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WORLD INTEREST RATES AND INEQUALITY: INSIGHT FROM THE GALOR–ZEIRA MODEL

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In this paper, we study the relationship between changes in the world interest rate and within-country inequality during the 1985–2005 period in which the world interest rate sharply declined. In line with the predictions of the seminal model of Galor and Zeira [Income distribution and macroeconomics. *Review of Economic Studies* 60, 35–52], the analysis suggests that the decrease in the world interest rate is associated with a decrease in inequality in poor countries and an increase in inequality in rich ones.

Keywords: Inequality, Economic Growth, Multiple Steady States, World Interest Rates

1. INTRODUCTION

What happens to inequality when interest rates change? Intuitively, income distribution will change because interest rates affect agents' incomes, both directly, through the returns on their savings, and indirectly, through their capacity to borrow funds to accumulate physical and human capital. In this paper, we analyze theoretically and empirically the effects on within-country inequality of changes in the world interest rate, following an insight of Galor and Zeira (1993) (GZ) model that went unnoticed so far.

The seminal contribution of Galor and Zeira (1993) suggests that in the presence of credit market imperfections income distribution has a long-lasting effect on investment in human capital, aggregate income, and economic development.

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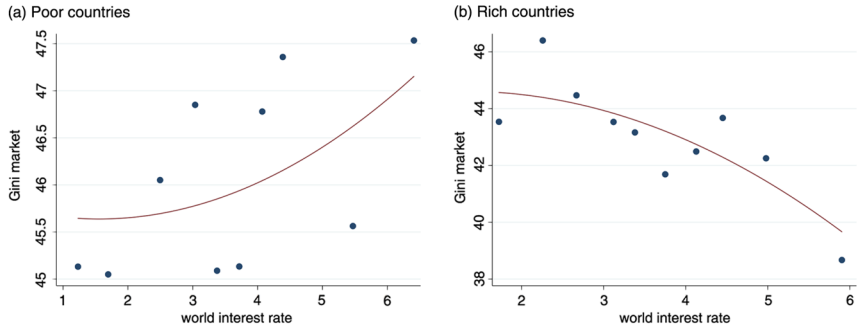

FIGURE 1. Inequality versus world interest rate (1985–2005). Conditional scatter plot: (a) poor countries and (b) rich countries.

In contrast to the Classical hypothesis, which highlighted the beneficial effect of inequality on the growth process, they argue that inequality may be detrimental to human capital formation and economic development. The GZ model further suggests that changes in the world interest rate have a differential impact on borrowers and lenders, and therefore on within-country inequality. The decline in world interest rate generates two opposite effects. On the one hand, inequality tends to decrease, as poorer individuals are able to increase to invest in human capital, but on the other hand, inequality tends to increase due to capital–skill complementarity, the rise in the stock of physical capital increases the wages of educated workers. Hence, in poorer economies where credit market constraints are more pronounced, a reduction in the world interest rate would be expected to reduce inequality, whereas in richer economies, where credit constraints are less binding, a reduction in inequality will be expected to increase inequality.[1]

In this paper, we show that in the period 1985–2005, which was characterized by a sharp decline in the world interest rate, inequality declined in poor countries and increased in rich countries. In line with the predictions of the Galor–Zeira model, the empirical analysis suggests that there exists a highly significant association between the decrease in the world interest rate and the observed dynamics of within-country inequality. Figure 1 highlights the main finding of the paper: A decline in world interest rate is associated with a decline in inequality among poor countries and an increase in inequality in richer ones.[2]

While the remarkable reduction of the world interest rate in recent decades has been studied extensively [e.g. Ahrend et al. (2006), Desroches and Francis (2010), and Bean et al. (2015)], its potential impact on the evolution of inequality has been largely neglected.[3] Notable exceptions are recent contributions on the impact of monetary policy via interest rates on inequality. In particular, Coibion et al. (2017) find that contractionary monetary policy increased inequality in the USA in the post 1980.[4]

The paper is organized as follows. In Section 2, we present the stylized facts that motivate our analysis. In Section 3, we show how the GZ model can account

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for these stylized facts. In Section 4, we present the results of the econometric analysis including several robustness checks. Section 6 concludes.

2. STYLIZED FACTS FOR THE PERIOD 1985–2005

In this section, we present some stylized facts on world interest rate and inequality for a large sample of countries for the period 1985–2005 (the sources for data utilized in this section are described in Section 4.1). We choose this period because it follows the oil shocks and precedes the economic crises of 2008, so we may abstract from major sources of change in our variables interest. In addition, the world interest rate as computed in this paper is extremely unstable in the period 1970–1985 (see Figure C1 in Appendix C). Most importantly for our aim, this period is characterized by a clear downward tendency of the world interest rate. Taking this into account, we selected a sample of countries in order to have the largest possible balanced panel of data on GDP and inequality at 5-year intervals: This implied a selection of 81 countries, both developed and less developed, allowing balanced panel estimations.[5]

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.[6]

Figure 2 presents the dynamics of the world interest rate, together with the US interest rate, reported for comparison: A clear declining pattern for both rates characterizes the period 1985–2005. The world interest rate, in particular, decreases from a value around 6% to less than 2%.

Table 1 reports the salient features of the dynamics of inequality in rich and poor countries in the same period.[7]

Table 1 shows that the dynamics of income inequality is remarkably different across the two groups. The first panel of Table 1, in particular, highlights that with respect to the Gini index of before-tax incomes [for simplicity denoted "Gini (market)"], inequality was on average initially lower for the rich, but subsequently the average value in rich countries remarkably increased, while it decreased in poor countries. The differences, especially for rich countries, are statistically significant. The percentage of countries experiencing an increase in the Gini index, in particular, was much higher in rich countries. This tendency is less evident for the Gini index on post-tax incomes [denoted as "Gini (net)"] although in rich countries the increase in its average value is still highly significant and the percentage of countries in which it increased is still much higher.[8]

Finally, we show that the growth rate of per worker fGDP was higher in rich countries, suggesting that the two groups of countries diverged in the period of observation, a fact in accordance with the predictions of the GZ model.[9]

In the next section, we introduce a theoretical interpretation of these stylized facts in the spirit of the GZ model, while in Section 5, we provide an econometric analysis of the relationships of interest.

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TABLE 1. Dynamics of inequality in poor and rich countries: 1985–2005. Within-group average values are reported, the percentage of countries in both groups in which inequality increased and the *p*-value of a *t*-test of equality on the average values of the Gini index in 1985 and 2005

	Rich	Poor
No. of countries	21	60
Gini (market) 1985	39.63	48.75
Gini (market) 2005	45.34	45.90
% countries with ΔGini > 0	85.7%	41.7%
p-value of *t*-test on ΔGini $\neq 0$	0.000	0.057
Gini (net) 1985	27.59	43.08
Gini (net) 2005	29.60	42.14
% countries with Δ Gini > 0	71.4%	46.7%
p-value of *t*-test on ΔGini $\neq 0$	0.024	0.99
Log per worker GDP 1980	10.914	9.566
Log per worker GDP 2005	11.344	9.843
Annual average growth rate	0.017	0.011

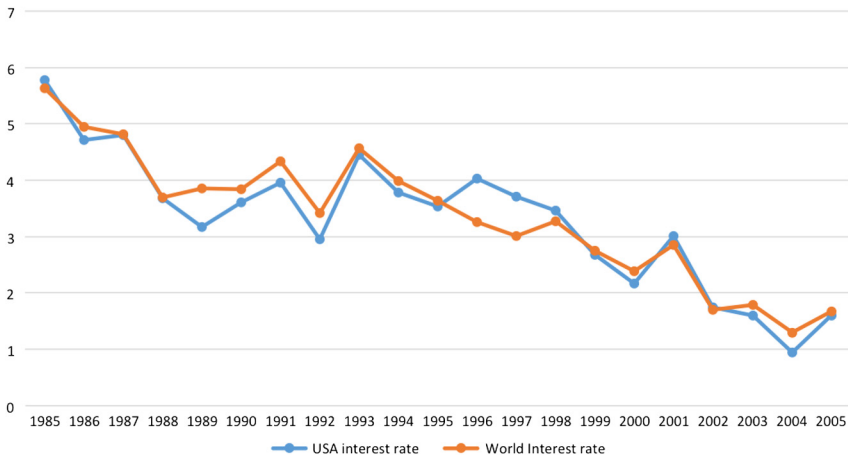

FIGURE 2. World and US interest rates 1985–2005.

3. THE WORLD INTEREST RATE AND INEQUALITY IN THE GALOR–ZEIRA MODEL

In this section, we analyze the consequences of a decrease in the world interest rate for inequality in the GZ model. In Appendix B.1, we summarize this model

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while for a detailed description, we refer the reader to the original paper of Galor and Zeira (1993) and to Galor (2011).

The principal aim of the GZ model is to study the impact of inequality on economic growth. The model features overlapping generations of agents who can acquire human capital in the form of education when young, work as skilled workers and leave a bequest x when old. The model is based on two fundamental assumptions: (i) education has a fixed cost h; (ii) the credit market is imperfect so that the borrowing interest rate i is higher than the lending interest rate r, given by the world interest rate. In particular, the borrowing interest rate is a positive function of r, that is, $i = i(r)$, with $i'(r) > 0$ [see equation (**B5**) in Appendix B.1].

Given these assumptions, the model implies that an individual's choice of investing in human capital depends on the initial level of income, which crucially depends on the bequest received. In particular, agents receiving a bequest $x_t > h$ in period t invest in human capital and become lenders leaving a bequest

$$x_{t+1} = (1-\alpha)\left[w_t^s + (x_t - h)(1+r)\right], \tag{1}$$

where $\alpha < 1$ is the parameter of the utility function measuring the weight of consumption on utility and w_t^s is the skilled wage.

Agents receiving $x_t < h$ can be lenders or borrowers. Specifically, an agent chooses to work as unskilled if $w_{t+1}^s \leq w_{t+1}^n$ (i.e. if $x_t < f$)[10] where w_{t+1}^n is the unskilled wage. Thus, s/he is a lender leaving a bequest

$$x_{t+1} = (1-\alpha)[(x_t + w^n)(1+r) + w^n]. \tag{2}$$

Alternatively, agents receiving $x_t < h$ that invest in human capital become borrowers who leave a bequest

$$x_{t+1} = (1-\alpha)\left[w_t^s + (x_t - h)(1+i)\right]. \tag{3}$$

The resulting bequest dynamics is summarized in the following equation:

$$x_{t+1} = \begin{cases} (1-\alpha)[(x_t + w^n)(1+r) + w^n] & x_t < f \\ (1-\alpha)\left[w^s - (h - x_t)(1+i)\right] & f \leq x_t < h \\ (1-\alpha)\left[w^s + (x_t - h)(1+r)\right] & h \leq x_t \end{cases} \tag{4}$$

Under some conditions (see Appendix B.1), the dynamics of intergenerational transfers features multiple equilibria as shown in Figure 3 (refer the blue and red lines, respectively, to the dynamics of intergenerational transfers before and after a decrease in the world interest rate, as discussed below). 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 $\bar{x}_s$: that is the model displays a "low-income" and a "high-income" equilibria.[11] Members of the former group 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)].

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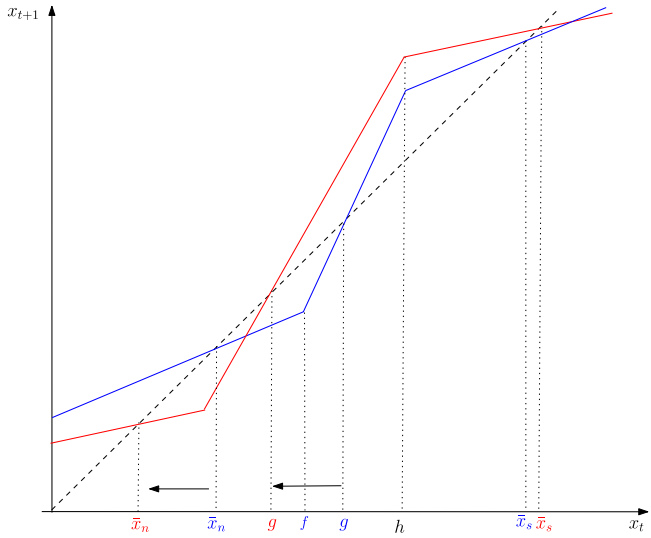

FIGURE 3. Bequest dynamics and multiple steady states in the GZ model before (blue line) and after (red line) a decrease in the world interest rate.

In the GZ model, a decrease in the world interest rate r, as shown in Figure 3, has the following effects. From equation (4), we see that the bequest of unskilled agents (i.e. those with $x_t < f$) decreases because the returns from lending are lower, while the bequest of agents with $f \leq x_t < h$ increases. This occurs because w^s increases and the borrowing interest rate i decreases (see Appendix B.1 for details). Differently, the effect on skilled agents' bequest is ambiguous as w^s increases while the return from lending (i.e. the second term in square brackets) decreases. Therefore, as shown in Figure 3, both the values of the low-income equilibrium $\bar{x}_n$ and the unstable equilibrium g decline. The impact on the high-income equilibrium $\bar{x}_s$ is instead ambiguous. In Figure 3, we represent the case in which $\bar{x}_s$ declines, that is, a positive relationship between the world interest rate and the high-income equilibrium exists (see Appendix B.2 for all technical details).

To sum up, when the world interest rate declines two opposite effects on inequality arise. On the one hand, inequality increases because the poor get poorer; on the other hand, inequality decreases as the number of agents able to invest in education increases. These effects are likely to be particularly relevant in poor countries as they are more presumably the small open economies of the GZ model, in which disparities in the access to credit and their relation to investment in education are important drivers of inequality. In particular, stylized facts shown in Table 1 suggest that, in poor countries, in the period 1985–2005, the latter effect prevailed. The intuition is that in poor countries the first channel is expected to be weaker and the second stronger. According to Demirgüç et al. (2012), in fact, in poor countries the saving of poor people is very low relative to that of poor

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people in rich countries: only 11.5% in poor compared to 40.9% in rich countries reported saving a fraction of income in 2011.[12]

On the other hand, a lower interest rate, favoring access to credit, is expected to allow a higher fraction of agents to invest in education to a greater extent in poor countries relative to rich countries, a fact pointed out in the literature on the argument [see e.g. Flug et al. (1998), Dehejia and Gatti (2002), and De Gregorio (1996)].[13] Empirical evidence shows, indeed, that during this period there was a considerable increase in the number of educated individuals (proportion of persons with secondary or tertiary educational attainment) in poor countries compared to the increase in rich countries. In particular, with respect to our classification of poor and rich countries, Barro and Lee (2013) report that the fraction of individuals with secondary education increased from 9% to 22% in poor countries whereas it increased from 20% to 32% in rich countries. Similarly, the fraction of individuals with tertiary education increased from 2.8% to 6.7% in poor countries whereas it increased from 12% to 15.7% in rich countries. In our econometric analysis, we will consider both a partition of countries in rich and poor based on GDP, and a partition based on these two effects.

In addition, a simple way to evaluate the dynamics of inequality in models featuring multiple steady states is suggested by de La Croix (2013, p. 13), who shows that an increase (decrease) of the difference between the high-income equilibrium and the low-income equilibrium increases (decreases) the Gini index. In the GZ model, the value of such difference is given by

$$\bar{x}_s - \bar{x}_n = \frac{(1-\alpha)[w^s - h(1+r) - w^n(2+r)]}{1-(1-\alpha)(1+r)}, \tag{5}$$

so that, the Gini index decreases when r falls, that is, $\partial(\bar{x}_s - \bar{x}_n)/\partial r > 0$, if

$$\frac{w^s(1-\alpha) - w^n(2-\alpha) - h}{1-(1-\alpha)(1+r)} > -\frac{\partial w^s}{\partial r}, \tag{6}$$

where $\frac{\partial w^s}{\partial r} < 0$ (see Appendix B.2 for the details).

Although a direct evaluation of equation (6) is difficult given that the GZ model is highly stylized, empirical evidence, as discussed above, suggests that in poor countries inequality in equation (6) should be satisfied, while it should not in rich countries. Moreover, by focusing on the LHS of equation (6), we notice[14] that it is likely to be higher in poor countries given that available evidence suggests that skilled/unskilled wage differentials are higher in poor countries.[15]

In the next section, we present the results of the econometric analysis aiming at rigorously testing the relationships presented as stylized facts.

4. DATA AND CLUSTERING

In this section, we present the empirical analysis. In Section 4.1, we describe the dataset while in Section 4.2, we illustrate the methodology to cluster the countries of the sample into poor and rich.

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TABLE 2. Sources for the main variables used in the empirical analysis

Variable	Description	Coverage	Source
Word interest rate (W.I.R.)	GDP-weighted rates for 8 large-GDP countries	1960–2005	IMF, Barro and Sala-i-Martin (1990)
Real GDP per worker	GDP from national accounts at constant prices	1950–2011	P.W.T. 9.0 Feenstra et al. (2015)
Trade Openness	Sum of import and export/GDP	1950–2011	P.W.T. 9.0 Feenstra et al. (2015)
Public spending	Public spending/GDP	1950–2011	P.W.T. 9.0 Feenstra et al. (2015)
Income inequality	Gini index of gross and net incomes	1963–2009	Solt (2009, 2016)
Financial openness	Sum of external assets and liabilities/GDP	1970–2011	Lane and Milesi-Ferretti (2007)
Degree of access to credit	Percentage of borrowers	2011–2014	Demirgüç et al. (2012)
Savings of the poorest fraction of population	Savings at a financial institution of the poorest 40% of the population	2011–2014	Demirgüç et al. (2012)
Rule of law index	Standardized cross-section measure	1984–2010	Knack and Keefer (1995), WGI (2015)
Major trade partners' growth	Weighted average of growth of major trade partners	1980–2005	Fouquin and Hugot (2017)

4.1. Data

Table 2 provides the details of the main variables used in the empirical analysis and their sources.

Our measure of inequality is the Gini index on before-tax incomes from the databases of Solt (2009, 2016) that report standardized values for a large set of countries (v.4.1, 2009), and different values for each country through multiple imputations (v.5, 2016), to take into account uncertainty in the estimation of Gini indices. The measure of income adopted is "income per capita, household adult equivalent."

Proxies for credit market constraints come from Demirgüç et al. (2012) ("percentage of people that borrowed money" and "percentage of people that borrowed money to pay school"), as well as the measure of savings by the poor ("Savings at a financial institution of the poorest 40% of the population"), while we use the Lane and Milesi-Ferretti (2007) dataset to build a measure of financial openness

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as the sum of external assets and liabilities on GDP. To proxy for other aggregate shocks that may overlap with the changes in the world interest rate, we consider the world GDP growth as a population-weighted average of countries' growth rates from P.W.T. 9.0 and, for each country in the sample, their major trade partners' average growth, computed as the weighted average of growth of countries whose share of imports or exports to/from each country of the sample amounts to at least 5% (or 10%) of total exports or imports.

4.2. Identifying Rich and Poor Countries

The analysis of Section 3 suggests that there might be differences between poor and rich countries in the dynamics of inequality. We partition our sample of countries in poor and rich by using mixture densities of GDP. This allows to avoid any ad-hoc classification.

The longitudinal mixture approach of Mcnicholas and Murphy (2010) allows to apply mixture clustering to a panel data framework. The idea is that a whole density of data is divided into n unknown subdensities, with specific means and variances. After an initial random set of probabilities of belonging to a given cluster, an EM (expectation-maximization) algorithm computes the weighted (by ex ante probabilities) log-likelihood and updates the ex-post probabilities. The process terminates when the log-likelihood converges. Battisti and Parmeter (2013) applied this approach to country GDP densities over time, finding evidence of two or three clusters, depending on different specifications. The unknown in this procedure is the number of clusters, so the choice is made ex-post by comparing the penalized log-likelihood (for instance through the Bayesian information criterion) of models featuring different numbers of clusters.

By applying this method, we find three clusters of countries in a possible range 1–6 (see Table 3). However, Table 3 shows that the second cluster is very similar to the third in terms of average GDP and very small, as it includes eight countries only. Therefore, we merge clusters 2 and 3 into a unique group, representing the "poor" countries, distinct from the group of 21 "rich" countries (see Appendix A for the list of countries). This partition will be used to analyze the dynamics of inequality in rich and poor countries in the next section.

5. ECONOMETRIC ANALYSIS

The aim of the econometric analysis is to identify the robustness of the relationship between changes in the world interest rate and inequality, if any, on the basis of the predictions from the GZ model discussed so far.

Since these predictions are made for small open economies, first all we focus on the subsample of poor countries as they are "smaller" than the rich ones, in the sense that their per capita GDP is, on average, smaller than the one of rich countries (see Table 3). Among them, we will then identify those who are more open. Then, we extend the analysis to the full sample that includes rich countries in

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TABLE 3. Log GDP means from longitudinal mixture clustering

	Cluster 1	Cluster 2	Cluster 3
1980	10.90	9.30	9.62
1985	11.00	9.28	9.61
1990	11.10	9.25	9.67
1995	11.19	9.07	9.77
2000	11.29	9.06	9.85
2005	11.34	9.26	9.33
Obs.	21	8	52

order to assess the presence of a different relationship between the world interest rate and inequality.[16]

In small open economies, the world interest rate is given and represents the lenders' rate, while the borrowers' rate is a positive function of the former. In such economies, disparities in the access to credit and their relation to investment in education are more likely to be important drivers of inequality. In principle, in these economies, economic growth (and thus industrialization and the emergence of a middle class) could have favored a reduction in inequality, a mechanism that is less likely to hold for rich countries. From an econometric point of view, this could imply the possibility of omitted variable bias so that focusing on poor countries and controlling for GDP may help to tackle this issue.[17]

5.1. Inequality and the World Interest Rate in Poor Countries

Following the previous discussion, we propose a panel regression procedure based on the estimation of the following relation:

$$\text{inequality}_{j,t} = \alpha_0 + \alpha_1 r_t + \cdots + \epsilon_{j,t}, \tag{7}$$

where country and time are indexed, respectively, by j and t, and where r_t represents the world interest rate.

This type of regression is also related to the literature on the Kuznets curve [see e.g. Barro (2000) and Brueckner et al. (2015)] where inequality is nonlinearly influenced by GDP and by other variables such as trade openness and institutional quality.[18] To take this into account, we estimate the following regression:

$$\text{Gini}_{j,t} = \alpha_j + \alpha_1 r_t + \alpha_2 \text{GDP}_{j,t} + \mathbf{Z}_{j,t} + \epsilon_{j,t}, \tag{8}$$

where t = 1985, 1990, 1995, 2000, and 2005 and $\mathbf{Z}_{j,t}$ is a vector of controls. We assume that country-specific unobservable characteristics can be present, as summarized by the country-specific intercept.

The expectation, therefore, is that α_1 is positive. We use GDP per capita as a regressor in this benchmark specification to control for the initial "location" of

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the country in the GZ framework, and as a synthetic index of other possible determinants of inequality, such as economic growth. We estimate this equation as a fixed effect (FE) panel regression with balanced panel data, even if it is possible that, when we consider other regressors than GDP, a country does not have observations for the whole period. Table 4 contains the main results for the subsample of poor countries.[19]

Models 1 and 2 are estimations of equation (8) including GDP as the only control or with its squared value. The estimates show that the documented decrease in the world interest rate has a positive and significant correlation with inequality for the poor countries (i.e. inequality in those countries decreased as well). When we add the quadratic term, in order to check evidence for "Kuznets curve" effects, the significant effect of the GDP terms disappears [as for instance in Brueckner et al. (2015)].

In Model 3, we add other possible determinants of inequality considered in the literature [see e.g. Barro (2000) and Beck et al. (2007)]. In particular, we consider the following: 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 of the economy; a measure of public expenditure on GDP, on the assumption that public sector intervention may reduce inequality.[20] Results show that these additional variables are scarcely significant with the exception of institutional quality. Our coefficient of interest, however, remains highly significant with the expected sign and a consistent magnitude.

In Models 4a and 4b, we consider the possible effect of the degree of openness to capital flows. Although by considering poor countries, we take into account this aspect, we try to assess whether among these countries the effect of the world interest rate is stronger in the subset where the degree of openness is higher. To this purpose, we add to our baseline estimation a sample splitting based on a measure of openness to capital flows, under the assumption that the effects of changes in the world interest rate should be stronger, the more open an economy is. The measure of openness we use is the ratio of the sum of external assets and liabilities to GDP, from the dataset of Lane and Milesi-Ferretti (2007).[21] The results of Models 4a and 4b show that the coefficients for the interaction terms have the expected signs and in the case of highly financially open countries the effect is four times bigger.

Another crucial aspect of the GZ model is credit rationing. In Models 5a and 5b, we take this aspect into account, under the assumption that the effect of the world interest rate should be stronger in countries in which credit rationing is a major problem. To this purpose, we split the countries in our sample on the basis of the percentage of individuals having access to credit. The dataset containing these data, that is, the World Bank dataset of Demirgüç et al. (2012), has data from 2011, that is, a period not included in our dataset. For this reason, we cluster the countries only in 2011, under the assumption that this classification holds for our period of interest.[22] Models 5a and 5b, respectively, present the results for the

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TABLE 4. Dependent variable: (market) Gini index. Period: 1980–2005. Poor countries. Five-year clustered standard errors in parenthesis

	1	2	3	4a	4b	5a	5b	6	7
GDP	5.590***	−2.158	5.834***	1.614	9.340***	2.803	5.705**	4.821***	6.504***
	(0.723)	(5.783)	(0.970)	(0.812)	(1.939)	(1.540)	(1.663)	(0.375)	(1.215)
GDP squared		0.402							
		(0.325)							
W.I.R.	0.370***	0.382***	0.492**	0.228**	0.949**	−0.373**	1.760***	0.439***	0.328***
	(0.065)	(0.075)	(0.128)	(0.056)	(0.289)	(0.104)	(0.141)	(0.071)	(0.063)
Trade openness % GDP			1.326						
			(1.584)						
Public expenditure % GDP			3.265						
			(4.691)						
Institutional quality			0.636**						
			(0.269)						
Trade partners' growth								2.066	
								(21.349)	
R^2 within	0.04	0.04	0.075	0.01	0.22	0.07	0.26	0.03	0.04
Obs.	300	300	288	220	60	210	70	272	245
Countries	60	60	60	44	12	42	14	56	49
Fin. openness	–	–	–	Low	High	–	–	–	–
Fin. inclusion	–	–	–	–	–	High	Low	–	–

Note: ***,**, and * denote significant coefficients at 1%, 5%, and 10%.

subsample of countries in which the percentage of borrowers is high and low. We obtain the expected results, as in the case of credit rationing the sign is positive and five times bigger than the standard in the case, while the relationship of interest does not hold in the case of no credit rationing. This confirms the expectation that the effects of the world interest rate on inequality are higher where credit rationing is a major problem as suggested by the GZ model.

In Model 6, we introduce a term to capture other macro-factors that can affect inequality besides the world interest rate. In particular, for each country we constructed a weighted average of the growth rate of major trade partners, using the dataset on international trade of Fouquin and Hugot (2017). Major trade partners of a country are defined as the countries accounting for at least 5% of its imports or exports (considering a threshold value of 10% does not affect the results). Results show that this effect is not significant and the main results are not affected.[23]

Finally, in Model 7, we consider a different way of partitioning the countries in order to assess the validity of the insights from the GZ model on the relationship between inequality and the world interest rate. Specifically, we partition the whole sample according to the expectation on the importance of the two effects of the world interest rate on inequality: the one that makes the poor poorer and the one that allows more individuals to invest in education. In particular, instead of the group of poor countries, we identify a group of countries in which the first effect is expected to be weak and the second strong and where, therefore, inequality is expected to decline when the world interest rate declines. We identify the countries where the first effect is weak and the in which the second effect is strong as those in which the savings of the poor and the initial education levels are both low.[24] In such countries, inequality is expected to be positively associated with the world interest rate. Results of Model 7 confirm this expectation, even in presence of a group of countries very different from the group of poor countries considered in Models 1–6.[25]

5.2. Robustness Checks

There are some issues we did not discuss in the previous section that we address now in order to provide robustness to our main results. Table 5 presents the results of several robustness checks, to prove that our main results are not sensitive to the specifications presented in Table 4. In particular, we consider the following issues.

Criterion to define rich and poor countries. A simple alternative criterion to classify a country as rich or poor is to count the times in which, in our panel dataset, its GDP is above or below the sample average. In particular, if a country's GDP is above (below) the GDP sample mean for the majority of periods (i.e. three out of five) we classify it as rich (poor).[26] In Model 1 of Table 5, we see that even by using this alternative criterion, which strongly modifies the relative sizes of the two groups (see Table A1 in Appendix A), results are unchanged. In addition, in Model 2, we see that by adding an interaction term between the world interest rate

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TABLE 5. Robustness checks regression of gross inequality on world interest rate, 1980–2005. Five-year clustered standard errors in parenthesis

	1	2	3	4	5	6	7	8
GDP	6.457***	6.436***	1.364	0.145	5.590***	5.834**		5.086***
	(0.270)	(0.596)	(1.135)	(0.939)	(0.723)	(0.970)		(0.402)
W.I.R.	0.647***	3.900***	0.574**	0.738**	0.370**	0.492**	0.046	0.401***
	(0.044)	(0.520)	(0.286)	(0.301)	(0.065)	(0.128)	(0.026)	(0.069)
W.I.R.* GDP		−0.367***						
		(0.056)						
Trade openness % GDP				0.155		1.326		
				(0.938)		(1.583)		
Public expenditure % GDP				−6.469		3.265		
				(5.044)		(4.691)		
Institutional quality				0.996***		0.636**		
				(0.228)		(0.269)		
$Gini_{t-5}$			0.819***	0.816***				
			(0.061)	(0.077)				
Trade partners growth (> 5%)								8.551
								(23.58)
World GDP growth								−14.36
								(9.024)
Mixture clusters	N	N	Y	Y	Y	Y	Y	Y
GMM estimations	N	N	Y	Y	N	N	N	N
Multiple imputations	N	N	N	N	100	100	N	N
Obs.	175	300	300	288	300	288	300	272
Countries	35	60	60	60	60	60	60	56

Note: ***,**, and * denote significant coefficients at 1%, 5%, and 10%.

and GDP, the effect decreases as a country gets richer. A more radical approach is based on considering continuous interaction between world interest rate and GDP as in Model 2 to check whether there is a bigger effect of the world interest rate on poorer countries. We return on this point in Section 5.

A dynamic specification. Following Brueckner et al. (2015), we consider a dynamic specification, by including the lagged inequality values among the regressors. This type of modification in a context where variables are very persistent usually implies the estimation of a large value of the coefficient of the lagged variable, which in turn implies a sensible change in the other estimated coefficients. This effect is discussed by Barro (2015) as Hurwitz bias in a dynamic growth convergence estimation. In Models 3 and 4, we show the results of GMM (generalized method of moments) estimations.[27] Results are very similar to the main ones: in both cases, we obtain the expected coefficients' sign and magnitude.

Uncertainty of Gini estimations. In order to have a fairly high number of observations for both groups in a balanced panel for the period 1985–2005, we used the Standardized World Income Inequality Database of Solt (2016), which contains a high number of observations. The measures of inequality are, however, subjected to measurement errors, so Solt (2016) updated the database with a multiple imputation version in order to take into account the variability of measurements of the Gini index values. In particular, for each observation 100 different values are reported to allow the consideration of uncertainty in the measurement. In Models 5 and 6, we show two regressions that use the maximum likelihood (average estimation of 100 imputed values) FEs estimation for a basic version of the model, without control variables and with control variables. Results are consistent under this scenario.

Endogeneity. While our variables of primary interest are not likely to be influenced by simultaneity relationships with the dependent variable,[28] a large literature emphasized the issue of reverse causality between inequality and GDP, although with the exception of Brueckner et al. (2015), no strategies were proposed to address this issue.[29] While this issue is not our primary interest, we make some remarks. We showed that our results are qualitatively the same with system GMM, which implies an IV strategy (although this clearly does not solve all the endogeneity problems). To avoid possible endogeneity bias due to the relationship between GDP and inequality, and in order to see if there is a pure effect of the world interest rate on inequality in absence of potentially endogenous regressors as GDP, in Model 7 we consider a simple specification without GDP, in which the coefficient of the world interest rate still positive even if scarcely significant (p-value is 0.15).

Other kinds of macro-shocks as confounding factors. In Model 8 of Table 5, we considered the weighted average of growth rates of major trade partners as another possible indicator of macro-shocks, different from the variations in the world interest rate. However, one could wonder if the world interest rate is just a

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common factor that may proxy for something else. In Model 7 of Table 5, we add the population-weighted growth rates' average. Even if this variable is negatively correlated with inequality it is scarcely significant (p-value is 0.12). We still see that the main results are robust.

5.3. Inequality and World Interest Rate Changes in Rich and Poor Countries

The last step is extending the analysis to rich countries. As pointed out, however, these countries are not expected to have the characteristics of small open economies of the GZ model and to be particularly sensitive to the world interest rate when it comes to explain the propensity to invest in education. In Section 3, however, we noticed that according to the GZ model the relationship between the world interest rate and inequality can have the opposite sign of the one identified for poor countries.

For these reasons, we will estimate the equation:

$$\text{Gini}_{j,t} = \alpha_j + \alpha_1 r_t + \alpha_2 \cdot Dr_t + \alpha_3 \text{GDP}_{j,t} + \mathbf{Z}_{j,t} + \epsilon_{j,t}, \quad (\mathbf{9})$$

in which D is a dummy variable such that $D = 1$ if the country is rich and $D = 0$ otherwise. As before, we expect that α_1 is positive, while now α_2 should be negative and greater in absolute value than α_1.

In Table 6, we report the estimations of the main models of Tables 4 and 5 and show that in all cases the coefficients of the effects of the World interest rate have the opposite sign in poor and rich countries and are significant.[30]

From an intuitive point of view, we may see it directly by the fact that the coefficient of the interaction term with the "rich" dummy variable is much higher in absolute value than the coefficient of the effect in poor countries, while from a statistical point of view, we see that testing for the sum of these coefficients to be zero always allows us to reject the null hypothesis of a zero effect.

In the case of rich countries, however, we cannot rule out the possibility of important omitted variables that independently acted to increase inequality, such as an increase in the wage skill premium due in particular to skill-biased technological change.[31] Models 6 and 7 of Table 6 present two possibilities to take this into account by adding, respectively, a variable to capture the effect of the skill-biased technical change and a variable to capture the changes in the supply of skilled workers. Both should affect inequality through changes in the wage-skill premium. The variable introduced in Model 6 is the ratio of efficiency levels of skilled and unskilled workers computed through the years of education according to the procedure of Caselli and Coleman (2006).[32] This variable has the same rate of change of the skill premium, assuming perfect labor market competition, as is the standard assumption in this literature [Violante (2016)]. In Model 7, we add the percentage of population with completed higher education, as a measure of the change in the relative supply of skilled workers.[33] As we see these variables have the expected signs even if they are not

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TABLE 6. Dependent variable: (market) Gini index. Period: 1980–2005. Rich and poor countries. Five-year clustered standard errors in parenthesis

	1	2	3a	3b	4	5	6	7	8
GDP	5.582***	6.099***	1.846*	8.828***	1.026**	4.878***	4.973**	6.117***	4.917**
	(0.725)	(0.876)	(0.793)	(0.276)	(0.507)	(0.693)	(1.630)	(1.112)	(1.108)
W.I.R.	0.370***	0.449**	0.240***	0.865**	0.319*	0.363***	0.515***	0.555**	0.258***
	(0.066)	(0.135)	(0.052)	(0.276)	(0.170)	(0.074)	(0.087)	(0.134)	(0.054)
W.I.R.* D	−1.187***	−1.271***	−0.987**	−1.433***	−0.940***	−1.198***	−0.988***	−1.132***	−0.709***
	(0.103)	(0.127)	(0.287)	(0.068)	(0.359)	(0.242)	(0.056)	(0.140)	(0.118)
Trade open. % GDP		1.220			0.155	0.748	0.787	0.975	
		(1.389)			(0.604)	(1.020)	(1.287)	(1.196)	
Public exp. % GDP		3.434			−9.043*	5.065	1.311	6.510	
		(4.852)			(5.091)	(3.615)	(5.975)	(6.058)	
Institutional quality		0.369			0.614***	0.632*	0.504*	0.254	
		(0.208)			(0.212)	(0.193)	(0.291)	(0.209)	
Efficiency ratio							0.632**		
							(0.204)		
% of pop with completed tert.edu								0.136	
								(0.068)	
Gini_{t-5}					0.741***				
					(0.121)				

TABLE 6. Continued

	1	2	3a	3b	4	5	6	7	8
Trade partners' growth						10.821			
						(17.45)			
World GDP growth						−20.132*			
						(7.537)			
GMM estimations	N	N	N	N	Y	N	N	N	N
Fin. openness	–	–	Low	High	–	–	–	–	–
Obs.	405	393	250	130	393	356	287	373	385
Countries	81	81	50	26	81	75	58	77	77
Test coeffs. W.I.R. + $D = 0$	23.95	9.61	8.27	6.22	4.71	9.60	17.81	4.77	7.85
p-value	(0.008)	(0.036)	(0.045)	(0.067)	(0.003)	(0.036)	(0.014)	(0.094)	(0.049)

Note: ***,**, and * denote significant coefficients at 1%, 5%, and 10%.

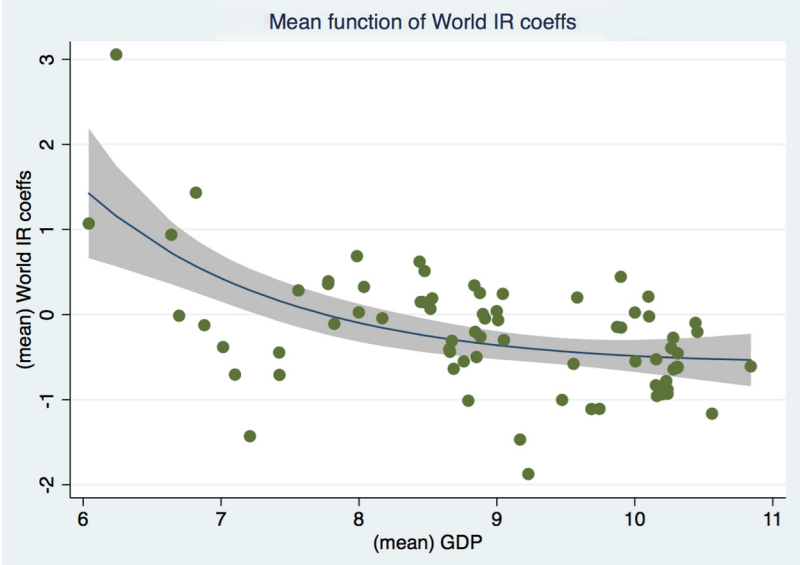

FIGURE 4. Nonparametric estimation of the effect of the world interest rate on inequality at different levels of log GDP per capita.

always significant, but most importantly, the interest rates variables maintain the same signs, significance and similar magnitudes. These evidences imply that we are also confident on this robust association for this pooled sample of countries.

Another version of this test, that is, of whether the effect of the world interest rate is different for poor and rich countries, can be based on the nonparametric estimation of Model 1 following Li and Racine (2007), which allows us to rank the coefficients of the effect of the world interest rate on inequality at different GDP levels on the pooled sample avoiding any ex-ante partition of the countries.

As we see from Figure 4, where we report the country average of the coefficients (gradients) measuring the effect of the world interest rate on inequality, ranked on the basis of each country's mean GDP for the available periods, the estimated relation is decreasing. This confirms the results from the FE estimation: as GDP increases, the marginal effect of the world interest rate on inequality decreases, moving from positive to negative values.

Finally, in Model 8, we report the results based on our alternative partition of countries in which the first effect of the world interest rate (the one affecting savings of the poor) is expected to dominate or not the second (the one affecting the possibility to invest in human capital). These results complement those of Model 7 in Table 4 and confirm the main findings of the paper: in countries where the second (first) effect is expected to dominate the first (second), the world interest rate has a robust positive (negative) association with inequality.[34]

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To sum up, the econometric analysis provides support for the following picture: a decreasing world interest rate is significantly correlated to a decrease in inequality in poor countries and an increase in inequality in rich countries.

6. CONCLUSIONS

In this paper, we studied the effects of changes in the world interest rate on the dynamics of within-country income inequality, following an insight of the seminal model of Galor and Zeira (1993). Consistent with the prediction of the Galor–Zeira model, the empirical analysis suggests that during the decades between the oil shocks and the recent financial crisis there exists a highly significant association between the decrease in the world interest rate and the observed dynamics of within-country inequality. A decline in world interest rate is associated with a decline in inequality among poor countries and an increase in inequality in richer ones.

NOTES

1. The testable predictions of the GZ model change if we consider a closed economy as in Galor and Moav (2004) or if the economy is agriculture-based and inequality in land concentration affects human capital formation and inequality as in Galor et al. (2009) in which, however, a world interest rate is not considered. In particular, in Galor and Moav (2004), the interest rate depends negatively on the capital–labor ratio. In the process of development, the increase in intergenerational transfers by the rich increases the capital–labor ratio and therefore the interest rate declines. The threshold level of transfer that enables poor agents to escape the poverty trap declines and eventually vanishes. The intuition in this case is that a lower interest rate is associated to lower inequality. Galor et al. (2009) differently suggest that inequality in the distribution of landownership adversely affects the emergence of human capital-promoting institutions. The basic idea is that landowners had no economic incentives to support public schooling because a higher level of education increased the productivity of labor in industrial production more than in agriculture, decreasing therefore the return to land due to labor migration. When the capital holdings in landlords' portfolio increased, the objection of landlords to education reforms declined. Therefore, as in the process of development, the capital–labor ratio increases, the capital holdings of landowners increases favoring the implementation of public education. The intuition also in this case is that a lower interest rate is associated to lower inequality.

2. In this figure, we show a scatter plot of inequality measured by the Gini index, and world interest rate conditioned on the main variables used in the econometric analysis: Per capita GDP, trade openness, institutions, and public spending. The estimated relationship is based on a nonparametric continuous estimation with 10 bins of equal size, after residualization of the Gini index and world interest rate, due to the other covariates. For the definition of the measure of inequality, and world interest rate and the classification of poor and rich countries, see Section 2 and Section 4.2, respectively.

3. Focusing on the inverse effect, Bean et al. (2015) suggest that the rise in inequality is a possible driver of low interest rates.

4. See also Kunieda et al. (2014) for the impact of international financial integration on inequality within a country.

5. For each country, therefore, we will utilize five observations in the econometric analysis. Appendix A contains the country list.

6. Specifically, data on interest rates are from the IMF's (International Monetary Fund) *International Financial Statistics*. Barro and Sala-i-Martin (1990) considered 10 countries while in

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this work we consider eight countries: Belgium, Canada, Japan, France, Netherlands, UK, USA, and 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 selected countries account for 46.9% of world GDP in 1985, computed considering 190 countries, while the 10 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, that is 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 55% of world GDP in 1985.

7. The classification of countries is based on the nonparametric procedure proposed by Battisti and Parmeter (2013). See Section 4.2 for the details. In the econometric analysis, we will also consider an alternative partition of countries based on the relative importance of the two effects of inequality envisaged by the GZ model: the one making the poor poorer, and the one affecting the possibility to invest in education.

8. In this paper, we will consider the relevant measure of inequality as the Gini (market) computed on gross incomes, as they represent the remuneration of factors, that is, the relevant ones according to the GZ model.

9. A thorough analysis of the consequences for economic growth, however, is beyond the scope of the paper.

10. For the definition of the threshold f, see Appendix B.1.

11. In the theoretical model, the equilibria correspond to levels of bequest. Being the bequest a part of income in the model, we can proxy bequests by income, an aspect that will be relevant in the empirical analysis.

12. Specifically, data refers to income saved at a financial institution, and denotes the percentage of respondents who reported saving or setting aside any money at a bank or another type of financial institution in the past 12 months [see Demirgüç et al. (2012)]. We consider 2011 as it is the first observation available. The figures in the main text refer to the definition of poor and rich countries of Demirgüç et al. (2012). With our definition, these figures are 18.57% in poor countries and 43.86% for rich.

13. In particular, De Gregorio (1996) argues that access to credit promotes human capital accumulation, as credit constraints will force students to work, which will reduce the time available for study. Dehejia and Gatti (2002) and Jacoby (1994) also find that access to credit increases investment in schooling. See also Marshall et al. (2017) and Ho (2016).

14. The GZ model does not make specific assumptions on technology, which makes an evaluation of the RHS of equation (6) particularly problematic in a cross-country perspective. For this reason, we only focus on the sources of possible differences between rich and poor countries in the LHS.

15. The measurement of w^s and w^n at cross-country level is made very difficult by the different definitions of skilled and unskilled wage [see e.g. Oostendorp (2012)]. A dataset with comparable data is OECD (2007, Table A9.2a), reporting dynamics of wage ratios for the adult population by skill level for the period 1997–2005 (not all years are available for each country) for 25 countries of our sample (20 rich and 5 poor). The countries from our sample covered by OECD (2007) are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Luxembourg, Netherlands, New Zealand, Norway, Spain, Sweden, Switzerland, United Kingdom, United States, and Israel (rich); Hungary, Korea, Poland, Portugal, and Turkey (poor). OECD (2007) shows that in rich countries the ratio of the wage of workers with tertiary education with respect to secondary education and to less than secondary education (proxies for w^s/w^n) amounts on average to 1.44 and 1.84, respectively. The same values for poor countries are 1.88 and 2.70. At the same time, if we look to Mincerian returns of education for the countries of our sample in the dataset of Caselli (2016), they are on average 7.59% for rich and 9.65% for poor countries. It means that under the hypothesis that skilled workers are more educated the wage premium should be higher in poor countries.

16. 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 of the distribution and possible modifications that can occur over time. They show that "squeezes" of the distribution

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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, which is a polarisation-sensitivity parameter, affecting the income distribution and polarization. Overall, we use the Gini index as our measure of inequality for two reasons. First, 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. Second, 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 1980 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 but we computed the correlation with the change of the Gini index in the same span of time for each country. The correlation is higher than 0.60 and if we check for the changes in the Gini index as in Table 1 for rich and poor we obtain the same results.

17. We thank two anonymous referees for stimulating us on these two points.

18. See, for example, Kraay (2006) and Beck et al. (2007) on the determinants of inequality.

19. Since the key variable, the world interest rate, is the same for every country, we are in a situation where there is no cross-sectional variation in this regressor, which requires the standard errors to be clustered by 5-year periods. Results in Table 4 report this type of standard errors. We thank an anonymous referee for this suggestion.

20. The institutional quality measure is the cross-section standardized rule of law score of Knack and Keefer (1995) until 1997. After 1997 this measure comes from the World Bank Governance Indicators (given we have not a unique source for the time series of this variable we use the cross-sectional standardized value to reduce as much as possible the possible heterogeneity in the change of source of 1997.)

21. To be consistent with the rich/poor definition, we use the same mixture clustering procedure used before (see Table A1).

22. We utilized the *flexmix R* package of Leisch (2004). See Table A1 in Appendix A for the results.

23. While our results are based on contemporary effects, in the textbook GZ model these effects need a generation to occur, through the bequest dynamics. In a world with public education the emphasis is much bigger for tertiary education that is usually not mandatory. Due to lack of observations for longer periods, we tried to look at this effect in two ways: First, we used yearly data for poor countries with a lag of 15 years for the effect of world interest rate on inequality and we obtain a positive coefficient of 0.297 for world interest rate that is significant at 1%, in line with results in Table 4. Then, for a poor country such as India with data on inequality from WWID (2018), we regress the share of income of top 1% or 10% on the world interest rate with a lag of one generation. We still find a confirmation of our main results, as the estimated coefficient is positive and significant. We thank an anonymous referee for this suggestion.

24. In particular, we use again mixture density approach, this time fitting a bivariate Gaussian density of savings at a financial institution of the poorest 40% of the population in 2011 from Demirgüç et al. (2012), and the initial level of tertiary education at the beginning of the period from Barro and Lee (2013).

25. In Model 8 of Table 6, we present the results for the whole sample based on this partition, and show that the sign of the relationship of interest for the countries in which the first effect is expected to dominate the second is negative, significant, and higher in absolute value.

26. This is the criterion we utilized in previous versions of this paper. See Battisti et al. (2014).

27. We applied the Blundell–Bond system GMM as in Brueckner et al. (2015) in order to preserve the same panel dimension but also because it is more consistent in the case of persistent data as inequality [Blundell and Bond (2000)]. With different GMM, we would lose one observation for each country or many countries in the sample.

28. Bean et al. (2015, pp. 27–28) suggest that the causal channel could go from inequality to interest rates. They point out that increases in inequality may increase the saving rate and therefore reduce

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the world interest rate. With respect to our results, however, this argument is unlikely to hold. The effect highlighted by Bean et al. (2015) could apply on a global scale, in which an increase in global inequality affects the world interest rate. In our estimations, a global factor affects inequality in individual countries, so the reverse causality argument seems difficult to sustain. In addition, Bean et al. (2015, p. 28) themselves remark that the timing of the rise in inequality detected in several countries do not match the timing of the decrease in the world interest rate.

29. Brueckner et al. (2015) use oil shocks as instruments as they are correlated with GDP but not with inequality, given their unexpected nature. We tried to consider oil shocks as instruments for GDP but the first stage results show that the instruments are not significant, so we did not follow this strategy.

30. We do not report the results of the other estimations from Tables 4 and 5 to save space. The results confirm our main findings and are available upon request.

31. For example, Berman et al. (1998, p. 1259) show that in developed countries, in the period 1979–1993, the wage gap increases on average of 4.2, while Feenstra and Hanson (2001) show that in the USA in the period 1979–1995 the wage skill gap increased of more than 20% points. Maoz and Moav (2004), in contrast to the literature on the skill-biased technological progress, attribute the increase in the education premium to the capital–skill complementarity and the endogenous accumulation of physical and human capital in the presence of credit constraints.

32. Differently from Caselli and Coleman (2006) that look at the world technology frontier from the 1960s, our period of observation begins in 1985–1990, so in this period it is more likely to consider skilled workers individuals with tertiary education. By doing so we follow the approach of Alesina et al. (2018). Similar results are obtained when considering as skilled people individuals with secondary or higher education.

33. Although we do not claim it is exogenous, especially in the light of GZ model.

34. If we perform the bivariate clustering considering secondary education instead of tertiary, the coefficients for the two groups have the expected signs and are significant. However, we cannot reject the null hypothesis that their sum is equal to zero.

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APPENDIX A: COUNTRY LIST AND CLUSTERING

Table A1 contains the country list and the classifications of countries in high/low income (rich and poor as defined in the main text), respectively based on the clustering procedure described in Section 4.2 (first column), and the criterion used in the first robustness check in Section 5.2 (fourth column). The second column reports the clustering based on the degree of financial openness, the third one based on the level of access to credit, while the fifth column reports the clustering based on the two effects on inequality envisaged by the GZ model. In particular, we label "high" the group of countries in which savings of the poorest fraction of the population and the initial level of tertiary education are high.

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TABLE A1. Country list and classifications

Country code	GDP	Fin. openness	Access to credit	GDP (mean)	Bivariate clustering
AUS	High	Low	High	High	High
AUT	High	High	High	High	High
BEL	High	High	High	High	High
CAN	High	Low	High	High	High
CHE	High	High	High	High	High
DEU	High	High	High	High	High
DNK	High	High	High	High	High
ESP	High	High	High	High	High
FIN	High	High	High	High	High
FRA	High	High	High	High	High
GBR	High	High	High	High	High
IRL	High	High	High	High	High
ISR	High	High	Low	High	High
ITA	High	Low	High	High	Low
JPN	High	Low	High	High	High
LUX	High	High	High	–	High
NLD	High	High	High	High	High
NOR	High	High	High	High	High
NZL	High	Low	Low	High	High
SWE	High	High	High	High	High
USA	High	Low	High	High	High
ARG	Low	Low	High	High	Low
BGD	Low	Low	High	Low	Low
BGR	Low	High	Low	–	Low
BHS	Low	–	High	–	–
BOL	Low	Low	High	Low	Low
BRA	Low	Low	High	High	Low
BWA	Low	Low	Low	High	Low
CHL	Low	Low	High	High	Low
CHN	Low	High	Low	–	High
CIV	Low	Low	High	Low	Low
CMR	Low	Low	Low	Low	Low
COL	Low	Low	High	Low	Low
CRI	Low	Low	High	Low	Low
DOM	Low	Low	High	Low	Low
ECU	Low	Low	High	Low	Low
EGY	Low	High	High	High	Low
ETH	Low	Low	High	Low	–
GHA	Low	Low	High	Low	Low
GRC	Low	Low	High	High	Low
GTM	Low	Low	High	Low	Low

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TABLE A1. Continued

Country code	GDP	Fin. openness	Access to credit	GDP (mean)	Bivariate clustering
HKG	Low	High	High	High	High
HND	Low	Low	High	Low	Low
HUN	Low	High	High	–	Low
IDN	Low	Low	Low	Low	Low
IND	Low	Low	High	Low	Low
IRN	Low	Low	Low	High	Low
JAM	Low	High	High	Low	Low
JOR	Low	High	High	High	Low
KEN	Low	Low	Low	Low	pw
KOR	Low	Low	High	High	High
LKA	Low	Low	High	Low	Low
LSO	Low	High	–	Low	Low
MAR	Low	Low	–	Low	Low
MDG	Low	Low	Low	Low	–
MEX	Low	Low	High	High	Low
MUS	Low	High	High	Low	Low
MWI	Low	Low	Low	Low	Low
MYS	Low	Low	Low	High	High
NGA	Low	Low	High	Low	–
NPL	Low	Low	Low	Low	Low
PAK	Low	Low	High	Low	Low
PAN	Low	High	High	High	Low
PER	Low	Low	High	Low	Low
PHL	Low	Low	Low	Low	Low
POL	Low	Low	High	High	Low
PRT	Low	High	High	High	Low
RWA	Low	Low	High	Low	Low
SGP	Low	High	High	High	High
SLE	Low	High	Low	Low	Low
SLV	Low	Low	High	Low	Low
THA	Low	Low	High	Low	High
TTO	Low	Low	–	High	High
TUN	Low	Low	High	High	Low
TUR	Low	Low	High	High	Low
TWN	Low	High	High	High	High
TZA	Low	Low	Low	Low	Low
URY	Low	Low	High	High	Low
VEN	Low	Low	High	High	Low
ZAF	Low	Low	Low	High	Low
ZMB	Low	High	Low	Low	Low

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APPENDIX B: THEORY

In this Appendix, we present the theoretical aspects of the dynamics of the world interest rate and inequality in the GZ model.

APPENDIX B.1: A SUMMARY OF THE GALOR AND ZEIRA MODEL

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. The 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. It is assumed a linear technology in the unskilled-labor sector so that the unskilled wage w^n is constant, while in the skilled-labor sector the output is produced with a neoclassical constant returns to scale technology:

$$Y_t^s = L_t^s f(k_t), \tag{B1}$$

where $k_t = K_t/L^s$.

Therefore, given the world interest rate r, producers' inverse demand function for capital is

$$r = f'(k_t) = r(k_t) \tag{B2}$$

and therefore,

$$k_t = f'^{-1}(r), \tag{B3}$$

and the skilled wage is[35]

$$w_t^s = f(k_t) - f'(k_t)k_t = w^s(r). \tag{B4}$$

In the first period agents receive an inheritance x from their parents. If $x \geq h$ where h is the fixed cost of education, agents can acquire human capital without borrowing. If $x < h$ agents can borrow at interest rate i and invest in human capital, or work as unskilled in both periods. Unskilled workers earn a wage w^n in both periods, whereas skilled agents earn a wage w^s in their adulthood.

The borrowing interest rate is given by

$$i = i(r) = \frac{1 + \beta r}{\beta - 1} > r, \tag{B5}$$

where $\beta > 1$ is a a parameter affecting the "evasion cost," that is, the cost that the borrowers incur to evade debt repayments.

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

$$(1 - \alpha)\left[w^s + (x_t - h)(1 + r)\right], \tag{B6}$$

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

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Agents receiving $x_t < h$ 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:

$$(1-\alpha)[(x_t + w^n)(1+r) + w^n]. \tag{B7}$$

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

$$(1-\alpha)\left[w^s + (x_t - h)(1+i)\right]. \tag{B8}$$

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

$$\frac{w^s - w^n(2+r)}{(1+r)} \geq h. \tag{B9}$$

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

$$x_t > f = \frac{1}{(i-r)}[w^n(2+r) + h(1+i) - w^s]. \tag{B10}$$

Equation (**B10**) 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)].

The bequests dynamics is therefore summarized in equation (**B11**)[36]

$$x_{t+1} = \begin{cases} (1-\alpha)[(x_t + w^n)(1+r) + w^n] & x_t < f, \\ (1-\alpha)\left[w^s - (h - x_t)(1+i)\right] & f \leq x_t < h, \\ (1-\alpha)\left[w^s + (x_t - h)(1+r)\right] & h \leq x_t, \end{cases} \tag{B11}$$

where i is given by equation (**B5**).

The dynamical system in equation (**B11**) is characterized by three equilibria, two stable, $\bar{x}_n$ and $\bar{x}_s$, and one unstable, denoted as g, if the following conditions hold:

$$(1-\alpha)(1+r) < 1 \Rightarrow r < r_{\max} = \frac{\alpha}{1-\alpha}, \tag{B12}$$

$$(1-\alpha)(1+i) > 1 \Rightarrow \frac{\beta}{\beta - 1}(1+r)(1-\alpha) > 1 \Rightarrow r > r_{\min} = \frac{\alpha\beta - 1}{\beta(1-\alpha),} \tag{B13}$$

and

$$x_{t+1}(x_t = f) < f \Rightarrow h > F_1(r),$$

where[37]

$$F_1(r) = \frac{1}{1+i}\left\{\frac{w_n(2+r)[(1-\alpha)(1+i) - 1]}{1 - (1-\alpha)(1+r)} + w_s(r)\right\} \tag{B14}$$

and

$$x_{t+1}(x_t = h) > h \Rightarrow h < w_s(r)(1-\alpha).$$

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The values of the three equilibria are presented in equations (**B15**)–(**B17**).

$$\bar{x}_n = \frac{(1-\alpha)\, w^n\, (2+r)}{1-(1-\alpha)\,(1+r)}, \tag{B15}$$

$$g = \frac{(1-\alpha)\,[h(1+i)-w^s]}{(1+i)\,(1-\alpha)-1}, \tag{B16}$$

$$\bar{x}_s = \frac{(1-\alpha)\,[w^s - h\,(1+r)]}{1-(1-\alpha)\,(1+r)}. \tag{B17}$$

APPENDIX B.2: CHANGES IN THE WORLD INTEREST RATE IN THE GZ MODEL

In this section, we consider the consequences of a reduction in r in the GZ model, characterized by multiple steady states, $\bar{x}_n$ and $\bar{x}_s$. When the interest rate changes it follows that

$$\frac{\partial \bar{x}_n}{\partial r} > 0, \tag{B18}$$

and

$$\frac{\partial g}{\partial r} = \frac{\partial i}{\partial r}\left[w^s(1-\alpha)-h\right] - \frac{\partial w^s}{\partial r}\left[(1-\alpha)(1+i)-1\right] > 0, \tag{B19}$$

given that $\frac{\partial w^s}{\partial r} < 0$ [see equation (**B4**)] and $w^s(1-\alpha)-h>0$ ensures the existence of equilibrium x_s (see the previous section).

Differently, the impact of interest rate on the equilibrium $\bar{x}_s$ is ambiguous. In particular,

$$\frac{\partial \bar{x}_s}{\partial r} = \frac{\partial w^s}{\partial r}\left[1-(1-\alpha)(1+r)\right] + w^s(1-\alpha) - h, \tag{B20}$$

where $w^s(1-\alpha)-h>0$. Therefore,

$$\frac{\partial \bar{x}_s}{\partial r} < (>) 0 \quad \text{if} \quad h > (<) \frac{\partial w^s}{\partial r}\left[1-(1-\alpha)(1+r)\right] + w^s(1-\alpha). \tag{B21}$$

Therefore, a reduction of r has the following consequences: it reduces the long-run values of $\bar{x}_n$ while it has an ambiguous effect on $\bar{x}_s$, 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.

Thus if $\frac{\partial \bar{x}_s}{\partial r} < 0$, that is if the education cost h is sufficiently high, then as the interest rate decreases, the equilibrium $\bar{x}_s$ shifts to the right, increasing the difference between rich and poor.

Moreover, if $\bar{x}_s$ decreases then the distance between the low-income and high-income equilibria increases (decreases) if

$$\frac{\partial(\bar{x}_s - \bar{x}_n)}{\partial r} > 0, \tag{B22}$$

that is, if

$$w^s(1-\alpha) - w^n(2-\alpha) - h > -\frac{\partial w^s}{\partial r}\left[1-(1-\alpha)(1+r)\right], \tag{B23}$$

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where

$$w^s(1-\alpha) - w^n(2-\alpha) - h > 0, \tag{B24}$$

is true to ensure that equation (B9) holds when $r = r_{\max}$.

APPENDIX C: FURTHER EMPIRICAL EVIDENCE

In this appendix, we present the empirical evidence on world interest rate and the world income distribution dynamics for the period 1970–1985. Figure C1 shows the dynamics of the world interest rate and the US interest rate for the period 1970–1985. We selected a shorter period than the one studied in the paper in order to preserve the same dimension of the sample.

As predictable, the oil shocks introduced strong instability in the time series.

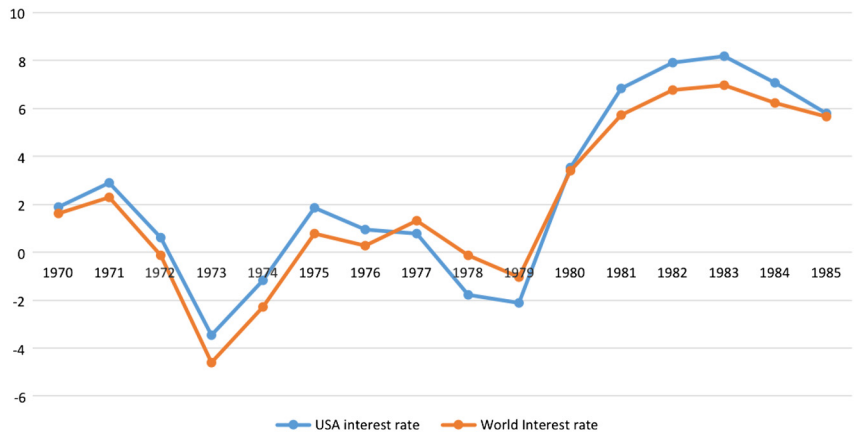

FIGURE C1. World and US interest rates 1970–1985.

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