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Towards a measure of income inequality freed from the volatility caused by variations in the rate of unemployment

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Towards a Measure of Income Inequality Freed From the Volatility Caused by Variations in the Rate of Unemployment[1]

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Abstract

By mixing together inequalities based on cyclical variables, such as unemployment, and on structural variables, such as education, usual measurements of income inequality add objects of a different economic nature. Since jobs are not acquired or lost as fast as education or skills, this aggreagation leads to a loss of relavant economic information. Here I propose a different procedure for the calculation of inequality. The procedure uses economic theory to construct an inequality measure of a long-run character, the calculation of which can be performed, though, with just one set of cross-sectional observations. Technically, the procedure is based on the uniqueness of the invariant distribution of wage offers in a job-search model. Workers should be pre-grouped by the distribution of wage offers they see, and only between-group inequalities should be considered. This construction incorporates the fact that the average wages of all workers in the same group tend to be equalized by the continuous turnover in the job market.

1 Introduction

Several works in the literature have documented, from an empirical perspective, a positive correlation between income inequality and the rate of unemployment. Mirer (1973), Beach (1977), Budd and Whiteman (1978), Blinder and Esaki (1978), Nolan (1986), Cardoso (1993) and Cardoso et alli (1995) are examples of this type. Elsewhere [Cysne (2004)] , I have used a job-search model to provide a framework under which such a correlation can be understood from a theoretical perspective as well.

The point I want to make here is of a normative nature. Usual measurements of inequality, by also reflecting a variable that is typically of a cyclical nature, the rate of unemployment, most of the times do not correspond to the underlying economic idea that one associates with an inequality measure: that of structural imbalances in a society. Imbalances like those determined, e.g., by an heterogeneity in the distributions of education or skills. By mixing together short-run and long-run determinants of inequality, such measurements lead to a loss of valuable information. Education and skills are not acquired or lost as fast as jobs.

Allowing the measures of inequality to reflect changes in the unemployment rate can lead to severe variations of this measure in the short run. Take for instance the following conclusion in Cardoso (1993. p.112), based on the observation of the evolution of indices of inequality in Brazil, in the 80s[1]: "income distribution can change dramatically in one year". One of the two main variables found by this author to explain the documented change of inequality was exactly the rate of unemployment (the other was inflation).

Such short-term variations can lead to misleading conclusions, mostly (for obvious reasons) when one compares cross-section data of different countries. One way of freeing the statistic of such noises, for the purpose of making comparisons among countries, is the one followed e.g., by Blinder and Esaki (1978), Cardoso (1993) and Cardoso et alli (1995). These authors used a time series of observations of income inequalities to regress it on unemployment and some other variables of a macroeconomic nature. Based on that they were able to assess how much of the inequality could be attributed to short run variations, and how much to structural factors. The method I propose here, though, by making an inference based on economic theory, can achieve an equivalent result with just one set of cross-sectional observations of income.

To further illustrate the argument, let's think in terms of the usual between-group (subscript b) and within-group (subscript w) decomposition

[1] This was a period of remarkable macroeconomic volatility in Brazil.

allowed by the Theil (T) index of inequality[2]:

$$T = T_b + T_w \tag{1}$$

Imagine an economy composed N different classes (or groups) of homogenous workers. One can think of this economy as a small economy, in which workers are employed by a foreign firm. Suppose, to simplify the argument, that workers belong to the same class if and only if they face the same distribution of wage offers, and that there is no overlapping (each worker belongs to only one class). In practical terms, this is to say that the N different classes are supposed to differ by structural parameters such as the level of education or skills of the workers, rather than by economic variables that are short run or cyclical by nature. As a practical problem, imagine that a researcher gathers income data from the entire population of workers in this economy, in order to measure its degree of income inequality[3].

In each of the N subgroups of homogenous workers, the available data will reflect the fact that some (workers) have just been laid off, some others have been laid off last period and have not found a job offer this period, others are unemployed because they have found an offer but have turned it down (using the usual terminology, because the offer was below their reservation wage), while, finally, others are employed, but with different wages (distributed in the whole range between the reservation wage and the upper bound of the distribution of wage offers).

The point to note, here, is that the cross-sectional data gathered by the researcher will necessarily include a dispersion of wages in each one of the

[2]Note that the point I want to make here applies to all statistical indices of income inequality, there being no particular connection with the Theil index. The nature of the point is economic, rather than statistic. Among the measures of inequality, some are decomposable, some are not. A decomposable inequality measure is a measure that can be broken down into a weighted average of inequalities within subgroups of the population and the inequality existing among those groups. Theil's coefficient is an example of a decomposable measure (see Bourguignon (1979)), whereas the Gini coefficient is an example of a measure which is not decomposable. The fact that a measure is not decomposable, though, does not mean that the overall inequality cannot be expressed as a sum of parts, including a within-group and a between-group inequality. Pyatt (1976) and Yao (1999) have shown, for instance, that the Gini coefficient can be decomposed into a within-group, between-group and a residual overlapping inequality, each term being necessarily nonnegative.

[3]I assume throughout the whole paper that the only source of income of each worker/consumer is the wage income. Transfers and capital income usually represent only a small fraction of most households' total income. For the United States, for instance, following the 1992 SCF (Survey of Consumer Finances), transfers and capital income account in average for only around 28% of the total income of the households surveyed. This percentage tends to be even lower in developing countries.

different subgroups. This will make $T_w > 0$ and positively correlated with the rate of unemployment [Cysne(2004)], even though, as we shall fromalize in this paper, $T_w = 0$ in a long-run measure that takes into consideration the turnover in the job market.

Indeed, each group is composed of homogenous workers, regarding the distribution of wage offers they see. This implies that, in the long run, given the fact that such workers alternate their positions along the employment/unemployment cycle, there should be no reason for the average wage of workers in the same group to differ. The inherent inequality within each class (T_w) is, by these means, of a temporary nature, economically different of the inequality among workers in different classes (T_b).

Under the usual procedure used to calculate inequality measurements, though, this fact (that the turnover in the job market tends to equalize workers belonging to the same group) is not taken into consideration. The normative point made here is that it makes sense to calculate inequalities taking this point into consideration. When this is not done, temporary inequalities among workers of the same group (T_w), which tend to generate (most of the times) an undesirable dependence of the overall inequality (T) upon temporary cycles of aggregate unemployment (implying volatility), but which tend to disappear in the medium or in the long run, are treated in the same way as more relevant and permanent inequalities, like those generated by the distribution of education (captured by T_b).

This type of concern about short-run and structural inequalities is not something new. It represents, indeed, one of the main reasons why so many empirical studies concentrate on the evaluation of how much of some measurements of inequality can be attributed to unemployment, as opposed to variables of a more structural nature.

Instead of having researchers measuring inequality adding apples (let's say, inequality explained by structural variables) and oranges (inequality explained by cyclical variables), and other researchers (like in the works mentioned above) sharing the burden of disentangling the sum or the parts, more reasonable, it seems to me, would be asking the first group not to add apples and oranges.

Most of this paper is dedicated to illustrate that, given the way how we have proposed to construct the different classes of workers, the within-group inequality turns out to be spurious in the long run. From a technical perspective, this is proved in terms of the existence of a unique invariant distribution of wages for any worker in the economy[4].

[4]This distribution also happens to be the cross-sectional distribution of wages in the economy, translating a point-in-time dispersion of incomes within each group. This inter-

The paper proceeds as follows. Section 2 presents the basic model, proves the uniqueness of the invariant distribution of wages, the convergence of the sequence of probability measures defined by the transition function of the underlying Markov process, and derives the invariant distribution. A counter-example is provided to show that the convergence of the sequence of probability measures defined by the Markov operator associated with the job-search problem is not trivial. Section 3 is used to propose a measure of income inequality which does not include within-group inequalities caused by the turnover in the job market. A second example is provided, this time to illustrate the method. Section 4 concludes.

2 The Model

The basic framework used here is a variation of McCall's (1970) job-search model. The presentation, as in Cysne (2004), follows the approach to this model offered in Stokey and Lucas (1989), with the additional feature of allowing for the possibility that, in each period, a worker does not receive a job offer.

Consider one class of workers facing a distribution of job offers. Suppose that these offers are governed by the distribution function F_w, with support in $[0, D]$, $0 < D < \infty$. Imagine that each worker in this class in involved in a job search, the states of which are given by "w" and sate "0". State w corresponds to a job offer of w at hand, and state 0 to no job offer. In state w the worker can accept or turn down the offer. If he accepts it, by assumption he stays employed with that wage till he is laid off, which can happen, in each period, with probability θ. If he does not accept the offer or if he gets no offer, he remains in state 0. Being in state zero the only thing he can do is wait again for a job offer next period, which happens with probability $1 - \alpha$. Assume that:

$$\begin{aligned} 0 &< \theta < 1 \\ 0 &< \alpha < 1 \end{aligned} \tag{2}$$

Note that the set in which we allow θ and α to take values is very reasonable from an economic perspective.

The individual is not allowed to search while in the job. Going to the job market again requires first quitting the job and then waiting for a new offer

pretation was the one used in Cysne (2004), in order to study the link between the rate of unemployment and the usual measurements of income inequality.

next period, which can be easily proved to make this option valueless. The job offers are independent. Consumers maximize:

$$E\left(\sum_{t=0}^{\infty}\beta^t c_t\right), \qquad 0<\beta<1$$

With $v(w)$ stating for the value function, and $\mathcal{A}$, $\mathcal{R}$, respectively, for "accept" and "reject", the recursive version of the consumer's problem is given by the maximization of:

$$v(w)=\max_{\mathcal{A},\mathcal{R}}\left\{w+\beta\left[(1-\theta)v(w)+\theta v(0)\right],v(0)\right\} \tag{3}$$

where

$$v(0)=\beta\left[(1-\alpha)\int_{[0,D]}v(w')dF_w(w')+\alpha v(0)\right]$$

Making $X=\frac{1-\alpha}{1-\alpha\beta}$:

$$v(0)=\beta X\int_{[0,D]}v(w')dF_w(w')$$

The solution type of problem is given in terms of a reservation wage, above which the worker accepts the offer, and below which the worker turns it down. In this case the reservation wage, $\bar{w}$, equals:

$$\bar{w}=\frac{\beta(1-\alpha)}{1-\beta(1-\theta)}\int_{[\bar{w},D]}(w'-\bar{w})dF_w(w') \tag{4}$$

The analysis as of this point follows very closely Stokey and Lucas (1989, c. 10 and 11), as well as Cysne (2004).

The reservation wage $\bar{w}(j)$ divides $[0,D]$ into two regions: the acceptance region $A=[\bar{w},D]$ and the non-acceptance region $A^c=[0,\bar{w}]$. Consider a new measurable space $([0,D],\mathcal{B}_{[0,D]},m_o)$. m_o is a measure of the wage offers of a certain worker in the economy[5]. Denote by m_{ot} its expression at time t. At each time t, m_o is determined by its initial value and by a transition function $P:[0,D]\times\mathcal{B}_{[0,D]}\to[0,1]$ (see (5) below) which, in turn, depends upon the rules of the job search process. The transition function P is determined in the following way: If the current state (given by the wage offer) is $w\in A^c$,

[5]It differs of the measure determined by F_w by taking into consideration the rules of the job search.

the probability of having an offer next period in any borelian $B \subset [0, D]$ is $(1-\alpha)q(B)+\alpha$, if $0 \in B$, and $(1-\alpha)q(B)$ if $0 \notin B$.

Alternatively, if the current state is $w \in A$, by the rules of the problem the worker can only lose his job (with probability θ) or keep the same wage next period. Therefore, with probability zero he will have a wage next period in a borelian B that does not contain neither 0 or w. If the borelian B contains 0, but not w, or w but not zero, the transition probabilities are, respectively, θ and $1-\theta$. If it contains both, since these are disjoint events (because $0 \notin A$), $P(w, B) = 1$.

This transition function implies that $[0, D]$ is the only ergodic set of the problem. m_{ot}, $t = 0, 1, 2, ...$, relates to the function P by the relation:

$$m_{o(t+1)}(B) = \int P(w, B) m_{ot}(dw) \tag{5}$$

Denote by $\Lambda([0, D], \mathcal{B}_{[0,D]})$ the set of probability measures in $([0, D], \mathcal{B}_{[0,D]})$. In the extension of this space given by the (vector) space of signed measures, define the total variation norm by:

$$\|\lambda\| = \sup \sum_{i=1}^{k} |\lambda(A_i)| \tag{6}$$

with the supremum above being considered among all finite partitions of $[0, D]$. (6) defines a metric on the space $\Lambda([0, D], \mathcal{B}_{[0,D]})$. This space, when endowed with the norm $\|.\|$ defined by (6), is a complete metric space. Define in this space the operator T^* by:

$$T^*(m_{o(t)})(B) = m_{o(t+1)}(B), \ B \in \mathcal{B}_{[0,D]}$$

In order to talk about an invariant distribution of wages under this setting, it is necessary to show that the distribution of wage offers has one fixed point (called the invariant distribution) under the operator T^*. To calculate the invariant distribution we will have (before we take limits) to use the fact that the sequence of probability measures $T^{*N}(m_{o(0)})$, $N \in \mathbb{N}$, converges under the total variation norm.

For the demonstration of these two important points it suffices proving that, for some $N \geq 1$, T^{*N} is a contraction in the metric space $\Lambda([0, D], \mathcal{B}_{[0,D]})$[6]. Indeed, since $\Lambda([0, D], \mathcal{B}_{[0,D]})$ is a complete metric space, if T^{*N} can be shown to be a contraction, by the N-stage contraction theorem (Corollary 2 of theorem 3.2 in Stokey and Lucas), T^* admits one and only one fixed point in $\Lambda([0, D], \mathcal{B}_{[0,D]})$.

[6] See Theorem 11.12 in Stokey and Lucas (1989).

Proving that T^{*N} is a contraction, therefore, is the only thing we have to do here. This can be easily done with the help of Lemma 11.11 in Stokey and Lucas (1989). Following these results, for T^{*N} to be a contraction in $\Lambda([0,D],\mathcal{B}_{[0,D]})$ it suffices to show that there exists a point $w_0 \in [0,D]$, an integer $N \geq 1$, and a number $\epsilon > 0$, such that $P^N(w,\{w_0\}) > \epsilon$ for all $w \in [0,D]$.

Proposition 1 *The adjoint operator T^* of the transition function P defined above has one and only one unique fixed point. This fixed point is the invariant measure of wage offers defined in $([0,D],\mathcal{B}_{[0,D]})$ by (5).*

Proof. Take $N = 1$ and $w_0 = 0$. From what we saw about the transition function P, there are two cases to consider: if $w \in A = [\bar{w}, D]$, $P(w,\{w_0\}) = \theta$. Alternatively, if $w \in A^c = [0,\bar{w})$, $P(w,\{w_0\}) = \alpha + (1-\alpha)m_w(\{0\})$. Take

$$\varepsilon = \frac{1}{2}\min\{\theta, \alpha\}$$

Then, $\epsilon > 0$ by (2) and $P^N(w,\{w_0\}) = P(w,\{0\}) > \epsilon$, all $w \in [0,D]$. This proves that T^{*N} is a contraction. The result then follows from the N-stage contraction theorem. The second assertion follows by definition. ■

The convergence of T^{*N} can fail if (2) is not explicitly required.

Example 1 *Suppose that the measure given by F concentrates all of its mass in a point $w_1 \in [0,D]$, that $\alpha = 0$ and $\theta = 1$. Note that such assumptions violate condition (2) above. Note, also, that the demonstration of Proposition 1 used the fact that $\alpha > 0$. In this case, the reservation wage is trivially equal to w_1. Therefore, there are only two states, $\{0\}$ and $\{w_1\}$, which alternate each period. The operator $T^*$is given by the transition matrix $A = \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}$, which satisfies $A = A^3 = A^5 ...$ and $I_{2x2} = A^2 = A^4 = ..., I_{2x2}$ denoting the 2x2 identity matrix. Of course, $T^{*N} = A^N$ does not converge in this case. There is one invariant distribution, though, which places mass $1/2$ at point $\{0\}$ and mass $1/2$ in point $\{w_1\}$. $\{0, w_1\}$, the only ergodic set, has two cyclically moving subsets, $\{0\}$ and $\{w_1\}$.*

After proving the uniqueness of the invariant measure of wage offers in Proposition 1, the next step is calculating this distribution. Stokey and Lucas (1989) do a particular case in which $\alpha = 0$. I make a similar development here. Note that, for any $C \subset A$:

$$m_{ot+1}(C) = m_{ot}(A^c)(1-\alpha)m_w(C) + m_{ot}(C)(1-\theta) \tag{7}$$

The determination of the invariant measure $m_o(C) = lim_{t\to\infty} m_{ot}(C)$ requires proving the existence of this limit, which has already been done in Proposition 1, as well as the calculation of $m_{ot}(A^c)$. To proceed with this second step note that, since a worker is unemployed in period $t+1$ if and only if he was already unemployed and drew a wage offer in A^c or was employed and lost his job, we have:

$$m_{ot+1}(A^c) = m_{ot}(A^c)\left[(1-\alpha)m_w(A^c) + \alpha\right] + m_{ot}(A)\theta \tag{8a}$$

Taking limits, equation (8a) trivially implies $m_o(A^c) = \theta/\left[\theta + m_w(1-\alpha)\right].$ Taking limits in (7) and using this result yields, for $C \subset A$:

$$m_o(C) = \lim_{t\to\infty} m_{ot}(C) = \frac{(1-\alpha)m_w(C)}{\theta + (1-\alpha)m_w(A)}$$

Make $f_p(s)ds$ represent the number of people earning income in the range $(s, s+ds)$. Taking into consideration that all wage offers in A^c imply a wage equal to zero, we can finally write the invariant measure of wages:

$$f_p(s) = \begin{cases} \frac{\theta}{\theta+(1-\alpha)m_w(A)} & if \qquad s = 0 \\ \\ \frac{(1-\alpha)dF_w(s)}{\theta+(1-\alpha)m_w(A)} & if \quad \bar{w} \leq s < D \end{cases} \tag{9}$$

The long-run average wage of any worker in this class is calculated as:

$$s_A = \int_{[\bar{w},D]} \frac{s(1-\alpha)dF_w(s)}{\theta + (1-\alpha)m_w(A)} \tag{10}$$

where $\bar{w}$ follows from (4).

3 An Alternative Measure of Income Inequality

Now, let's go back to our researcher trying to measure the degree of income inequality in an economy in which there are N different groups of homogeneous workers. Suppose that the researcher collects the income data of each group, separately, and uses the Theil coefficient to calculate the within-group and the between-group inequalities. Then the usual measure reads: $T = T_w + T_b$, with $T_w > 0$ and $T_b > 0$. Under the invariant distribution, though, $T_w = 0$. Assuming that the long-run measure $(T = T_b)$ is the correct one, under a certain situation, the usual procedure then leads to a bias given by T_w. Cysne (2004) has shown that this bias can be expected to increase when unemployemt increases. Proposition 2 sums up the point I want to make and example 2 illustrates it:

Proposition 2 *Suppose all workers in this economy have been pre-grouped in terms of the distribution of wage offers they see, when looking for a job and that there are N of such homogenous-workers groups. Then, under a long-run perspective, only the between-group inequality should be used for the purpose of the calculation of a measure of inequality for the economy.*

Proof. By (10), under the invariant distribution, the average wage of all workers in a certain group is given by the same real number, equal to $s_A = \int_{[\bar{w},D]} \frac{s(1-\alpha)dF_w(s)}{\theta+(1-\alpha)m_w(A)}$. ■

Example 2 *Suppose $N = 2$ (two groups of homogeneous workers). Let's assume that, in the first group, the distribution F_w is given by the uniform distribution in $[0,1]$. Just to make the point that the claim made here does not depend upon any specific meausure of inequality, let's work this time with the Gini coefficient of income inequality (insted of the Theil index). Given (9) and (10), the Lorenz curve, $L(j)$, reads:*

$$L(j) = \begin{cases} 0, & 0 \leq j < \frac{\theta}{\theta+(1-\alpha)(1-\bar{w})} \\ \frac{\left[\frac{j(\theta+(1-\alpha)(1-\bar{w}))+\bar{w}(1-\alpha)-\theta}{1-\alpha}\right]^2-\bar{w}^2}{(1-\bar{w}^2)}, & \frac{\theta}{\theta+(1-\alpha)(1-\bar{w})} \leq j \leq 1 \end{cases} \tag{11}$$

The are under the Lorenz curve is then given by:

$$U = \frac{(1-\alpha)(1-3\bar{w}^2+2\bar{w}^3)}{3(1-\bar{w}^2)\left(\theta+(1-\alpha)(1-\bar{w})\right)} \tag{12}$$

By using (4),

$$\bar{w}(\theta,\alpha) = \frac{1-\beta\alpha+\beta\theta}{\beta-\beta\alpha} - \sqrt{(\frac{1-\beta\alpha+\beta\theta}{\beta-\beta\alpha})^2-1} \tag{13}$$

One can then obtain a closed-form solution to the Gini coefficient (G) by using (13) in (12) and the definition: $G = 1-2U$. This is the within-group inequality in group 1. Note that the within-group Gini coefficient is an increasing function of both theta and alpha, the same happening with the rate of unemployment, $\frac{\theta}{\theta+(1-\alpha)(1-\bar{w})}$. As pointed out by Cysne (2004), this can explain the positive correlation between unemployment and inequality many times documented by the empirical literature.

Now let's turn our attention to the second group. To simplify the point I want to make, without the need of resorting to further calculations, suppose *that in this second group $\alpha = \theta = 0$ and all the mass of the distribution of wage offers is concentrated on the average wage of the first group.*

Then, under the long-run measure here proposed, the long-run inequality in this economy as a whole, considering the two groups, should be equal to zero, because under the respective invariant distributions (in the second case, with mass one in one single point), both groups have the same average wage, and in each group all workers will have the same wage as well.

However, the data collected by the researcher will necessarily show some workers with income equal to zero (since $\theta \neq 0$ in the first group) and some others with a positive wage (since the average wage of group one is strictly positive). Therefore, the overall income inequality calculated by the researcher will be strictly positive, even though all workers are homogenous from a long-run perspective. Moreover, as we have seen above, such a bias between the usual measurement and our desired long-run-measure will be positively correlated with (and as volatile as) the rate of unemployemt.

Note that the procedure here detailed, considering the way how the workers are grouped, uses the inference provided by economic theory to allow for the derivation of a measure of income inequality that has characteristics of a long-run measure, but can be calculated using only one set of cross sectional data.

Under our assumptions, the way of calculating the long-run measure of inequality would simply involve: i) classifying the consumers in N different groups, by the distribution of wage offers they face and; ii) using the average wage in each one of these N groups to construct a N-point measure of inequality.

4 Conclusions

In this paper I have argued that inequality measures should distinguish between inequalities based on cyclical variables, such as unemployment, and inequalities based on structural variables, such as education. In order to obtain an inequality freed from cyclical variations caused by unemployment, but at the same time feasible to be calculated with only one set of cross-sectional data, I have proposed that workers be pre-grouped by the distribution of wage offers they face, and that only between-group inequality be considered. Example 2 was used to illustrate the method.

Technically speaking, the proposal is based on the existence and uniqueness of a convergent measure of wages within anyone of such groups, under which all workers are equal in the long run. The underlying economic fact is that the average wage of all workers in each group is equalized by the continuous turnover in the job market.

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