include some of the opportunity costs of education, and not only direct costs. From Figure 1, indeed, it is clear that the scale of h should correspond to the one of w_n and w_s which, as remarked, should have the scale of lifetime earnings.

[64] The condition in Eq. (5), and Assumptions 1 and 2 are also satisfied, so that the computed values of the three equilibria $\bar{x}_n$, $\bar{x}_s$ and g have coherent values.

[65] The computed values of the wages are: $w_n = 342754.6$, and w_s=3623293.

[66] Proxing wage differentials by deciles' average income levels seems therefore more appropriate than using wage ratios as defined by education levels only, as those in Eurostat (2007) which are much more narrower (i.e. around 2 averaging across rich and poor countries). Robbins (1999) report some values for some developing countries (Argentina, Chile, Colombia, Costa Rica, Malaysia, Philippines, Taiwan, Uruguay) suggesting that in the latter this ratio can be much higher, reaching values of about 6 or 8 between 1980 and 1995

[67] The average value of the world interest rate between 1981 and 1985, i.e. between the end of the turbulences caused by the oil shocks and the beginning of our period, was 5.43%. The average value of similar periods, i.e. 1982-1985 and 1982-1986, was 6.20% and 6.08%. Comparing two periods of equal length, i.e. 1981-1992 and 1993-2005, we have that the average world interest rate decreased from 4.93% to 2.68%.

B Multiple equilibria before and after the fall of world interest rate and changes in the wage gap

In Appendix A we provided a numerical evaluation of the conditions for the existence of multiple equilibria. Given the caveats of such an analysis, in this section we consider the consequences of a reduction in r in the case the dynamics is characterized by multiple equilibria also in the initial state, to derive the empirically testable implications.

That is, we assume that initially, $r_{min} < r < \bar{r}$. In this case if, *ceteris paribus*, the interest rate decreases, from Eqq. (8) and (10) we obtain that the levels of both the low and high equilibrium decrease, as well as the level of g. In fact, we have:

$$\frac{\partial \bar{x}_n}{\partial r} = \frac{w_n(1-\alpha)^2}{[1-(1-\alpha)(1+r)]^2} > 0, \tag{23}$$

$$\frac{\partial \bar{x}_s}{\partial r} = \frac{(1-\alpha)[w_s(1-\alpha)-h]}{[1-(1-\alpha)(1+r)]^2} > 0, \tag{24}$$

$$\frac{\partial g}{\partial r} = \frac{(1-\alpha)\beta(\beta-1)[w_s(1-\alpha)-h]}{[\beta(1+r)(1-\alpha)-(\beta-1)]^2} > 0. \tag{25}$$

Thus, as shown in Figure 12, a reduction of the interest rate has the following consequences: it reduces the long-run values of both $\bar{x_n}$ and $\bar{x_s}$, but it increases the basin of attraction of $\bar{x_s}$, as g decreases. This increases the potential share of skilled workers that a country could accumulate. That is, if the initial distribution, i.e. the distribution existing when r decreases, features a positive mass to the right of g' (as in Figure 12), than the long-run share of skilled workers and of aggregate output is predicted to increase following a decrease in r.

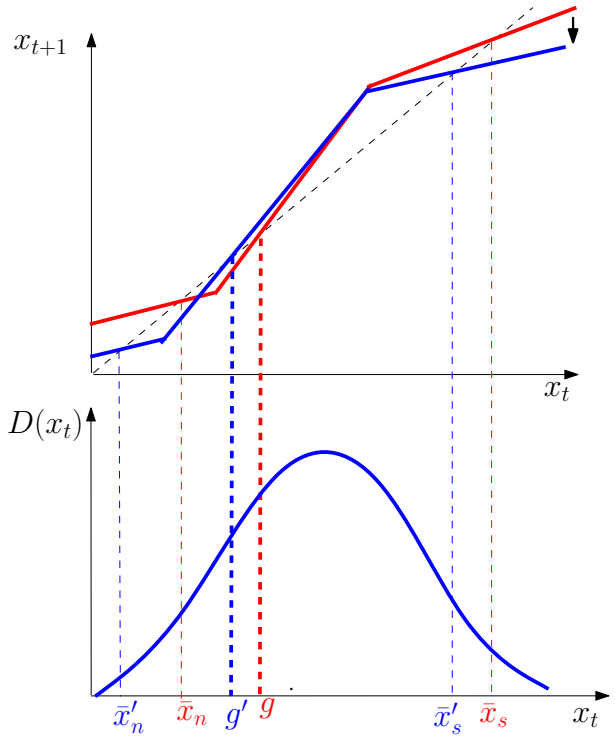

Figure 12: Income Distribution

Thus, a decrease in r should favor initially rich countries by increasing the share of skilled workers they can potentially accumulate in the long run. The convergence, however, should occur towards a lower level of $\bar{x}_s$, making the overall effect ambiguous.[68] By increasing the basin of attraction of $\bar{x}_s$, however, it makes more likely that inequality in rich countries decreases: a fact that we did not find in the data.

In addition, we can show that a reduction in r also reduces the difference between $\bar{x}_s$ and $\bar{x}_n$, given by:

$$\bar{x}_s - \bar{x}_n = \frac{(1-\alpha)[w_s - h(1+r) - w_n(2+r)]}{1-(1-\alpha)(1+r)}. \tag{26}$$

The derivative of this difference with respect to r is, in fact, positive,

[68] Galor and Zeira (1993, p. 42) show that the long-run level of average wealth (see Footnote 10 for a discussion of the use of wealth in income in the GZ model) increases with $\bar{x}_t$ and with the share of skilled workers.

i.e.:

$$\frac{\partial(\bar{x}_s - \bar{x}_n)}{\partial r} = (1-\alpha)\frac{[w_s(1-\alpha) - h - w_n(2-\alpha)]}{[1-(1-\alpha)(1+r)]^2} > 0, \qquad (27)$$

if:

$$h < w_s(1-\alpha) - w_n(2-\alpha), \qquad (28)$$

which is true if Eq.(5) holds when $r = r_{max}$.

Hence, a reduction in r should reduce, *ceteris paribus*, the long-run difference between poor and rich countries, considering that $\bar{x}_n$ and $\bar{x}_s$ affect the long-run GDP levels. This fact does not seem to appear in the data but we might have not considered another important factor.[69]

That is, we have not considered so far a change in the wage ratio. It is a well-known fact that, in the period we are considering, the wage of skilled workers increased with respect to the wage of the unskilled, in particular because of skill-biased technological change.[70]

This change in the parameters may affect the dynamics of inequality and growth in the GZ model.[71] In particular, for a given level of r and w_n, if w_s increases the unstable equilibrium g decreases (i.e. $\frac{\partial g}{\partial w_s} < 0$) and the equilibrium $\bar{x}_s$ increases (i.e. $\frac{\partial \bar{x}_s}{\partial w_s} > 0$).

When both factors are present, i.e. when the interest rate decreases ($dr < 0$) and the skilled wage rises ($dw_s > 0$), the equilibrium g decreases ($\frac{\partial g}{\partial r} > 0$ and $\frac{\partial g}{\partial w_s} < 0$).

The value of the equilibrium $\bar{x}_s$, instead, increases if the variation of w_s is particularly strong, i.e. if the following condition holds:

$$dw_s > -\frac{(1-\alpha)w_s - h}{1-(1-\alpha)(1+r)}dr \qquad (29)$$

[69] With the numerical values considered in Appendix A, the condition in Eq. (28) is actually violated.

[70] For example, Berman et al. (1998) show that in developed countries, in the period 1979-1993, the wage gap increases on average of 4.2 (table II p. 1259), while Feenstra and Hanson (2001) show that in the US in the period 1979-1995 the wage skill gap increased of more than 20 percentage points. Differently, Freeman and Oostendorp (2000) found substantial stability in skill differentials in rich countries, a reduction in low-income countries, and an increase in low/middle income and transitions countries.

[71] Using the data in UNU-WIDER (2008) we find that for the US, for example, the ratio of the tenth over the first Household disposable income group share rose from to 14.79 to 16.03 from 1986 to 2000, that is a period close to the one analyzed in this paper. On the other hand, in a country such as Bolivia this ratio fell from 29.1 to 23.4 between 1993 to 2004.

Therefore, if we add to the overall picture a "relevant" increase in w_s, we obtain that the equilibrium $\bar{x}_s$ may shift to the right, increasing the difference between rich and poor countries and, in particular, implying a positive effect on the long-run level of GDP for rich countries, both pieces of evidence that we find in the data.[72] The main empirical implication of this scenario, therefore, which does not seem corroborated by the data is the decrease in inequality in rich countries.

C Large Sample

In Figures 13 and 14 we show the distribution dynamics and the estimated stochastic kernel for a larger sample of 158 countries for the period 1985-2005, while in Figures 15 and 16 we present the same analysis for the period 1970-1985 (the country list is in Appendix E).

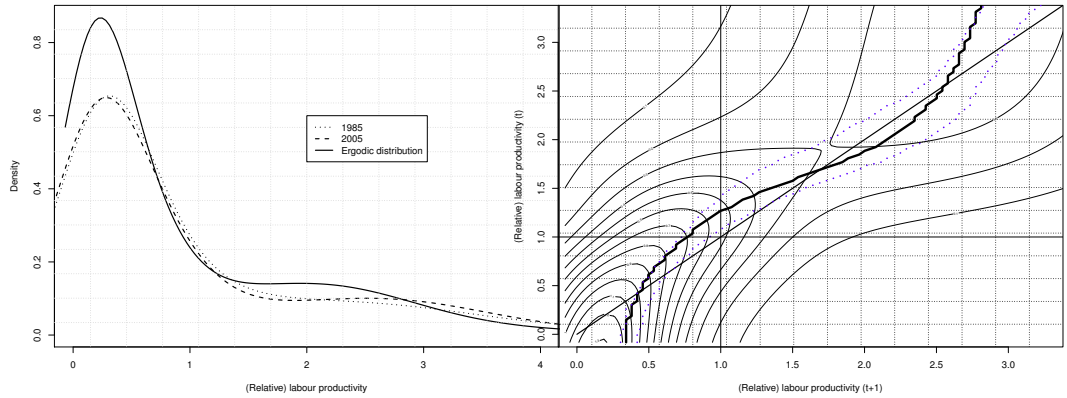

Figure 13: Distribution dynamics of per capita GDP: 1985-2005. 158 countries

Figure 14: Stochastic Kernel: 1985-2005, 158 countries, $\tau = 21$. Thick line: median of the stochastic kernel; dotted lines: 95% confidence bands.

[72] With the numerical values considered in Appendix A, considering a value of dr of three percentage points (see Footnote 67), the ratio of the right-hand side of Eq. (29) to w_s (as computed in Appendix A) is 0.024. In other words,Eq. (29) is satisfied for a relatively small increase in w_s.

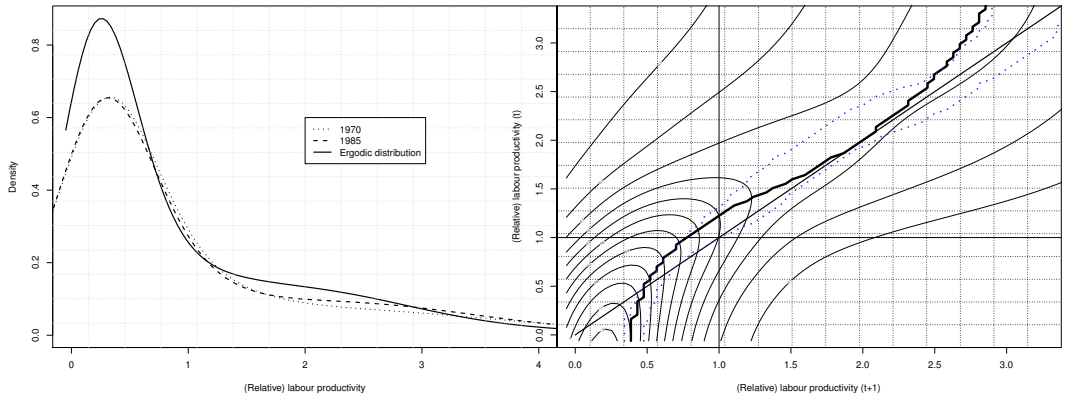

Figure 15: Distribution dynamics of per capita GDP: 1970-1985. 158 countries

Figure 16: Stochastic Kernel: 1970-1985, 158 countries, $\tau = 16$. Thick line: median of the stochastic kernel; dotted lines: 95% confidence bands.

It can be observed that, in line with the results of Section IV.A., there appears a stronger tendency for polarization in the period 1985-2005.

D World Interest Rates and Distribution Dynamics: 1970-1985

In this appendix we present the empirical evidence on world interest rate and the world income distribution dynamics for the period 1970-1985. We select a shorter period than the one studied in the paper in order to preserve the same dimension of the sample.

Figure 17 shows the dynamics of the world interest rate and the US interest rate. As predictable, the oil shocks introduce strong instability in the time series.

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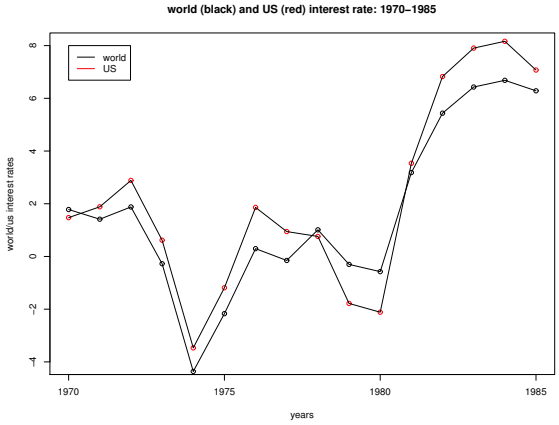

Figure 17: World and US interest rates 1970-1985

Figure 6 show the distribution dynamics. The appears a tendency for polarization, albeit not as strong as the one characterizing the period 1985-2005, presented in Figure 6.

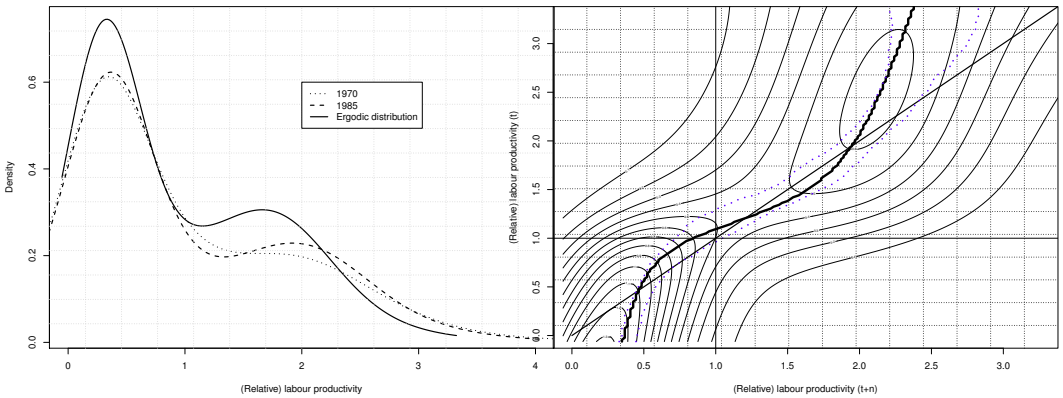

Figure 18: Distribution dynamics of per capita GDP: 1970-1985. 75 countries

Figure 19: Stochastic Kernel: 1970-1985. 75 countries

Figure 19, finally, presents the estimated stochastic kernel. It can be observed that the tendency for polarization, highlighted by the curvature of the median of the kernel and of the the distance between the median, the 45° degree line and the confidence interval, is less evident and significant that the one found for the period 1985-2005 (see Figure 7).

E Country Lists

In Table 6 we report the list of the countries in the main sample analyzed in this paper, with the adopted classification in poor or rich. In Table 7 we report the larger list of countries in the sample analyzed in the analysis of the distribution dynamics in the periods 1985-2005 and 1970-1985.

Argentina	poor	Spain	rich	Jordan	poor	Philippines	poor
Australia	rich	Ethiopia	poor	Japan	rich	Poland	poor
Austria	rich	Finland	rich	Kenya	poor	Puerto Rico	rich
Belgium	rich	France	rich	Korea, Republic of	rich	Portugal	rich
Bulgaria	poor	United Kingdom	rich	Lesotho	poor	Singapore	rich
Bahamas	rich	Germany	rich	Luxembourg	rich	Sierra Leone	poor
Bolivia	poor	Ghana	poor	Morocco	poor	El Salvador	poor
Brazil	poor	Greece	rich	Madagascar	poor	Sweden	rich
Botswana	poor	Guatemala	poor	Mexico	poor	Thailand	poor
Canada	rich	Hong Kong	rich	Mauritius	poor	Trinidad and Tobago	rich
Switzerland	rich	Honduras	poor	Malawi	poor	Tunisia	poor
Chile	poor	Hungary	poor	Malaysia	poor	Turkey	poor
China	poor	Indonesia	poor	Nigeria	poor	Taiwan	rich
Colombia	poor	India	poor	Netherlands	rich	Uruguay	poor
Costa Rica	poor	Ireland	rich	Norway	rich	United States	rich
Denmark	rich	Iran	poor	New Zealand	rich	Venezuela	poor
Dominican Republic	poor	Israel	rich	Pakistan	poor	South Africa	poor
Ecuador	poor	Italy	rich	Panama	poor	Zambia	poor
Egypt	poor	Jamaica	poor	Peru	poor		

Table 6: Country list, 75 countries

Afghanistan	Denmark	Lao	Rwanda
Albania	Djibouti	Lebanon	Samoa
Algeria	Dominica	Lesotho	Sao Tome and Principe
Angola	Dominican Republic	Liberia	Senegal
Antigua and Barbuda	Ecuador	Luxembourg	Seychelles
Argentina	Egypt	Macao	Sierra Leone
Australia	El Salvador	Madagascar	Singapore
Austria	Equatorial Guinea	Malawi	Solomon Islands
Bahamas	Ethiopia	Malaysia	Somalia
Bahrain	Fiji	Maldives	South Africa
Bangladesh	Finland	Mali	Spain
Barbados	France	Malta	Sri Lanka
Belgium	Gabon	Marshall Islands	St. Kitts & Nevis
Belize	Gambia	Mauritania	St. Lucia
Benin	Germany	Mauritius	St. Vincent and the Grenadines
Bermuda	Ghana	Mexico	Sudan
Bhutan	Greece	Micronesia. Fed. Sts.	Suriname
Bolivia	Grenada	Mongolia	Swaziland
Botswana	Guatemala	Morocco	Sweden
Brazil	Guinea	Mozambique	Switzerland
Brunei	Guinea-Bissau	Namibia	Syria
Bulgaria	Guyana	Nepal	Taiwan
Burkina Faso	Haiti	Netherlands	Tanzania
Burundi	Honduras	New Zealand	Thailand
Cambodia	Hong Kong	Nicaragua	Togo
Cameroon	Hungary	Niger	Tonga
Canada	Iceland	Nigeria	Trinidad and Tobago
Cape Verde	India	Norway	Tunisia
Central African Republic	Indonesia	Oman	Turkey
Chad	Iran	Pakistan	Uganda
Chile	Iraq	Palau	United Kingdom
China	Ireland	Panama	United States
Colombia	Israel	Papua New Guinea	Uruguay
Comoros	Italy	Paraguay	Vanuatu
Congo, Democratic Republic of	Jamaica	Peru	Venezuela
Congo, Republic of	Japan	Philippines	Viet Nam
Costa Rica	Jordan	Poland	Zambia
Cote d'Ivoire	Kenya	Portugal	Zimbabwe
Cuba	Kiribati	Puerto Rico	-
Cyprus	Korea, Republic of	Romania	-

Table 7: Country list, 158 countries

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