# A widening global divide? A bipolarization analysis

Florent BRESSON* Gaston YALONETZKY†

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**Abstract**

In contrast to reported improvements in world inequality, we document the decline of the world middle class between 2002 and 2012, as interpreted by the bipolarization approach. Using a balanced panel of countries representing more than 80% of the world's population, we find that reduced inequality within the world's bottom 50% is the main driver of higher relative bipolarization; while that inequality reduction among the bottom 50% together with a widening gap in mean income between the world's top and bottom halves help explain the observed rise in absolute bipolarization. The crucial role of Chinese economic progress is also underlined.

**Keywords**: Global income distribution, middle class, bipolarization.

**JEL Classification**: D63, I3.

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## 1 Introduction

During the last few decades, numerous studies have stressed the dramatic changes in the global distribution of income (see Bourguignon and Morrisson, 2002, Bhalla, 2004, Sala-i-Martin, 2006, Atkinson and Brandolini, 2010, Milanovic, 2013, Lakner and Milanovic, 2015, Niño Zarazúa, Roope, and Tarp, 2017). Moving the focus on distributional issues from the national level to the world scene deserves to be highlighted as it is indicative of the growing concern for global imbalances. Of course, this change in perspective was notably motivated by the commitment of the international community to the success of the Millennium Development Goals in improving living conditions in the developing World. More specifically, monitoring progress on the first target of halving the share of the population living in extreme poverty called for the construction of a global income distribution. Such a technically demanding exercise (Anand and Segal, 2008, Deaton, 2010, World

* Université Clermont Auvergne, CNRS, CERDI, F-63000 Clermont-Ferrand, France. Email: florent.bresson@uca.fr.

†University of Leeds; email: G.Yalonetzky@leeds.ac.uk.

Bank, 2017) is still necessary for tracking progress over the different targets listed in the recent Sustainable Development Goals, chiefly Goal 10: "Reduce inequality within and among countries".[1]

Concerns about the global distribution of income may also be regarded as a sign of the (wishful?) emergence of a feeling of global citizenship (Shaw, 2000). Indeed, building an income distribution for the World Population means disregarding nationality and bringing together individuals as if there were no borders. From a normative point of view, such a simple but peculiar hypothesis is not trivial. If it is intrinsically relevant to view the distribution of income from a global perspective, then we logically have to study the various aspects of this distribution like aggregate well-being, inequality, poverty, affluence, polarization, etc. For instance, global income inequality shall be regarded as an essential component of social welfare. But studying the world income distribution is also bound to be relevant from an instrumental perspective, for it is likely to affect economic performance, financial and political stability, or sustainable development.

At the national level, there is also a common preoccupation with the existence of a large middle class: a relatively large homogeneous part of the population around the median income is often deemed desirable. Arguments in favour of this manifestation of low distributional bipolarization are roughly the same as those in favour of low inequality. For instance, it is generally supposed that the larger the middle class, the larger the share of the population with the ability to fully contribute to national economic activity. It is also often argued that homogeneity in economic status favours political stability and the emergence of political consensus; hence limiting social conflicts, the cost of defining policies, and the burden of redistribution (Easterly, 2001, Acemoglu and Robinson, 2006).

It seems reasonable to claim that, in a more interconnected world, the development of a large and well-off middle class is also desirable since most of the aforementioned issues at the national level become even more relevant at the global level. This shift in focus is specially necessary regarding some challenges like climate change, which call for international consensus toward global collective action. Based on the aforementioned motivations, we propose studying changes in the dispersion of income around the median at the world level for the period 2000-2015 in order to check whether the global distribution of income favoured the development of a world middle class.

The present paper does not attempt to track directly changes in the size of this world middle class, but considers trends in bipolarization. Our assessment of relative bipolarization relies on the visually convenient relative-bipolarization-Lorenz (RBL) curves introduced by Yalonetzky (2014). By way of methodological innovation, we also propose and implement absolute-bipolarization-Lorenz (ABL) curves. We construct a world income distribution, for which we compute and compare bipolarization Lorenz curves between 2002 and 2012. We also conduct these comparisons with alternative specifications (robustness checks). Remarkably, we find increases in both relative and absolute bipolarization across our empirical specifications over the chosen period. That is, the reported decrease in rela-

[1] http://www.un.org/sustainabledevelopment/inequality/.

tive inequality at the global level is not accompanied by the development of a world middle class, as defined by the bipolarization approach. From a relative perspective, it turns out that the main driver of increased bipolarization is the reduction in inequality among the world's bottom 50%. From an absolute perspective, the aforementioned increase in clustering among the bottom half also helps explain the increase in bipolarization, but together with a substantial widening of the gap between the income means of the world's top and bottom 50%. Interestingly, the results are particularly sensitive to China, but not to India.

The rest of the paper proceeds as follows. Section 2 discuss the bipolarization measurement methods used in the paper. Details on data collection and preparation are provided in section 3. Section 4 discusses the empirical results and contrasts global inequality and bipolarization changes. Then the paper ends with some concluding remarks.

## 2 Methodology

Traditional assessments of the size of the middle class (e.g. Lopez-Calva and Ortiz-Juarez, 2014, Kharas, 2017)[2] rely on identifying an income range, i.e. setting upper and lower income thresholds. By contrast, we conduct a bipolarization assessment in the present paper. Bipolarization is a distributional concept that shares some features with inequality, while remaining distinct. Just like Lorenz-consistent inequality definitions, bipolarization should increase when regressive transfers occur across the median partition. These regressive transfers signal widening spreads between mean incomes of the top and bottom halves of the population. However, unlike Lorenz-consistent inequality definitions, any progressive transfers involving income pairs either below the median or above, should increase bipolarization, thereby signalling higher clustering within the two halves. Likewise, bipolarization measurement identifies a 'full middle class' society in the benchmark of perfect equality. Bipolarisation and inequality measurements also differ in their benchmarks of maxima: while extreme inequality resembles situations where one individual owns all income; in extreme bipolarization situations there is always perfect bimodality, that is, the two halves must be both internally egalitarian.

Here, we do not measure bipolarization changes with the help of synthetic indices but use the relative bipolarization Lorenz curve introduced by Yalonetzky (2014). This curve is relative bipolarization's visual counterpart of the traditional Lorenz curve used for relative inequality comparisons and is similarly helpful to provide robust orderings in a set of income distributions. Let $y \in \mathfrak{R}_+$ be some well-being indicator such that well-being is a strictly increasing function of it. For the sake of simplicity, we will call that variable income, though it can be any non-negative continuous monetary or non-monetary well-being indicator.

For any distribution $\boldsymbol{y}$, $y(p) : [0,1] \rightarrow \mathfrak{R}_+$ is the quantile function. Let $m$ denote the median value for $\boldsymbol{y}$, that is $y(0.5) = m$. The population can then be split into two halves, namely the bottom 50% comprising those individuals with $y \leqslant m$, and the top 50%, characterized

[2]See also references of pioneering work in Foster and Wolfson (2010).

by $y \geqslant m$. We can then define the two following functions:

$$y_L(p) \equiv y\left(0.5 - \frac{p}{2}\right) \quad p \in [0,1], \tag{1}$$

$$y_H(p) \equiv y\left(0.5 + \frac{p}{2}\right) \quad p \in [0,1]. \tag{2}$$

It is then clear that $y_L(0) = y_H(0) = m$, $y_L(1) = \min\{\boldsymbol{y}\}$, and $y_H(1) = \max\{\boldsymbol{y}\}$. Finally, letting $\mu$ be the average income in $\boldsymbol{y}$, we can introduce the relative bipolarization Lorenz curve $\Psi : [0,1] \to [0,1]$ as:

$$\Psi(p) \equiv \frac{1}{\mu}\int_0^p \left[y_H(t) - y_L(t)\right]\, dt. \tag{3}$$

Among the many advantages of this curve is its intuitive reading: $\Psi(p)$ indicates the average maximum income discrepancy, as a proportion of mean income, among the $p$ percent of the population around the median.[3] Consequently, its values can be understood as a measure of dispersion around the median and, in the spirit of the linkages between the generalized Gini coefficient and the Lorenz curve, may be used for the design of bipolarization indices using appropriate weighing schemes.

Moreover, as Bresson and Yalonetzky (2019) show, $\Psi(p)$ participates in a high-order dominance condition for relative bipolarizaton comparisons. More specifically, if and only if the $\Psi$ curve for $\boldsymbol{y}$ is nowhere below the curve associated with another distribution $\boldsymbol{x}$ (and strictly above for at least one $p \in ]0;1[$), then $I(\boldsymbol{y}) > I(\boldsymbol{x})$ for any relative bipolarization index $I(.) : \Re_+^N \to \Re_+$ satisfying the two bipolarization transfer axioms proposed by Foster and Wolfson (2010), in addition to scale invariance, anonymity and population principle, as long as $I(.)$ can be expressed as a function of the gaps $y_H(0) - y_L(0), ..., y_H(t) - y_L(t), ..., y_H(1) - y_L(1)$.[4]

Another useful property is that the relative bipolarization Lorenz curve is additively decomposable into two parts:

$$\Psi_L(p) \equiv \frac{1}{\mu}\int_0^p -y_L(t)\, dt, \tag{4}$$

$$\Psi_H(p) \equiv \frac{1}{\mu}\int_0^p y_H(t)\, dt, \tag{5}$$

that provide some guidance regarding the relative contribution of the bottom and top half of the income distribution to changes in bipolarization orderings.[5] Indeed, $\Psi_L(p)$ is a scaled

[3] Strictly speaking it does not provide an estimate of the average distance for each pair of individual belonging to these $p$ median percents of the population, since for each value within the interval $[0,p]$ we only consider the largest income difference. Another interpretation of $\Psi(p)$ is the difference, as a proportion of mean income, between the average income of the bottom $\frac{p}{2}$ percent above the median and the average income of the the top $\frac{p}{2}$ percent below the median. So a value of $\Psi(0.5) = 0.4$ means that the difference between the average income of the third and second quartiles of the population is as large as 40% of mean income.

[4] Remarkably, several relative bipolarization indices in the literature fit this description, including the corrected version of the popular Foster-Wolfson index proposed by Rodriguez and Salas (2003).

[5] It is straightforward to see that $\Psi(p) = \Psi_H(p) + \Psi_L(p)$.

version of the traditional Lorenz curve applied on (minus) the bottom half portion of the income distribution, the scaling factor being $\frac{\mu_L}{\mu}$, where $\mu_L$ is the average income of the bottom half of the population. In the same vein, $\Psi_H(p)$ is the product of the Lorenz curve for income above the median income times the ratio $\frac{\mu_H}{\mu}$ with $\mu_H$ being the mean income for the top half of the population.[6] This makes it possible to decompose changes in either $\Psi_L(p)$ or $\Psi_H(p)$ into the effect of changes in relative inequalities within the corresponding income group and changes in the between component of inequalities as expressed by $\frac{\mu_L}{\mu}$ or $\frac{\mu_H}{\mu}$.

Moreover, as shown by Kosny and Yalonetzky (2016) and Bresson and Yalonetzky (2019), the first-order dominance condition of relative bipolarization requires comparing the curves $\Psi_L(p)$ and $\Psi_H(p)$ of two distributions. More specifically, if and only if the $\Psi_H$ and $\Psi_L$ curves of $\boldsymbol{y}$ are simultaneously nowhere below the respective counterparts for $\boldsymbol{x}$ (and strictly above for at least one $p \in ]0;1[$ at least either in $\Psi_H$ or $\Psi_L$), then $I(\boldsymbol{y}) > I(\boldsymbol{x})$ for any relative bipolarization index satisfying the two bipolarization transfer axioms proposed by Foster and Wolfson (2010), in addition to scale invariance, anonymity and population principle. Since the fulfillment of the first-order dominance condition implies satisfaction of the higher order condition involving $\Psi$, then clearly if two relative bipolarization Lorenz curves cross then the pairwise bipolarization comparison is not fully robust to all possible alternative indices satisfying the two transfer axioms, scale invariance, anonymity and population principle.

As mentioned, the relative bipolarization Lorenz curve as well as its two components, $\Psi_L(p)$ and $\Psi_L(p)$, are fully consistent with the two bipolarization axioms introduced by (Foster and Wolfson, 2010); in contrast to the median-dependent relative bipolarization curves introduced by these authors.[7]

When comparing two income distribution with the same average the bipolarization orderings that can be obtained with the help of $\Psi_L(p)$ and $\Psi_H(p)$ are then perfectly equivalent to those obtained with the dominance procedure proposed by Bossert and Schworm (2008). But Bossert and Schworm (2008) do not consider the case of distributions with different means. Here this restriction is dropped and we extend the ordering power by assuming scale invariance for bipolarization indices.

The use of the relative bipolarization Lorenz curve and its components makes it possible to increase the ordering power by assuming that the bipolarization effects of income decrements (increments) in the bottom part of the distribution can be compensated by those of

[6] An alternative interpretation of these curves is that they are a normalized version (with a scaling factor $\frac{1}{\mu}$ of Shorrocks's (1983) generalized Lorenz curve. This presentation is interesting as it stresses the relationship between the ordering obtained using the relative bipolarization curve (or its absolute counterpart) and Bossert and Schworm's (2008) ordering criterion based on generalized Lorenz curves.

[7] Yalonetzky (2017) showed that the use of the median for the design of relative bipolarization indices, hence yielding median-dependent relative bipolarization indices, resulted in indices violating the transfer axioms originally proposed by Foster and Wolfson (2010). The reason is essentially that the median is likely to be affected by the mean-preserving transfers involved in the two transfer axioms (spread and clustering). This problem equally affects the bipolarization curves proposed by Foster and Wolfson (2010) and Wang and Tsui (2000). Meanwhile, when the median is absent from the index or curve and normalization is performed using the mean instead of the median, we do not face these issues as the mean is left unchanged after any mean-preserving transfers.

income decrements (increments) in the upper part and vice versa.

Here, we also consider an absolute counterpart $\Psi_A : [0,1] \to \Re_+$ of the relative bipolarization Lorenz curve proposed by Bresson and Yalonetzky (2019):

$$\Psi_A(p) \equiv \int_0^p \left[ y_H(t) - y_L(t) \right] \, dt. \tag{6}$$

This absolute curve is not scale invariant, but complies with translation invariance, a property that is used in inequality measurement to incorporate the point of view of social evaluators who care more about absolute than relative income differences among individuals. In the bipolarization literature, indices following this absolute approach have been proposed by Bossert and Schworm (2008) and Chakravarty and D'Ambrosio (2010). The absence of crossings among two absolute bipolarization Lorenz curves, i.e. $\Psi_A(p)$, induces full robustness across any indices of absolute bipolarization satisfying the two key transfers axioms of bipolarization (Foster and Wolfson, 2010), in addition to symmetry, population principle and translation invariance; as long as the index can be expressed as a function of the gaps $y_H(0) - y_L(0), ..., y_H(t) - y_L(t), ..., y_H(1) - y_L(1)$. The latter class includes a wide array of median-independent indices found in the literature.

# 3 Data

The prime difficulty in estimating a global distribution of income is the lack of internationally comparable household surveys with a comprehensive coverage of the World's population. As a consequence, researchers have to rely on secondary datasets that provide grouped data for household income (see for instance Bourguignon and Morrisson, 2002, Milanovic, 2002, Sala-i-Martin, 2006).

Here we follow the method used in Bresson (2014) and use the data on mean income and the Lorenz curve given by the World Bank's poverty calculator and platform PovcalNet for the periods 2000–2004, and 2010–2014, in order to get estimates of the World income distribution for the years 2002 and 2012.[8] We then obtain distributional information for 109 countries that accounted for approximately 82% of the World population back in 2012.[9] The use of PovcalNet as a source for our dataset is very interesting regarding the quality of information since the current version of PovcalNet provides information on most distribution using population centiles.[10] This makes it possible to use generated income distribution that fit close well original income series from household surveys.

Moreover, in the case of China, India, and Indonesia, representing about 40% of the World's population, PovcalNet provides separate information for rural and urban areas. Since

[8] An exception is Cote d'Ivoire for which data for the year 2015 were used.

[9] The exact percentages are respectively 82.5 and 81.8% for the years 2002 and 2012.

[10] More precisely, for 199 of the 218 distributions used for the present study we could rely on 100 points for the Lorenz curve. This level of precision is highly desirable for such highly populated countries as China or India. It is worth pointing that for five distributions, we only have between 95 and 99 points due to duplicated informations in PovcalNet.

average income is also available for each area, the estimations of rural and urban distributions are treated separately in the present paper. For each observation, PovcalNet provides mean income expressed in Purchasing Power Parity using the 2011 ICP, so that income values are directly comparable at the global level and over the two periods. Like most studies that estimate the world income distribution using household survey data, we could not avoid the simultaneous use of both income and consumption data, so that, as stressed by Anand and Segal (2008, p.74): "it is therefore not clear exactly what type of global distribution emerges from combining these surveys [based on either income or consumption expenditures]." This may be a serious limitation, not only for estimating the extent of bipolarization or some of its components, but also to assess the sign of bipolarization changes, notably because income and consumption are imperfectly correlated. We tried to circumvent that problem by selecting data for each country in a consistent manner so that all corresponding distributions either refer to income or consumption. So, for a given country, observed distributional changes are generally not due to changes in the underlying concept.[11] Regarding the estimated global income distribution, the mixture of both income and consumption surveys may still be a matter of concern as the relative share of income and consumption data are not constant in our series. Indeed, these variations are prominently caused by demographic changes and there is no way of proving that results presented in the next section are not partly due to the imperfect structure of our initial dataset.

It is worth pointing out that distributions were chosen so that all countries in the sample are reprented for both years 2002 and 2012. This contrasts, for instance, with Lakner and Milanovic (2015) who chose to be as comprehensive as possible at each date, but at the cost of comparing distributions based on different set of countries, so that results are likely to be contaminated by changes in sample composition.

For each country, the income distribution is estimated using a two-step procedure. First, the income distribution is modeled parametrically using different functional forms. In the present paper, our attention is confined to the lognormal, Singh-Maddala, Dagum, and Beta 2 distributions as well as Maddala and Singh's (1977) parametric Lorenz curve. These proved to be the most interesting functional forms in Bresson (2009). The estimation showing the best fit as expressed by the sum of squared residuals is chosen for each distribution. A random sample of $2,000$ values is then generated from the parametric distribution and adjusted using Shorrocks and Wan's (2008) procedure in order to get a perfect fit with respect to the information on the Lorenz curve available from PovcalNet. Finally, generated individual incomes are taken together and weighted using population size data from the World Bank (World Development Indicators).

We then compare the bipolarization curves, using both the absolute and the relative approaches, for 2002 and 2012, to check whether the global distribution of income became more twin-peaked or not since the beginning of the 21st century. To explain the observed changes in bipolarization, we emphasize the role of changes in cross-country average in-

[11] Of course, this does not preclude other methodological changes, like a modified sampling design or a different coverage of income sources, that may affect the shape of the observed income distribution.

come differences and, more generally, between-country bipolarization changes. The influence of within-country inequality changes is also highlighted by comparing observed bipolarization evolutions with the one that would have occurred with an inequality-neutral growth process within each country. The role of demographic evolution is finally considered as well as the contribution of the two most populated countries in the World, namely China and India.

Our approach differs from previous studies like Milanovic and Yitzhaki (2002) and Ravallion (2010) both methodologically and in its scope. Indeed, we are considering a more recent period than Milanovic and Yitzhaki (2002), and we do not disregard high-income countries as in Ravallion (2010). Another possibly important difference is the use of the 2011 PPPs from the last ICP. As documented in many studies (e.g. Kakwani and Son, 2015, Jolliffe and Prydz, 2015, Ferreira et al., 2015), these last PPP conversion factors differ slighty from the previous one. Consequently, the move from the 2005 to the 2011 PPPs is likely to produce a different picture regarding global distribution changes. Moreover, as mentioned in the introduction, we do not consider a precise definition for the middle class as our approach does neither imply nor require setting bounds for the income domain of the global middle class.

# 4 Results

We preamble the bipolarization results with a glance at world (relative) inequality, as measured by Lorenz curves. Then we present the results for relative bipolarization based on the Relative Bipolarisation Lorenz (RBL) curve (equation 3), followed by absolute bipolarization based on the Absolute Bipolarisation Lorenz (ABL) curve (equation 6). In each subsection we implement alternative specifications in order to gauge the sensitivity of our results.

**Table 1: Summary statistics**

| Year | 10% | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | Mean |
|---|---|---|---|---|---|---|---|---|---|---|
| 2002 | 38.48 | 51.13 | 63.71 | 78.83 | 99.75 | 131.80 | 187.78 | 318.23 | 864.72 | 327.86 |
| 2012 | 53.53 | 72.43 | 93.38 | 119.94 | 157.73 | 216.04 | 311.22 | 504.91 | 1,029.83 | 409.51 |
| Ratio | 1.39 | 1.41 | 1.46 | 1.52 | 1.58 | 1.63 | 1.65 | 1.58 | 1.19 | 1.24 |

Table 1 provides for 2002 and 2012 the world's mean and nine quantiles corresponding to the percentiles: 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80% and 90%. The quantiles for the 60% and 70% grew the fastest, whereas the quantiles 10% and 90% (the extreme ones among those shown) saw the lowest growth rates. However, in absolute terms, the top three quantiles shown grew by the greatest amounts. On the other extreme, the bottom two quantiles increased by the smallest amounts.

(a) Relative Lorenz curve.

(b) Relative bipolarization Lorenz curve.

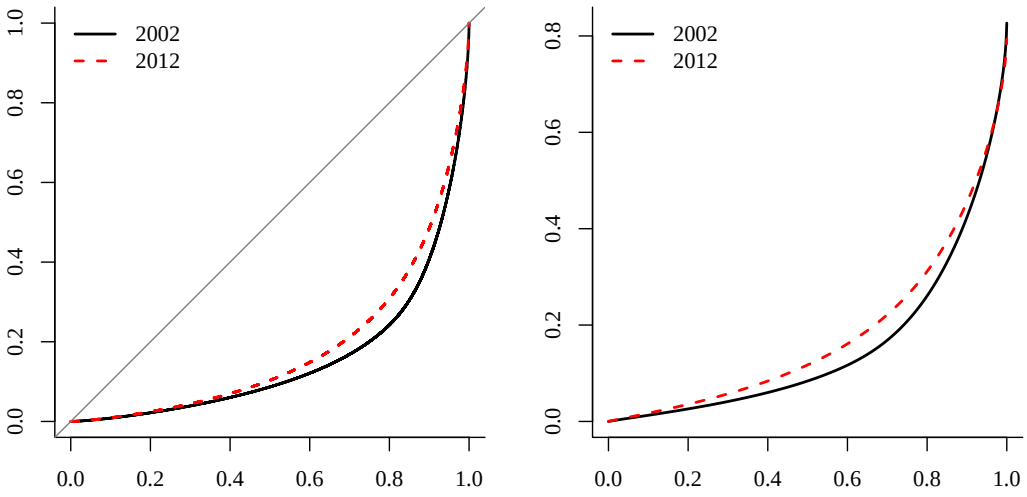



**Figure 1: Global inequality and bipolarization changes, 2002–2012.**

### 4.1 Relative inequality and bipolarization

Figure 1a shows the Lorenz curves for the world income distribution between 2002 and 2012. Despite some overlapping segments at the tails, the 2012 Lorenz curve is closer to the equality line, thereby signalling a reduction in Lorenz-consistent inequality from 2002 to 2012. That observation is consistent with the decline observed in Lakner and Milanovic (2015) over the period 2003–2008 (using observations between 2001 and 2010) and in Niño Zarazúa et al. (2017) over the period 2000–2010.

Figure 1b presents one of our key results. By contrast to changes in the Lorenz curves, the RBL curve for 2012 lies strictly above that for 2002 for the 97% of the population around the median. The two curves crosses at the upper tail and so, strictly speaking, we do not observe a dominance relationship between the two distributions in terms of relative bipolarization. However, the pattern of the crossing and the non-significant difference between the two curves at the tail makes it possible for us to witness reasonably, coexisting with a decline in Lorenz-consistent inequality, an increase in the relative bipolarization of the world income distribution. Put it differently, we do not find evidence of an expansive world middle class, but rather of a declining world middle class. Also, interestingly, the mean-deflated spread between the top and bottom means (i.e. $\Psi(1)$) stayed at around 160% in both years.

Figures 2a and 2b unpack the world's RBL curves (figure 1b), following equations (4) and (5). On figure 2a we added a scaled version of the 2012 curve so that the resulting curve equals the 2002 curve at $p = 0.5$, hence making it possible for us to check Lorenz domination within the bottom half of the income distribution.[12] From figure 2a we note a

[12]The same adjutsment is not necessary for figure 2b. Indeed with such highly skewed distribution the average income essentially reflects the average income of the top half so that the ratio of the two values only marginally differs from unity. As a consequence, the scaled version of the 2012 curve would hardly be distinguished from its original version.

(a) Bottom part. (b) Top part.

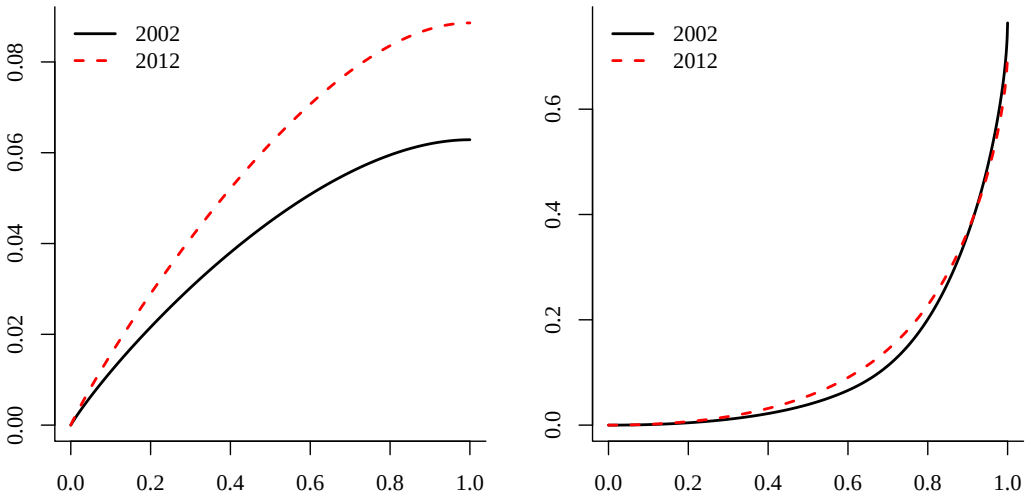



**Figure 2: Bottom and top parts of the RBL curves, 2002–2012.**

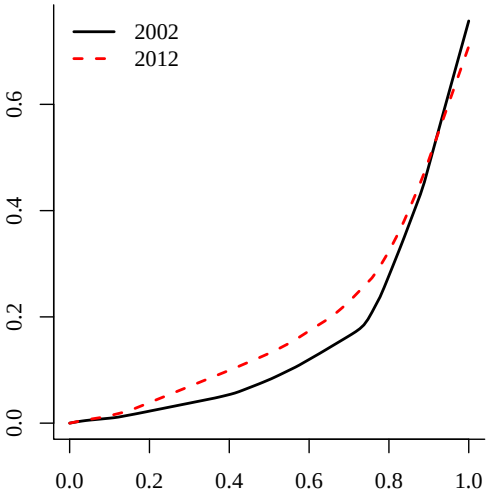



**Figure 3: RBL curves with suppressed intra-national inequality, 2002-2012.**

robust, but modest, increase in inequality among the bottom part of the population (hence a decrease in clustering) along with a more than proportional increase in the average income of the poor when compared with average income. Both factors have contributed as mitigation factor for the increased bipolarization process observed in figure 1b.

Regarding the top half of the population, we note from figure 2b that changes are essentially due to reduced inequalities within the top half, hence increased clustering. A possible explanation for the lower value of the curve in 2012 for top population quantiles is the slow recovery of high income countries after the Great Recession along with the huge economic progresses for the top and middle income classes in China. Combined together, the two parts of the RBL curves explain both the relative stability of the mean-deflated spread and the general increase in clustering, which in turn manifest in an overall increase in relative bipolarization from 2002 to 2012.

As observed bipolarization changes may be due to both within-country and between-country evolutions in the distribution of income, we first try to disentangle these two effects. Figure 3 helps us test the importance of national-level inequalities in driving the result observed in figure 1b, assuming there is no income inequality within each country. Once we replace (synthetic) individual incomes with their respective national averages, the picture looks similar to the one depicted previously, though robustness is clearly lost: the two RBL curves clearly cross at a high point in the percentile domain. Nevertheless we still can observe the dramatic increase in the income spread around the median for the central 90% population. This result is indicative that changes in per-capita income between country and/or demographic changes have been decisive in increasing bipolarization since 2002. In fact, a RBL curve computed using the 2012 estimated distributions in each country combined with the 2002 population weights can hardly be distinguished from the RBL for 2012, hence clearly indicating that changes in the (unweighted) world distribution of per-capita income was the main driver of the observed bipolarization trend.[13]

Due to their huge population size, China and India both play a crucial role in shaping the global distribution of income. Here, we investigate whether income distribution changes in these two countries may have contributed to the observed bipolarization shift. Figure 4a shows first the Lorenz curves for the world income distribution between 2002 and 2012, excluding China from the sample. Interestingly, the distance between the two curves is narrower than in figure 1a. Lorenz dominance deeming 2012 a less unequal year still prevails, but the narrow distance show that China's impressive economic progress was a major driver of global inequality reduction. Performing the same exercise for the RBL curve yields figure 4b. It seems that China's role is also salient for bipolarization. Indeed, excluding China preserves the bipolarization ordering observed at the global level, but the difference between the two curves for 2002 and 2012 is less marked. Moreover, excluding China leads to straighter, less kinked curves, thereby signalling more clustering and bimodality.

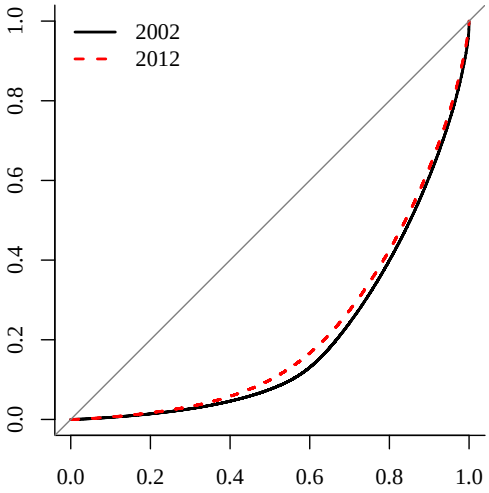
Changes in the Indian distribution of income during the period were also decisive for observed changes in bipolarization. Figure 4c shows the Lorenz curves for the world income distribution between 2002 and 2012, now excluding India from the sample. The result of reduced inequality remains robust and the picture is barely the same as the one obtained from figure 1a with the whole population. However, we can note from figure 4d that dropping India from the sample results in relative bipolarization Lorenz curves crossing at $p = 92\%$, hence making the relative bipolarization ordering less robust.

### 4.2 Absolute bipolarization

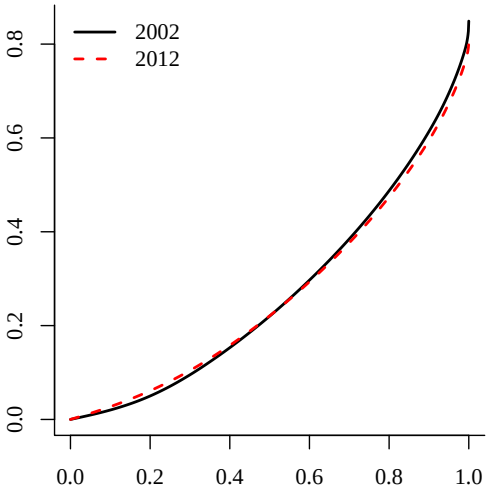
We now turn to an absolute analysis of bipolarization. Unsurprisingly, using Moyes's (1987) absolute Lorenz curve (figure 5a) we first confirm the increase in global absolute inequality stressed by Niño Zarazúa et al. (2017). Figure 5b presents a new key result: a robust increase in absolute bipolarization from 2002 to 2012, accompanied by a whopping

[13] Results regarding the effect of demographic changes are not reported here, but are available upon request.

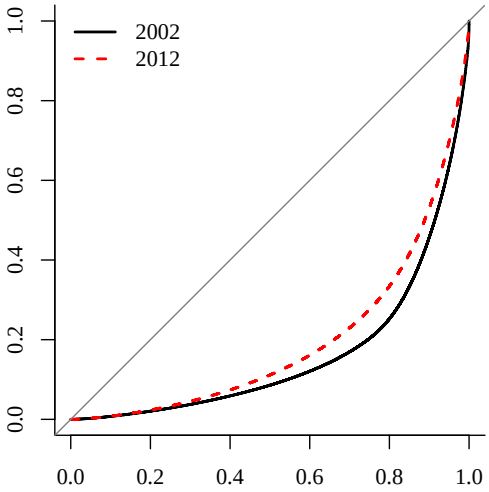
(a) Relative Lorenz curve, without China.




(b) RBL curve, without China.




(c) Relative Lorenz curve, without India.




(d) RBL curve, without India.

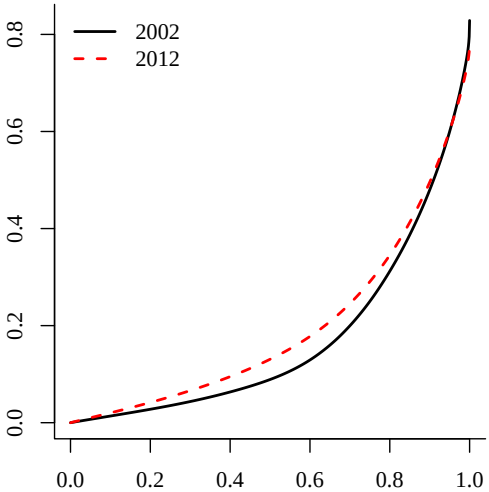



**Figure 4: The contribution of China and India in global inequality and bipolarization changes, 2002–2012.**

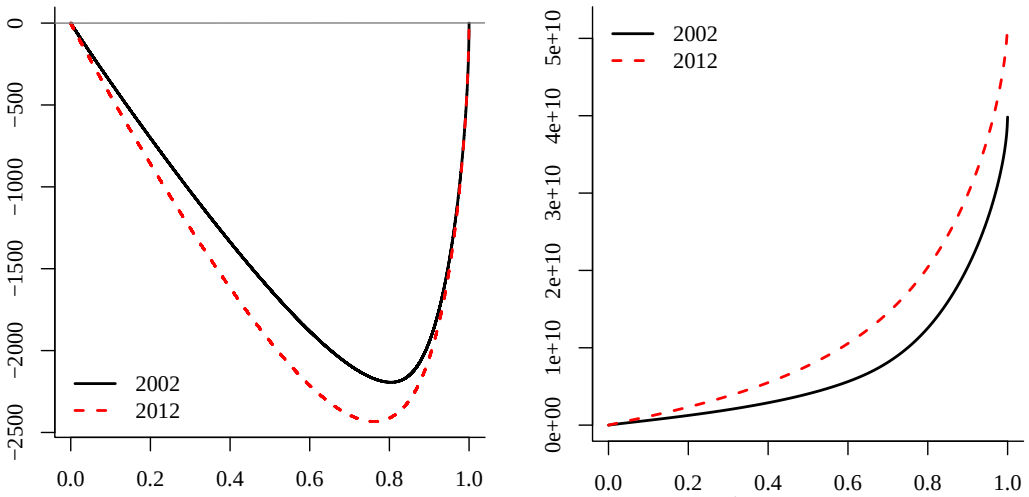
25% increase in the gap between the top and the bottom mean incomes, i.e. $\Psi_A(1)$.

Remarkably, the increase in absolute bipolarization reflected in figure 5b survives the exclusion of China, as shown in figure 6a. Interestingly, the absolute spread between mean incomes increases when China is excluded, but the change is relatively less marked. Again, as in the relative bipolarization case, excluding China renders the world income distribution more clustered toward bimodality. If we exclude India, figure 6b shows that the increase in absolute bipolarization remains, but with a larger absolute spread between the top and bottom. Interestingly, this effect is more pronounced that when China is dropped from the sample of countries.

While Lorenz-consistent relative inequality robustly decreased from 2002 to 2012, both relative and absolute bipolarization robustly increased during the same period, accompanied

(a) Absolute Lorenz curve.

(b) Absolute bipolarization Lorenz curve.




Note: Values on the vertical axis refer to monthly income in 2011$PPP.

**Figure 5: Global inequality and bipolarization changes, 2002–2012, absolute approach.**

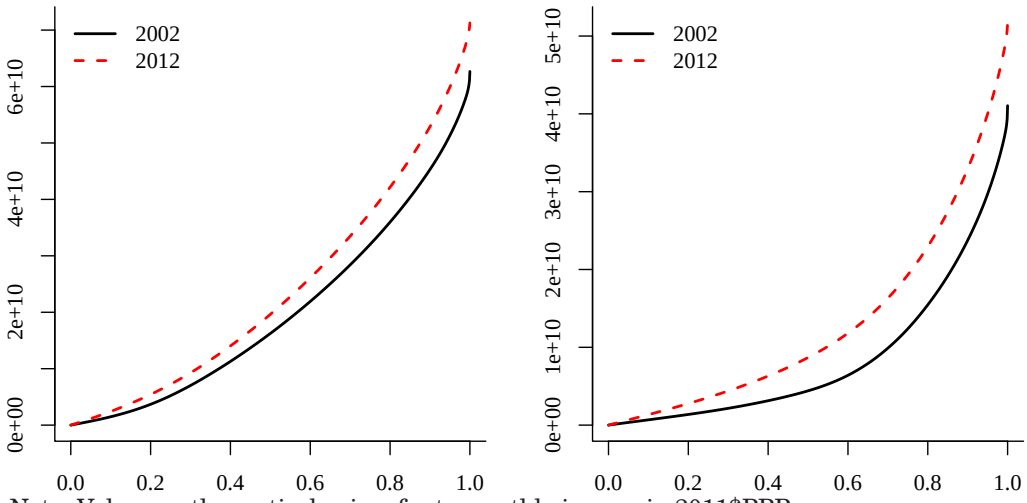
by a 20% increase in the gap between the world's top and bottom mean incomes. Meanwhile, since the relative spread ($\Psi(1)$) remained largely unchanged, we must attribute the bulk of the increase in relative bipolarization to increased clustering, especially among the world's top 50%. This substantial decrease in inequality among the top half of the global distribution of income, is certainly consistent with the observed decrease in Lorenz-consistent inequality during the same period.

We tested the importance of China and India in driving these results. Interestingly, the exclusion of India does alter the robustness of the bipolarization ordering. By contrast, excluding China does not wipe out the robust increase in relative bipolarization, but the two the RBL curves are closer, hence showing the mitigating effect of Chinese economic progresses on relative bipolarization. The increase in absolute bipolarization is also robust to the exclusion of China, but in this case the gap between the top and bottom mean incomes widens. In both approaches, the exclusion of China renders the respective curves straighter; that is, reflecting more bimodality.

These results warrant a broader empirical inquiry into the nature and causes of the seemingly divergent trends among different, but complementary, notions of inequality and distributional change. The current consensus states that global (relative) inequality is mildly decreasing, along with the growth of the within-country component (Lakner and Milanovic, 2015). Our preamble results for Lorenz-consistent inequality coincide with the literature. However, our main findings do not warrant concluding the emergence of a world middle class from the decreasing trend in inequality. To the contrary, we find evidence of increased bipolarization both in relative and absolute terms. This stands in clear contrast with some recent findings in the literature pointing to an increase in the size of the middle class when measured by income thresholds (e.g. Kharas, 2017).

(a) ABL curve, without China.

(b) ABL curve, without India.




Note: Values on the vertical axis refer to monthly income in 2011$PPP.

**Figure 6: The contribution of China and India in global inequality and bipolarization changes, 2002–2012, absolute approach**

Potentially, several explanations could reconcile these otherwise opposing findings. Besides the potential differences in the methodological choices behind the construction of datasets, the differences in the definitions of the middle class embedded in each measurement approach deserve especial attention. As explained by Foster and Wolfson (2010), the threshold approach bears the advantage of intuitiveness at the expense of ditching a richer notion of social polarisation phenomena and its relationship to distributional change, which are captured by the bipolarization approach. Future work should hopefully provide more coherent and robust trends of world-as-one inequality and bipolarization, benefitting from better datasets and from a clearer understanding of the interaction between the different implemented notions of distributional change and middle class measurement.

## References

ACEMOGLU, D. AND J. ROBINSON (2006): *Economic Origins of Dictatorship and Democracy*, Cambridge University Press.

ANAND, S. AND P. SEGAL (2008): "What Do We Know about Global Income Inequality," *Journal of Economic Literature*, 46, 57–94.

ATKINSON, A. AND A. BRANDOLINI (2010): "On Analyzing the World Distribution of Income," *World Bank Economic Review*, 24, 1–37.

BHALLA, S. (2004): "Poor Results and Poorer Policy: A Comparative Ananlysis of Estimates of Global Inequality and Poverty," *CESifo Economic Studies*, 50, 85–132.

BOSSERT, W. AND W. SCHWORM (2008): "A class of two-group polarization measures," *Journal of public economic theory*, 10, 1169–87.

BOURGUIGNON, FR. AND CHR. MORRISSON (2002): "Inequality among World Citizens: 1820-1992," *American Economic Review*, 92, 727–744.

BRESSON, F. (2009): "On the estimation of growth and inequality elasticities of poverty with grouped data," *Review of Income and Wealth*, 55, 266–302.

——— (2014): "Poverty has Declined, but What about the Burden of Non-Extreme Poverty? Generalized Dominance Criteria for Convex Subsets within the Poverty Domain," in *Economic Well-Being and Inequality: Papers from the Fifth ECINEQ Meeting*, ed. by J. Bishop and J. G. Rodriguez, Emerald Group Publishing Limited, vol. 22 of *Research on Economic Inequality*, 147–184.

BRESSON, F. AND G. YALONETZKY (2019): "Robust relative bipolarisation comparisons: a sequential dominance approach," Mimeograph.

CHAKRAVARTY, S. AND C. D'AMBROSIO (2010): "Polarization orderings of income distributions," *Review of Income and Wealth*, 56, 47–64.

DEATON, A. (2010): "Price Indexes, Inequality, and the Measurement of World Poverty," *American Economic Review*, 100, 5–34.

EASTERLY, W. (2001): "The Middle Class Consensus and Economic Development," *Journal of Economic Growth*, 6, 317–335.

FERREIRA, F., S. CHEN, A. DABALEN, Y. DIKHANOV, N. HAMADEH, D. JOLLIFFE, A. NARAYAN, E. B. PRYDZ, A. REVENGAN, P. SANGRAULA, U. SERAJUDDIN, AND N. YOSHIDA (2015): "A Global Count of the Extreme Poor in 2012. Data Issues, Methodology and Initial Results," Policy Research Working Paper 7432, World Bank.

FOSTER, J. AND M. WOLFSON (2010): "Polarization and the decline of the middle class: Canada and the US," *Journal of Economic Inequality*, 8, 247–73.

JOLLIFFE, D. AND E. PRYDZ (2015): "Global Poverty Goals and Prices: How Purchasing Power Parity Matters," Policy Research Working Paper 7256, World Bank.

KAKWANI, N. AND H. SON (2015): "Global Poverty Estimates Based on 2011 Purchasing Power Parity: Where should the New Poverty Line Be Drawn?" Working Paper 371, ECINEQ.

KHARAS, H. (2017): "The unprecedented expansion of the global middle class. Un update," Brookings Global Economy & Development Working Paper 100.

KOSNY, M. AND G. YALONETZKY (2016): "Relative p-bipolarisation measurement with generalised means and hybrid Lorenz curves," ECINEQ WP 2016-404.

LAKNER, C. AND B. MILANOVIC (2015): "Global Income Distribution: From the Fall of the Berlin Wall to the Great Recession," *World Bank Economic Review*, 1–30.

LOPEZ-CALVA, L. AND E. ORTIZ-JUAREZ (2014): "A vulnerability approach to the definition of the middle class," *The Journal of Economic Inequality*, 12, 23–47.

MADDALA, G. AND S. SINGH (1977): "A Flexible Functional Form for Lorenz Curves," *Économie Appliquée*, 30, 481–486.

MILANOVIC, B. (2002): "True World Income Distribution, 1988 and 1993: First Calculation Based on Household Surveys Alone," *The Economic Journal*, 112, 51–92.

——— (2013): "Global Inequality in Numbers: in History and Now," *Global Policy*, 4, 198–208.

MILANOVIC, B. AND S. YITZHAKI (2002): "Decomposing World Income Distribution: Does the World have a middle class?" *Review of Income and Wealth*, 48, 155–178.

MOYES, P. (1987): "A New Concept of Lorenz Domination," *Economic Letters*, 23, 203–207.

NIÑO ZARAZÚA, M., L. ROOPE, AND F. TARP (2017): "Global inequality: Relatively lower, absolutely higher," *Review of Income and Wealth*, 63, 661–684.

RAVALLION, M. (2010): "The Developing World's Bulging (but Vulnerable) Middle Class," *World Development*, 38, 445–454.

RODRIGUEZ, J. G. AND R. SALAS (2003): "Extended bi-polarization and inequality measures," *Research on Economic Inequality*, 9, 69–83.

SALA-I-MARTIN, X. (2006): "The World Distribution of Income: Falling Poverty and... Convergence, Period," *Quarterly Journal of Economics*, 121, 351–397.

SHAW, M. (2000): *Global society and international relations: sociological concepts and political perspectives*, Polity Press, online edition. ed.

SHORROCKS, A. (1983): "Ranking Income Distributions," *Economica*, 50, 3–17.

SHORROCKS, A. AND G. WAN (2008): "Ungrouping Income Distributions: Synthetising Samples for Inequality and Poverty Analysis," Research Paper 2008/16, UNU WIDER.

WANG, Y.-Q. AND K.-Y. TSUI (2000): "Polarization Orderings and New Classes of Polarization Indices," *Journal of Public Economic Theory*, 2, 349–363.

WORLD BANK (2017): *Monitoring Global Poverty : Report of the Commission on Global Poverty*, The World Bank, 260 p.

YALONETZKY, G. (2014): "Relative Bipolarization Lorenz Curve," *Economics Bulletin*, 34, 1103–1113.

——— (2017): "The Necessary Requirement of Median Independence for Relative Bipolarisation Measurement," in *Research on Economic Inequality*, ed. by S. Bandyopadhyay, Emerald Publishing Ltd, vol. 25, chap. 3, 51–62.